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The aesthetics of the scientific image

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Abstract

Images in science are often beautiful but their beauty cannot be explained using traditional aesthetic theories. Available theories either rely upon concepts antithetical to science, e.g. regularity as an index of God's design, or they omit concepts intrinsic to scientific imaging, e.g. the image is taken as a representation of 'beautiful nature'. I argue that the scientific image is not a representation but a construction: a series of mutually defining intra-actions, where 'intra-action' signifies that the object depicted cannot be extricated from the technologies of picturing. But how can the beauty of intra-active, picturing-depicted constructions be explained, when philosophical aesthetics traditionally understands objects of appreciation to be distinct, discrete items? I argue that metaphor provides a model for the aesthetics of the scientific image, on the grounds that it is itself an intra-action that promotes salience in perception.

Key words: Barad, Elkins, Ihde, intra-action, metaphor, practice, representation, technoconstruction.

Images produced in the course of scientific enquiry are often beautiful, striking or visually impressive outside of the context that generated them. The fact that public exhibitions of scientific images are held – for example, in the United Kingdom, the Wellcome Trust's annual *Wellcome Image Awards*,[1] and the Royal Photographic Society's biannual *International Images for Science* exhibition,[2] and in the United States, Princeton University's annual *Art of Science* exhibition[3] and, worldwide, the Max Planck Society's annual *Images of Science* exhibition[4] – is an indication of the interest

that these images attract beyond their research usefulness. Scientific images take a variety of forms: diagrams, drawings from observation, depictions of method, data visualization, and the outcomes of technological or instrumental processes, such as positron emission tomography, magnetic resonance imaging, and different kinds of microscopy. It is the technological or instrumental image that I am interested in, since this kind dominates exhibitions of scientific images and comes closest to suggesting that nature is being depicted, in contrast, say, to diagrams and graphs where it is evident that processes other than the immediate (or mediated) depiction of nature are at work, such as classification, measurement, inference, etc. It is also the kind that poses a difficulty for the concept of beauty in aesthetics and the idea of imitating nature, as I explain below. Two examples are: a sequence of the chemical bases adenine, cytosine, guanine, and thymine that make up a given stretch of DNA (fig. 1),[5] and a fifteen-inch bubble chamber event (fig. 2).[6] They are very different images, and each is visually striking in its own way: the contrast between clear, vertical ordering and an overwhelming number of colour bands in the DNA sequence, and the deep, dark tones and the criss-crossing lines of the bubble chamber event.

One might assume that these features do not matter for the scientist. According to Marc Tramier, 'a scientific image has no aesthetic purpose. It could even take the form of graphs and matrices. Its role is to allow quantitative and qualitative analysis of phenomena'.[7] But this overlooks that fact that scientists themselves make aesthetic decisions in the production of images for scientific journal publication, as Michael Lynch and Samuel Edgerton have observed in a series of ethnographic studies of laboratory work.[8] The technological scientific image uses apparatus and the processing of data to access realms beyond human vision. During the production process, an image might be selected in the interest of salience, of allowing the point of the image to stand out more prominently (i.e. where there is minimal interference from artefacts, the distortions or intrusions introduced by the imaging technology), as well as in the interest of publishing an image that will maintain the research team's reputation for generating pictures that are strong technically.[9] This is not to deny, or should not deny, the capacity of the

image to support a hypothesis. The image refers *to something,* where reference is achieved through a series of causal connections with that 'something'. It is just that the series has been designed and constructed, and subject to a number of selections.[10]

What is happening when scientific images are appreciated outside of the scientific context that generated them? What is behind their beauty? Is it reasonable to call them 'beautiful'? The last question might seem a bizarre one to ask, since on one theory of aesthetics at the very least (the eighteenth century concept of taste as sentiment), beauty is in the eye of the beholder. In other words, if I want to call them beautiful, then that is enough; I don't need to seek further confirmation or approval. As Hume and Kant make the point respectively (as claims to be questioned, not as theses they hold): 'Beauty is no quality in things themselves: It exists merely in the mind which contemplates them; and each mind perceives a different beauty',[11] and 'everyone has his own taste… [meaning] that the basis determining a judgment of taste is merely subjective, and that such judgments have no right to other people's necessary assent'.[12] This is only one moment in aesthetics though, and in making the judgment of beauty wholly a subjective matter, it fails to acknowledge the many metaphysical schemes and distinctions – dealing with subjectivity and objectivity, art and nature, and interest and disinterest – that have been introduced throughout the history of aesthetics to define and explain beauty. But, as I shall show, there is a problem in that these metaphysics are at odds with the nature of the scientific image. On one view, it amounts to a major misunderstanding of scientific imaging even to consider the results as beautiful. However, if close attention is paid to what scientific imaging involves, to the extent that the metaphysics implicit in scientific imaging practice is drawn out, then I think there is one concept within aesthetics *consistent with that metaphysics* that can account for the images' beauty.

Theories that don't fit

One way of accounting for the aesthetics of the scientific image might be to suggest that the images fit straightforwardly a number of theories of beauty from the history of aesthetics. The ones that seem pertinent initially are those that identify beauty with properties such as symmetry, proportion and regularity, for example, the aesthetics of Aristotle and Augustine.[13] Symmetry, proportion and regularity are arguably present, to varying degrees, in the columns of the DNA sequence (fig. 1) and the trails and tonal distribution of the bubble chamber image (fig. 2). But there is the question of what is posited as the origin of symmetry, proportion and regularity by the theories. Aristotle is not clear on the matter. He declares in the *Metaphysics* that 'the main species of beauty are orderly arrangement, proportion, and definiteness; and these are especially manifested by the mathematical sciences',[14] but the claim is not developed. The emphasis on the mathematical sciences suggests that it might not be immediately relevant to images derived from empirical science anyway. Augustine does not have a single doctrine on aesthetics; his comments on the subject occur as scattered remarks throughout his writings.[15] However, when he does refer to beauty, it is evident that unity, number, equality, proportion, and order are key concepts. A Christian thinker influenced by neo-Platonism, especially the Plato of the *Timaeus*, he applies them in support of the view that the universe is the result of mathematical order imposed on pre-existent chaos by a divine craftsperson, and that beauty, when produced by humans, is the discovery of the divine craftsperson's order. As Monroe Beardsley notes in relation to Augustine's *De Musica*, 'perceptual rightness and wrongness cannot be given in sensation alone; it presupposes that the spectator bring with [them] a concept of ideal order and unity which is never exhibited in the corporeal world'.[16] Unfortunately, the idea that the aesthetics of the scientific image might be attributable to symmetry, proportion and regularity as expressions of a divine order does not sit comfortably alongside contemporary theories of scientific knowledge. The most metaphysical of scientific epistemologies, metaphysical realism, holds that objects, properties and relations in the world exist independently of our thoughts about them, but neither requires nor refers to a transcendent, order-giving agency. Some accounts offer the possibility of compatibility between scientific and religious understanding, for example, the

position of imagery in the dialectical progression Hegel charts from sense certainty to absolute consciousness, and the claim from Mary Gerhart and Allan Russell that theology and science are aligned in seeking to transcend the subjectivity of experience.[17] But the substantial challenge facing defenders of this explanation is the cogency of reference to a divine craftsperson when all surrounding theories of knowledge are secular.

Might not more modern concepts of symmetry, proportion and regularity be applicable though? To treat scientific images as occasions for admiring pleasing proportions or regularities, it could be argued, is to treat them in purely formalistic terms, as arrangements of form and colour. In which case, the twentieth-century formalisms of Clive Bell and Clement Greenberg might apply. We could take Bell's suggestion that the appreciation of the modern, abstract image requires nothing from life except 'a sense of form and colour and a knowledge of three-dimensional space',[18] or adopt Greenberg's view and treat the lines, colours and patterns within scientific images as though they 'confine [themselves] exclusively to what is given in visual experience, and make no reference to anything given in other orders of experience'.[19] But to do so would fail to account for the fact that these are *scientific images*, images which, as a result of complex visualization processes, bring aspects of reality unobservable to the naked eye, such as the behaviour of subatomic particles or the precise scale and time of earthquakes, into being. If I had to surrender the idea that what I am looking at is a scientific image, then I would have to conclude that there is no aesthetics *of* (or peculiar to) *the scientific image* as such, other than a general appreciation of form.

This approach is taken by Silvia Casini.[20] She assigns the aesthetics of the scientific image wholly to art. For her, images generated by magnetic resonance imaging (MRI) are not beautiful, and the only 'aesthetic' examples she acknowledges are occasions when MRI technology has been used by artists to create works, for example, the MRI-based sculptures by Marc Didou. Casini's aim is to define an aesthetic for MRI by examining the shifts in form and meaning that occur when it is moved from being a laboratory-based technique for diagnosis to being an art-

making technology, independent of any diagnosis. But it is *the move from science to art* that is the source of the aesthetic for her, with the aesthetic nature of the move provided by Jacques Rancière's concept of the distribution of the sensible, *not the imaging properties of the technology itself*. The way some things are clustered together and others are kept apart in experience, according to Rancière, is attributable to principles of ordering in which we participate. This means that, on Casini's terms, the scientific image has no aesthetic, and only acquires aesthetic value when it is relocated in the art world. It is not surprising that the connection with art is made. As Casini points out, the concept of *imaginatio* – 'a basic, creative ability to observe natural phenomena over and beyond the directly visible' – is shared by both art and science.[21] But the danger of placing too much emphasis on art and science sharing the concept is that it threatens to equate art and science, to unite the two cultures in one fell swoop. Against this, I would argue, understanding image-making in science, and its similarities and differences with image-making in art, requires finer distinctions than a single, unified, homogeneous domain or, even for that matter, a binary art–science opposition.

The scientific image is not a representation

Surely the most likely explanation is that the scientific image continues the tradition of representing beauty in the natural world, a defining moment of which was Charles Batteux's 1746 'reduction' of fine art to the single principle of imitating the beautiful in nature.[22] The problem with this, however, is that the scientific image does not conform to the 'beautiful nature *imitated*' arrangement. Although seeming to offer an objective representation of an object or event, i.e., this part of reality occurs in this way independently of human perception, it is in actual fact a bringing-into-being of that mode of appearing, according to the research interests, technology and rules of interpretation involved. It is not an 'icon' in Peirce's meaning of the term, i.e. a copy of a source object whose properties resemble those of the original object.[23] The objects that are depicted in scientific images are not pre-existent and imaginable independently of the image,

for the image *is their being brought into being*. I am using 'depict' to mean 'making visible' or 'bringing to light' in a sense that is a combination of Peirce's concepts of symbolic and indexical signification.[24] Depiction here is not a matter of resemblance but *symbolism* through convention, i.e. it is readable by a scientific community, and *indexicality* through cause and effect, where the instruments and conventions that generate the display have been arranged to allow some*thing* (a cause) to appear (to have an effect). Considering the question 'what does a virus look like?' can help this point. The question is in fact posed by Stephen Harrison, James Elkins and Stephen McGrath as part of their attempt to show that a virus has no appearance of its own.[25] Elkins and McGrath detail five ways in which a virus can be visualized by different imaging technologies, to make the point that viruses do not 'look like' anything; instead, its appearance is made possible and determined by the theories, apparatuses and interpretations that create the images.[26]

As Ihde notes, the compulsion is to see scientific images as representational, as depicting the true nature of reality, when they are in fact 'technological constructions' that bring into being their objects by *giving them a voice, but the voice will be a duet*.[27] Ihde's 'voice' metaphor in turn relies upon a metaphor from musical percussion: 'the sound produced is both the voice of the thing struck and the voice of the striking instrument… A bell struck with a wooden mallet produces a different "duet" of sound than one struck with a brass mallet'.[28] In other words, what is shown in the picture derives just as much from the design and operation of the instrument as it does from the portion of reality at which it is pointed. The use of the sound metaphor is significant, since sound introduces the idea that properties do not inhere in objects but are relations between them, in contrast to appearances, which are commonly attributed to their objects (irrespective of the distinction between primary and secondary qualities). Ihde's analogy relies upon reference to bells and mallets, familiar, to-hand objects that we can imagine being struck. But in the case of scientific images, target-object and instrument are not pre-existent and to-hand. Theory construction, instrument design and experimentation have to combine to give voice in such a way that the image has a

figure-ground relationship: something stands out from a background. Again, this will be a duet: 'not something simply "given" [in the sense that it comes with the object, on the object-side of the duet] but [something] *constituted* by its context and field of significations'.[29]

A similar thesis on the technoconstructed nature of the scientific image is given by Karen Barad.[30] A key consideration for Barad is Neils Bohr's concept of 'phenomenon': the idea that the object to be measured *is constituted by the process of measurement.*[31] All relevant features of the experimental arrangement need to be described in any account of the object, Barad maintains, because they are collectively responsible for creating the phenomenon, the object as it occurs within the experimental arrangement. In this sense, the elements within the experimental arrangement do not *interact,* which implies the prior existence of the distinct entities, but *intra-act,* where 'intra-action' signifies '*the mutual constitution of objects and agencies of observation within phenomena*'.[32] Strictly speaking, my use of the word 'element' is wrong, given that 'element' means 'basic unit'. With intra-action, there are no basic units as such, as they all mutually depend on one another. Barad offers ultrasound imaging as an example. Sound waves are reflected from the foetus and converted into electronic signals for visual display in ultrasonic scanning, but this is not a neutral view of the foetus. Not only do we have the process of translation (from sound to signal to display), but also there is the consideration that several factors affect the success of the translation and, therefore, the image produced on screen, for example, 'different kinds of tissue have different acoustic impedances' and 'the reflection of the beam varies with… the differences in impedances between the materials' involved.[33] Furthermore, apparatuses 'are not pre-existing or fixed entities' but 'are themselves constituted through particular practices that are perpetually open to rearrangements, rearticulations, and other reworkings'.[34]

Ihde's 'bell' reference is in actual fact a good metaphor for intra-action. The point of the metaphor is that the sound cannot be analysed in terms of the sound *of the bell* and the sound *of the mallet,* whether wooden or brass, because *neither object has its*

own sound. Although we might refer to the sound of the bell ringing, the sound is in actual fact an intra-action between bell and mallet. The particular sound is a phenomenon in Bohr's sense because it, as a singular thing, can only come about through a specific arrangement of contributing parts, none of which can produce or hint at the sound in isolation. One danger of the 'duet' metaphor, however, is that it entails two terms and therefore suggests that a subject–object split might not be too far away. To avoid the unhelpful dualistic associations of 'duet', I shall adopt the acoustically-related but more overtly intra-active metaphor of 'chime', following Ihde's example of the mallet–bell sound that cannot be attributed to either the bell or the mallet.

The concept of the scientific image as a technoconstruction demonstrates that the scientific image cannot be a copy of a source object whose properties resemble those of the original object. This means that the idea at the start of this section – that the aesthetics of the scientific image might belong to the tradition of representing beauty in nature – fails. Elkins takes a similar view.[35] Viewers of scientific images, both inside and outside science, he observes, frequently appeal to notions of beauty when describing them, thinking this confers upon them a kind of arthood that connects them with the tradition of representing the beautiful. The problem with this, for Elkins, is that these concepts are not up to addressing the complexity of image-making within science, and this lack of understanding affects scientists and non-scientists, e.g. artists, philosophers, and other art–science commentators. 'Public talk and journalism about art and science', he writes,

> is a kind of faux-discourse: it has the appearance of creating meaning, but it often fails to do so because the two sites of knowledge, historical or critical and scientific or technical, are too generalized to make contact. Even the small amount of academic writing on art and science, such as Martin Kemp's, only attains its purchase by narrowing its focus to very small extracts of art history.
>
> One way to improve this situation would be to avoid generalized tag-words like 'beauty', elegance', and 'pattern', and

> another way would be to avoid setting up contrasts between science and art.[36]

The aspect of the scientific image that aesthetics has failed to grasp, according to Elkins, is that it is first and foremost *part of a practice*, rather than a representation that can be regarded in isolation as the depiction of a thing. By 'practice', Elkins means a series of processes involving transformation, codification, interpretation and exchange between different departments and institutions, that creates complexity in terms of technological detail and discipline specialisation that cannot be reduced to the idea of image-as-surface or as-thing (that stands in a correspondence relation with an object). In this respect, he is of the same opinion as Ihde and Barad. The problem with finding a scientific image beautiful, as far as Elkins is concerned, is that we resort to seeing it as a representation, and in so doing, overlook the practical, constructed nature of the depiction and scientific conduct in general. It is a limitation of philosophical aesthetics, on his reading of it at least, that looks set to restrict understanding of scientific visual practice. In fact, he positively resists any philosophizing in his treatment of the scientific image. He is keen for his position not to be 'yet another capitulation to philosophy' since philosophy, as he sees it, 'eats other disciplines', with the result that the concerns and vocabularies that are specific to individual disciplines are lost.[37] This is the criticism that most subjects deal in particulars whereas philosophy works with universals, and so misses much of the grain of real life.

This article is not the place to respond to this criticism, other than to point out that his understanding of philosophical aesthetics is too narrow and overlooks other accounts of beauty that might be applicable, one of which I go on to develop in this paper. It is also worth noting that Elkins's criticism of finding beauty in the scientific image has wider political and epistemological implications, not noted by him. The beauty of the images might be used to seduce audiences into believing that science is getting better at portraying the true nature of reality, and that the level of invention, technology design, and trial and error needed to create and understand these images (and needed within scientific practice in

general) gets overlooked. Science may be able to offer increasingly microscopic, macroscopic, and data-rich visualizations, but with the nature of image-making in question, one cannot assume that they are isomorphic representations of their subject matter. And to overlook the invention, technology design, and trial and error involved in their production is to forget that science is a practice, that scientific knowledge is produced and not simply read-off from nature. The two claims regarding representation and practice, I admit, are positions on the epistemological status of scientific knowledge, specifically in relation to the debate on whether scientific knowledge is committed to realism or anti-realism (or social constructionism), which I cannot defend here. But my point is that the aesthetics of the scientific image has implications that could be gathered in support of wider concerns in epistemology and the philosophy of science.

Intra-active aesthetics

As we have seen, the history of aesthetics is, to a large extent, a history of metaphysics. Offer an account of why an image or object is beautiful, and there will be an aesthetic theory from the past that can support the account or take it further using concepts such as subject, nature, a reality-in-itself, form, regularity and possibly a supreme being, arranged in a metaphysical scheme. It's just that none of the theories from the history of aesthetics acknowledge the metaphysical, bringing-into-being work of the scientific image. Does this matter? If people who find beauty in scientific images attribute that beauty to a divine order or to an essential nature or to the scientist-as-artist, and overlook the fact that the image is a bringing-into-being, what's the problem? People find many things beautiful, and might offer up a variety of reasons that may or may not be sound philosophically. I am not trying to establish the right way to appreciate scientific images. Rather, I want to address the following: if aesthetic appreciation always rests upon a metaphysics, is there a theory that can explain the aesthetics of the scientific image in a way that is appropriate to the metaphysics embedded within scientific imaging practice? The philosophy of beauty conventionally studies the beauty of things:

artworks, representations, landscapes, natural objects, people, etc. However, image-making that is an intra-active bringing-into-being is a different proposition. How might aesthetics account for beauty in an image that is not simply a mode of viewing an object, i.e. it is not just a solo performance, but a mode of viewing that *itself* has to be designed, worked for and targeted in a way that will give a voice to its object, i.e. it is a chime? Is it the case that the practice of scientific imaging is too particular for philosophical aesthetics to deal with?

The scientific image, the objection runs, has an ontological complexity, on account of its practical, technologically-constructed nature, that means it is not a contender for being called 'beautiful', because beauty entails a commitment to aesthetics as the representation of beautiful nature, and to the subject–object metaphysics that underpins representation (on the basis that a subject's perception is a representation of an object). In other words, we describe things or representations of things as beautiful, yet the scientific image, on the terms and Ihde, Barad and Elkins, *is not a thing but an ongoing sequence of transformations and discursive exchanges.* On this account, wrenching the image from its place in scientific discourse and presenting it as an object for aesthetic appreciation is a violent act. Something that only exists within a series theoretical, technological and interpretive acts is removed from this flow and held in relative isolation, away from the contexts that give it meaning, as something to be appreciated on its own, visually impressive terms, whatever they might be (over and above being visually impressive). In Kantian terms, this is the switch from interested (in this case, scientific) to disinterested judgment. In the former, concepts are applied determinatively in the interpretation of the image, fixing its identity and setting it in a context, while in the latter, no concepts are exercised determinatively because beauty is an experience that confounds judgment in subjective and objective terms (what Kant calls the antinomy of taste).[38] In the context of science, the image exists to enable interested, determinative judgment to take place, and there is no disinterested reflection by the scientist on the image as a form in its own right, as an arrangement of shapes, colours and patterns. Therefore, the scientific image cannot be a contender for beauty because aesthetic judgment entails a stepping

back from the flow of determinative technoconstruction on which the scientific image depends.

The idea that appreciating a scientific image for its beauty *wrenches it away from its constructed, scientific context*, I think, needs to be examined further. The fact that there are interested, scientific judgments on the one hand, and disinterested, aesthetic judgments on the other, is not the issue. What's at stake is the claim that a disinterested, aesthetic judgment loses the sense of active, interpretative technoconstruction in which the image is set as part of scientific practice, with Elkins's concern that we slide into regarding the scientific image as a representation. But this is not necessarily the case. The danger here is that we let eighteenth century aesthetic thought govern the proceedings, in the forms of Batteux's concept of fine imagery imitating beautiful nature (that Elkins is relying upon implicitly), and Kant's distinction between interested and disinterested judgment. But cannot aesthetic judgment also exist as a chime, to recall Ihde's 'bell' analogy? That is to say, when we appreciate something aesthetically, cannot that moment also occur as an intra-action involving the concepts and technologies that have brought the image into being, but possibly adding other poetic meanings and associations into the arrangement? The immediate issue is whether aesthetic appreciation exists only in a domain of its own, cut off from the construction of scientific knowledge or any form of interested judgment, or actually is able to maintain some kind of relationship with the intra-actions that form the construction of knowledge. The larger issue is what we understand by aesthetics and its position in relation to what might be thought of as the tougher, more world-confronting areas of philosophy, such as epistemology, philosophy of science, metaphysics, etc.

Metaphor as a model for intra-active aesthetics

A concept within aesthetics that can show how aesthetic appreciation is consistent with the intra-actions that form the construction of knowledge is metaphor. When

something is described metaphorically, for example, Schelling's 'architecture is frozen music', part of the enjoyment of the phrase is thinking through the possibilities stimulated by conceiving of architecture as frozen music. This is emphasized by Max Black's interactionist theory of metaphor which asserts that the two subjects in a metaphor are complexes of implication: systems of association shared by the linguistic community that determine all the various ways in which their subjects might be perceived and understood. In a metaphor, the two complexes interact and mutually sieve the implications that they have for one another to create a third implicative complex, a new way of seeing the metaphor's primary subject that was not available prior to the metaphor.[39] So it is possible to understand aesthetic judgment occurring as an intersection of concepts.

But, an objection might run, metaphor is presented here as an *interaction*, its two terms existing prior to the metaphor, whereas the scientific image, as it is presented here, is an *intra-action*, meaning it cannot be separated out into its component parts, just as the sound of a bell being struck by a wooden mallet cannot be separated out into mallet-sound and bell-sound. The point of the chime analogy, and the emphasis on intra-action as a context defined by mutually dependent factors, is that mutual dependence creates a unique particular or what Bohr (quoted above) terms a 'phenomenon'.[40] I accept that the name 'interaction theory' is not helpful, given the importance of the interaction–intra-action distinction. However, what needs to be recognized is the significance Black attaches to the idea that the interaction between the two terms creates a third implicative complex, a new perspective on the metaphor's primary subject, that *cannot be separated out in terms of its constituent parts.* Black is challenging the comparison theory of metaphor which holds that a metaphor simply makes explicit what was already implicit, and in response, asserts that the third term is entirely new, something that neither of the two terms in isolation prior to the formation of metaphor, could signify or anticipate. On Black's understanding, metaphors make new features of reality stand out by creating new perspectives on the world. My phrasing is not quite accurate though, for 'new features of reality' attributes these features to the world, when I am working in an intra-active context

when ascription to one side of the subject–world distinction is not an option. But Black is aware of the problem. While I have been likening the aesthetic dimension of scientific images to metaphors, Black compares metaphors to 'cognitive instruments' in as much as they allow us to see things in a new way, as in the case of the first cinematograph 'creat[ing] the aspect' of a horse appearing to gallop in slow-motion and, in particular, how a horse's legs move in relation to another.[41] 'Some metaphors', he writes,

> enable us to see aspects of reality that the metaphor's production helps to constitute. But that is no longer surprising if one believes that the world is necessarily a world *under a certain description* – or a world seen from a certain perspective. Some metaphors can create such a perspective.[42]

One could argue that horse's legs have always moved in relation to one another *in a certain way,* and it was simply a matter of human technology reaching a level of sophistication that allows us to see with this detail. But Black is a perspectivalist in the sense that all knowledge and perception is undertaken from a point of view; a world is always 'a world *under a certain description*'. He asks: 'Did the slow-motion appearance of a galloping horse exist before the invention of cinematography?'.[43] As far as he concerned, *an aspect is created* – 'the slow motion *appearance* of a galloping horse' – but this is not to say that metaphor and technology can generate new entities or natural kinds in the world willy-nilly. For the aspect is not simply 'of the world'; the novelty is not all on the side of reality, with nothing left over for the viewer. Rather, it is an aspect made possible by a new perspective, where the aspect cannot be separated out from the perspective that is necessary to perceive the aspect. A new aspect stands out, much in the way of the figure–ground structure that Ihde attributes to the scientific image. Scientific research, Ihde asserts, is always intentional, i.e. object-directed: scientists will be looking for *something*, and the search will be governed by a theoretical framework that embodies interests and concepts that allow a figure to emerge from a ground.[44] The figure–ground structure 'is not "given" but is *constituted* by its context and field

of significations… Figures "stand out" relative to interest, attention, and even history of perceivability'.[45] It is Black's perspectivalism that ensures the intra-active nature of his theory. A perspectivalist maintains that the world is always encountered from a perspective, and the way the world appears cannot be divided into the contribution made by the perspective and the contribution made by the world. On the perspectivalist's view, there can never be immediate, perspective-free contact with the world.

What would it mean then to say that the scientific image can be enjoyed aesthetically as a metaphor? It would mean looking at the image not as the representation of an object or event but instead as something that has implications for its scientific subject. As a *scientific* image, its subject matter would invariably be described in a caption on the gallery wall or catalogue page. This is one context where information about the image appearing alongside it is appropriate, in contrast to art exhibitions, where sometimes there are concerns that titles and explanations on the gallery wall dominate the artworks. But it is not the scientist's understanding of the subject displayed in the image, the knowledge of the specific intra-actions of which the image is a part, that is important here. Aesthetic appreciation is not expected to be the same as scientific knowledge. If it were the case that aesthetic intra-active experience was the same as scientific intra-active experience, then we wouldn't be talking aesthetics and the aesthetics of the scientific image wouldn't be a problem. With aesthetic appreciation of the scientific image, it is important to enjoy the images as intra-actions: complexes whose meaningfulness is a result of informing and being informed by other realms. In the case of scientific enquiry, these will be theory construction, apparatus design and experimentation. In the case of aesthetics, these will be the perspectives that are created through metaphorical associations. On the metaphorical model given here, aesthetic enjoyment of the image is a matter of exploring how its forms, lines and colours create associations in *and around* the subject, where 'around' signifies that associations might be generated that are departures from, and possibly at odds with, scientific meaning.[46]

With the DNA sequencing image (fig. 1), the 'chime' element of its metaphor lies in acknowledging that the colours and their vertical arrangement are not wholly of the DNA sequence, but complexes of association with implications for how DNA might be thought, considered, imagined. Part of the image's appeal is that a very small part of the sequence of chemical bases (adenine, cytosine, guanine, and thymine) responsible for the proteins that govern cell production is manifest as an expanse of shimmering colours. An exact, vertical base sequence becomes the occasion for arbitrary, horizontal relationships between colours on account of the sequences being laid graphically alongside one another. Thoughts of DNA as 'the instructions needed for an organism to develop', to adopt a common scientific metaphor, meet head-on a display of rhythm, conjunction and disjunction in colour on which it is difficult for the eye to settle. This move, from sequence to shimmer, could be construed as working against scientific understanding of DNA but, as an aesthetic response, it is valuable in demonstrating how graphic depiction does not just represent information but intra-actively constructs meaning, in this instance, in a direction that introduces concepts – 'shimmer', 'rhythm', 'conjunction' – not commonly associated with DNA-as-instruction.

The 'chime' nature of the fifteen-inch bubble chamber event image (fig. 2) consists in acknowledging that the lines and tones are not representations of particle collisions but complexes of association with implications for how particle physics might be thought. Viewed metaphorically, it invites the subatomic realm to be considered from the perspectives of 'conflict', 'space' and 'material'. It looks as if there are flashes and debris, perhaps in a night sky or in a field observed from an aerial viewpoint. This is not to read the image as representational, but to introduce themes of 'explosion' and 'fragmentation' as perspectives from which particle collisions might be considered aesthetically. Events appear in different ways. There are the flash-like white circles, at different levels of brightness, but there are also lines, trails and spirals. Are two domains actually colliding here: flashes in a night sky, and courses plotted in a field? Then there is the black cloud on the bottom-right of the image. Is this trying to encroach on the grey area? Are the black specks that litter the grey field debris from a previous battle between the black and the

grey? Then there is the question of the medium in which the greys reside. Away from the thought that the greys might be set in a sky or a field, there is the suggestion of certain kinds of movement: advancing clouds, expanding flashes, lines of flight. But how are these different forms moving? What kind of medium could accommodate or enable such diverse movements? I don't ask this in expectation of the answer 'superheated liquid hydrogen'. Rather, it is an articulation of the sense of material evoked by the image.

Is my theory an anti-climax? After the hope of finding an aesthetics of the scientific image, it would seem my suggestion boils down to simply the associations generated by an image. This interpretation is reinforced by the familiarity of metaphor as a poetic device, just a way of describing one thing as something else. In one sense, my theory does rely on the idea of images generating associations. But what has to be remembered is the importance that is given to association in Black's theory. It is too easy to treat association as simply the triggering of one idea by another in the mind of the viewer. In contrast, in Black's theory, the associations are part of a cognitive process, creating new perspectives on the metaphor's primary subject. Accordingly, my theory does not just amount to 'What do these images suggest to you?' but more substantially asserts that the properties of the image have the potential to generate perspectives on the scientific subject. These perspectives will not necessarily be scientifically accurate, but will be consistent with the intra-active, perspectivalist thesis that perception is always shaped by the technology or perspective from which it is made. One thing – a vertical line of colour bands – is a form that *opens onto something else* – a shimmering, uncertain identity – just as each chemical base in a given stretch of DNA can be *assigned a colour dye so that it becomes* a region in a series of adjacent vertical lines. From the point of view of metaphorical, intra-active aesthetics, visual marks are the condition of other things appearing: they are the basis of a world of signification, and not simply an appearance borrowed from an already colourful source. This is aesthetics foregrounding the epistemological and ontological thread running throughout the theories of Ihde, Barad and Black:[47] in any act of technologically-constructed perception, it is impossible to distinguish the

contribution of the technology (this would be a perspective in Black's idiom) from the contribution of reality, because the former is already an active part of reality, seeking out the forms that might be relevant or meaningful.

In this respect, I am also allying myself with recent theories that see metaphor not as one poetic device among others, but a principle of conceptual pairing that is fundamental to metaphysics, especially the way in which experience and reality are configured. I have in mind theories from Friedrich Nietzsche,[48] Paul Ricoeur,[49] Graham Harman,[50] and Miguel de Beistegui.[51] Although different in many respects, they share a commitment to experience not being the impression of a world in the mind of a subject, but a state of being that is pregnant with possible drives towards other states of being, with continuous, subjective experience as a consequence, and metaphor positioned as the drive *par excellence.* The relevance of these to my aesthetics of the scientific image is that they help to move understanding of the image away from being the impression of a world, and in the direction of being a condition that is pregnant with drives towards other meanings.

It might also be asked whether my theory could draw support from the concept of 'seeing as' explored by Ludwig Wittgenstein and Richard Wollheim, since it would seem to be present in the idea of cell production being seen as an expanse of shimmering colours, and collisions between subatomic particles being seen as the conflict between light and dark. [52] However, our concepts of 'seeing as' are different. As Wittgenstein and Wollheim have argued, the act of recognizing a picture to be a picture of something, for example, seeing a drawing *as a drawing of a rabbit,* is part of the experience of looking at representational art. But this cannot apply to the scientific image, since in cases of representational art there will usually be some form of resemblance between the image and its object, whereas in the scientific images discussed here, there is no resemblance relation. The images are not recognizably *of the objects or events they portray*, since they (the images) are the bringing-into-being visually of the objects and events. My 'seeing as' is a relation where one thing opens onto or becomes about another entirely different thing, where there is no resemblance relation. However, one area of possible overlap for

further investigation might be whether one thing opening onto another informs the conditions of possibility of representation, one of the enduring concerns of Wittgenstein's philosophy.

Unfortunately, there is a problem that the scientific image and metaphor share: their intra-active, constructed nature is forgotten in the face of representational thinking. As Ihde notes, technoconstruction tends to conceal itself. In order for technoconstructed objects 'to stand forth with the greatest possible clarity… the instrumentation, in operation, must "withdraw" or itself become transparent so the thing may stand out'.[53] This is a version of Heidegger's observation that tools, when they are working, tend not to draw attention to themselves. 'What is peculiar to what is initially at hand', he writes, 'is that *it withdraws*, so to speak, in its character of handiness *in order to be really handy*'.[54] Tools disappear into the background of activity and are only useful because they disappear. If they called attention to themselves as objects, and therefore became objects of attention, they would get in the way and stop us from doing the job. The warning here as far as the scientific image is concerned is that something's standing out in an image that is of interest to researchers *occupies those researchers* to the extent that the technoconstruction *that created the standing out* recedes almost entirely from consideration. The same could apply to viewers who are appreciating the image aesthetically: they focus on the thing depicted, but are oblivious to the technological conditions that brought in into being and sustain it in its being. As Ihde is keen to point out, in the case of the scientific image, the instrumentation 'can never *totally* disappear. Its "echo effect" will always remain within the mediation. The mallet (brass, wooden or rubber) makes a difference to the sound produced'.[55] Another sonic metaphor, this time an 'echo', is doing important work: something is present or returns to us even though the origin is absent or overlooked, but is only present weakly, almost imperceptibly; it is there if you listen out for it, hence the emphasis on 'never *totally* disappear'. This might go some way towards explaining why the scientific image is so readily viewed as a representation of nature. In seeing a thing depicted – a line, a shape, a series of marks – the assumption is that this thinghood is borrowed from the world, when

in fact it is a product of a series of intra-acting theories, technologies and interpretations.

Metaphor also conceals itself. In metaphor theory, there is the distinction between a living or freshly-minted metaphor, for example, a metaphor's first formation within a poem, and a dead metaphor, a figure that has become part of everyday speech, such as '*grasping* an idea' or '*seeing* what you mean'. The contrast is between, one the one hand, a poetic setting in which we are made aware of the power of language to redefine an experience by bringing together semantic fields that are ordinarily remote, and on the other, an everyday setting in which it seems that language does nothing more than individuate items in the world, with the sense of 'remote semantic fields being combined' lost through usage. To adopt the contrast between interruption and transparency from the tool analogy above, metaphor lives and occupies us with its collision of concepts, yet it disappears and dies when it passes us on to things with ease. It would seem that both technoconstruction and metaphor involve intra-active combinations that are responsible for bringing new objects to light, yet because they deliver objects to us, their generative dimension is overlooked because we devote all our attention to the object and not to its means of construction or delivery.

This is a problem that cannot be resolved here. It is a question of the ontology of perception, language, and knowledge. How do we carve up – to whom or to what do we attribute – the properties that occur in perception, language, and knowledge? Dualistic, representational metaphysics seeks to distribute properties to the subject, the object or an intermediary, such as sensory impressions or sense data. While this metaphysics is well established, and gains much support from corresponding to the common sense perception that there are individuals (subjects) moving about a world, it is at odds with the technoconstructed nature of scientific knowledge discussed here, and suffers the epistemological problem of how to explain the correspondence between mind and reality in general (not discussed here). Intra-active aesthetics requires us to understand image-making, knowledge-construction and human activity in a manner where tidy, two-term

attribution is impossible. This is the metaphysical implication of the terms 'technoconstruction', 'intra-action' and 'practice': whichever element one tries to isolate as a thing or a stage within technoconstruction will always already be saturated with or influenced by determinations from other elements within the process, thereby preventing any clean ascription of properties to it. The wider political and ethical implications of this might be termed ecological, in as much as technoconstruction calls attention to our rootedness in an environment, and the importance of recognizing the interdependence of factors in all forms of activity or production. Furthermore, technoconstruction, as a metaphysics of construction, is more conducive to that dimension of political and ethical thought that sees the value of philosophy as being a stimulus for rethinking knowledge and how lives might be lived better or differently; a two-term, subject–object model, the argument runs, is inclined towards acceptance of a reality that is 'external to' or 'opposite' a subject and 'concrete' or 'fixed', and therefore not a stimulus for change. So while the world will keep turning if scientific imaging and metaphor are understood simply to refer us to things in the world, what is in fact at stake is a metaphysical difference with epistemological, political and ecological implications, not least of which is recognition of the rooted, intra-active nature of scientific knowledge.

Conclusion

I embarked on this article because I was intrigued by the challenge that the scientific image posed for aesthetics. As I demonstrated in the first section, the principal contender theories from the history of aesthetics that at first *appear to be able explain why scientific images are beautiful* all fail because: (1) they rely upon concepts antithetical to science, e.g. regularity as an index of God's design, or the image is simply placed in an art context (with Casini), or (2) they omit concepts intrinsic to scientific imaging, e.g. regularity is taken on purely formal terms and not as an indication that something of scientific interest stands out, or the image is taken as a representation of 'beautiful nature'. Three theories of image-making in

science, from Ihde, Barad and Elkins, cluster around the idea that the scientific image is constituted by a series of mutually defining and dependent operations involving theory, apparatus and experiment design, technological transformation and interpretation, under the almost-synonymous headings of 'technoconstruction' (Ihde), 'intra-action' (Barad) and 'practice' (Elkins). The problem that this approach poses for aesthetics is that the conventional notion of finding something beautiful relies upon the idea of fixing on that thing *as an object*, when technoconstruction (to use Ihde's phrase as shorthand for all three theories) requires that there is awareness of the intra-active, mutually constitutive nature of all the elements involved. Metaphor, I have argued, provides a model for the aesthetics of the scientific image that can accommodate technoconstruction, on the grounds that it has two affinities with the image: metaphor is itself an intra-action, and promotes salience in perception. The associations generated by appreciating a scientific image as a metaphor might not be scientifically correct, but they will be in keeping with scientific epistemology in that they demonstrate how colours, lines and tones point intra-actively towards other things.

As I have already noted, the history of aesthetics is, to a large extent, a history of metaphysics: offer an account of why an object is beautiful, and there will be an aesthetic theory that can support the account in terms of concepts drawn from metaphysics, e.g. subject, nature, a reality-in-itself, etc. However, the aesthetics of the scientific image differs from this is in showing that it is not simply a case of importing a theory from the history of aesthetics as a convenient explanation, but rather that a challenge to metaphysics is laid down, albeit one that is easily forgotten due to the dominance of representational, subject–object thinking. As well as disclosing this metaphysical difference, an aesthetic interest in the scientific image might also be significant as a way of calling attention to the question of the ease with which it is forgotten. Addressing the reasons for it – almost certainly at the intersection of ontology, politics and ecology – and identifying the disciplines and institutions that might have to interact to bring about recognition of intra-action must remain the subjects of papers to come.

Illustrations

Fig. 1. Automated DNA sequencing output. © The Sanger Institute, Wellcome Images.

Fig. 2. Fifteen-inch bubble chamber event. © Lawrence Berkeley National Laboratory Image Library.

The Wellcome Trust can provide a high-resolution copy of fig. 1 upon request. I shall approach the Trust for a copy if the article is accepted for publication. I shall also pay the permissions costs for both images.

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Notes

[1] See <http://www.wellcomeimageawards.org/> accessed 29 July 2014.

[2] See <http://www.rps.org/exhibitions-and-competitions/current-exhibitions/international-images-for-science> accessed 29 July 2014.

[3] See <http://artofsci.princeton.edu/> accessed 29 July 2014.

[4] See <http://www.maxplanckflorida.org/exhibit.html> accessed 29 July 2014.

[5] The Wellcome Images website explains the image as follows: 'The output from an automated DNA sequencing machine used by the Human Genome Project to determine the complete human DNA sequence. Each vertical lane shows the sequence of bases in a given stretch of DNA. Each of the four different bases is labelled with one of the four coloured dyes. The order of the bases is analysed by a computer and assembled to give the continuous base sequence of each chromosome. This image shows the sequence of only a tiny part of one chromosome.' < http://wellcomeimages.org/indexplus/result.html?_IXMAXHITS_=1&_IXACTION_=query&_IXFIRST_=13&_IXemailreal=true&_IXbox=260017&_IXSPFX_=templates%2Ft&_IXFPFX_=templates%2Ft> accessed 22 August 2014.

[6] The fifteen-inch bubble chamber event image is from a subatomic particle detector designed to measure collisions between particles. The chamber is so-named because it contains a liquid, such as superheated liquid hydrogen, that causes a trail of bubbles to form along the path of a charged particle fired through the chamber. Properties of the curvature of the trails give indications as to the identities of the particles. For a good account of the methods behind bubble chamber images, see James Elkins, *Six Stories from the End of Representation* (Stanford: Stanford University Press, 2008), 156–190.

[7] Engineer Marc Tramier is quoted in Escalón, "Bio-Imagery: Cells from Within", accessed 30 July 2014.

[8] Lynch and Edgerton Jr, "Aesthetics and Digital Image Processing", 184–220.

[9] Lynch and Edgerton Jr, "Aesthetics and Digital Image Processing", 197–204.

[10] For a good account of the indexical value of the image to science, see Perini, "Visual Representation and Confirmation", 913–926.

[11] Hume, "Of the Standard of Taste", 136–137.

[12] Kant, *Critique of Judgment.*

[13] Hanfling, "Aesthetic Qualities", 41–42.

[14] Aristotle, *Metaphysics,* 1078b.

[15] Beardsley, *Aesthetics from Classical Greece to the Present,* 93.

[16] Beardsley, *Aesthetics from Classical Greece to the Present,* 96.

[17] Gerhart and Russell, *Metaphoric Process: The Creation of Scientific and Religious Understanding,* 37–60.

[18] Bell, "The Aesthetic Hypothesis", 115.

[19] Greenberg, "Modernist Painting", 758.

[20] Casini, "The Aesthetics of Magnetic Resonance Imaging", accessed 15 August 2014.

[21] Casini, "The Aesthetics of Magnetic Resonance Imaging", accessed 15 August 2014.

[22] Hanfling, "The Problem of Definition", 7–8.

[23] See Peirce, *The Writings of Charles S. Peirce: A Chronological Edition,* Volume 2, 53–56, for the introduction of the icon–symbol–index distinction.

[24] It has to be admitted that some scientific images resemble their object in some way, for example, magnetic resonance imaging scans of the human brain that correspond to the shape of the subject's head. But in these cases, there will be other phenomena in the scan – arguably the reason for conducting the scan, for why else would the scan be produced if the phenomena were visible to unaided human perception – whose appearance in the scan cannot be said to *look like* their target object.

[25] See Elkins, "Visual Practices Across the University", 183–192. Stephen McGrath is a contributor to only a part of Elkins's chapter, and so is not listed as a

co-author. Stephen Harrison is the first to pose the question, in his lecture "What Do Viruses Look Like?", 127–152.

[26] To give an indication, three of the five ways are: (1) the plaque assay method of visualizing the bacterio-phage life cycle: inert parasites (phages), when attached to bacterial cells, trigger the release of DNA that leads to the infection of the cell, causing clear spots to appear in a 'lawn' of bacteria; (2) electrophoresis is the use of an electric field to separate individual constituents of proteins into homogeneous and, therefore, visible bands, to enable the sequence of amino acids contained in the proteins to be determined; and (3) immunogold electron microscopy tags antibodies with gold that are highly specific for individual proteins, and then introduces the antibodies into the bacterio-phage structure to enable the location of the proteins, with the gold appearing as dense black spots when viewed under a transmission electron microscope. This technique supplements electrophoresis, for the latter reveals the presence of a protein in the bacterio-phage structure but doesn't pin-point its location.

[27] Ihde, *Expanding Hermeneutics,* 151, 163, 178–183.

[28] Ihde, *Expanding Hermeneutics,* 151.

[29] Ihde, *Expanding Hermeneutics,* 162.

[30] Barad, *Meeting the Universe Halfway*.

[31] Barad, *Meeting the Universe Halfway*, 197.

[32] Barad, *Meeting the Universe Halfway*, 197; original emphasis.

[33] Barad, *Meeting the Universe Halfway*, 202.

[34] Barad, *Meeting the Universe Halfway*, 203.

[35] Elkins, "Visual Practices Across the University".

[36] Elkins, "Visual Practices Across the University", 180.

[37] Elkins, *Six Stories from the End of Representation,* 17, 19.

[38] See Kant, *Critique of Judgment,* §§56–57.

[39] Max Black, "Metaphor", 273–294, and "More about Metaphor", 19–41. See 'More about Metaphor', 27–28, for the reference to the 'implicative complex'.

[40] See Barad, *Meeting the Universe Halfway,* 197.

[41] Black, "More about Metaphor", 37.

[42] Black, "More about Metaphor", 38; original emphasis.

[43] Black, "More about Metaphor", 37.

[44] Ihde, *Expanding Hermeneutics,* 162.

[45] Ihde, *Expanding Hermeneutics,* 162; original emphasis.

[46] Elkins declares that the scientific images and its interpretation are metaphors, but does not develop the point into an aesthetic theory. 'What looks like a picture of the procession of a spinning top', he observes with reference to angular momentum vectors for an electron, 'is actually a trope, a metaphor for something else. Students find this metaphor useful because… the picture looks a bit familiar from their basic mechanics courses'; *Six Stories,* 200–201. He chooses 'to mark the places where metaphors begin to guide the inquiry, so that they can at least become objects of discussion and self-criticism'; ibid., 18. This means that the metaphorical nature of the scientific image is a heuristic property for Elkins, and not a concept from aesthetics that can explain their beauty.

[47] I have not included Elkins in this list as, strictly speaking, he only criticizes philosophy's binary, representational epistemology and does not recognize that other ontologies are available, although his concept of 'practice' is consistent with Ihde's and Barad's views.

[48] Nietzsche, "On Truth and Lie in an Extra-Moral Sense", 65–73. On the centrality of metaphor to Nietzsche's thinking, see Cazeaux, *Metaphor and Continental Philosophy*, 104–132, and Kofman, *Nietzsche and Metaphor.*

[49] Ricoeur, *The Rule of Metaphor.*

[50] Harman, *Guerilla Metaphysics,* 101–124.

[51] Beistegui, *Aesthetics After Metaphysics.*

[52] Wittgenstein, *Philosophical Investigations,* §§193–214; Wollheim, *Art and Its Objects,* 205–226; Wollheim, *Painting as an Art,* 217–226.

[53] Ihde, *Expanding Hermeneutics,* 163.

[54] Heidegger, *Being and Time,* 69, emphasis added.

[55] Ihde, *Expanding Hermeneutics,* 163; original emphasis.