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Nature's Handmaid, Art[1]

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Works of fiction are either false or truth-valueless. Representational paintings and sculptures, being non-propositional, make no claims. Absolute music does not even denote. Whatever the value of such works, it may seem, that value is not, even in part, epistemic. In this respect, art is the polar opposite of science. I disagree. My thesis is that art, like science, embodies, conveys, and often constitutes understanding. I am not using 'understanding' in a loose or extended sense. Rather, my contention is that the arts and the sciences use the same symbolic resources to achieve much the same symbolic ends. The typical response is 'That's ridiculous! Everybody knows that art aspires to beauty and science aspires to truth. They're not even trying to do the same thing, much less succeeding.' This stereotype is false and misleading. It distorts both the ends and the means of both disciplines. To establish this, I'll set aside worries about beauty and focus on truth.

The stereotype assumes that to function cognitively is to be or aspire to be true. But science unblushingly uses models, idealizations, and thought experiments that are not, and do not purport to be true. Physics talks of frictionless planes. But friction is ubiquitous. There are and could be no frictionless planes. To exclude friction from the description of a moving body is to represent things as they are not. Thermodynamics appeals to the ideal gas. The ideal gas is supposed to consist of dimensionless, perfectly elastic spheres molecules that exhibit no mutual attraction. But every material model has some dimensions; no molecule is a sphere; and every object being

subject to gravity, attracts every other object. To be sure, there are more 'realistic' gas models that do not depart so far from reality. But thermodynamics must simplify. A representation of the interactions of gas molecules as they really are would be computationally and conceptually intractable. We could make no sense of it. What simplifications to make is subject to negotiation. Whether to simplify is not. Scientists rely on thought experiments. Einstein asks what a person riding on a beam of light would see. The conditions he imagines could not be met. No one could ride on a light beam; it is too small. Even if, à la *Alice in Wonderland,* someone circumvented that difficulty, light travels so fast that the rider would be promptly smeared into oblivion. And even if she managed somehow to escape that fate, since her eye would be smaller than a photon, she could not see anything! Still, scientists deploy such devices. They know full well that the conditions could not be realized. But they find it epistemically fruitful to bracket the difficulties and represent things in terms of them.

It won't do to insist that such representations are merely heuristic. There is no expectation that science could or should do without them. An ideal gas law is required by thermodynamics; the Hardy-Weinberg formula is critical to population genetics; and every version of quantum mechanics has to worry about Schrödinger's cat. Moreover, such devices are not eliminable, even at the end of inquiry. To be sure, scientists expect current models and idealizations to be supplanted in the way that the van der Waals equation and the virial equation supplanted (or perhaps just augmented) earlier ideal gas laws. But current models will be supplanted by better models and idealizations – that is models and idealizations that better perform the desired epistemic functions – not by the unvarnished truth. Or, anyway, that's what working scientists think. Since they are the ones whose decisions determine the direction in which science

progresses, we should take their views seriously.

Still, it is not the case that every false representation is scientifically estimable. We have to see what qualifies a representation for scientific standing. The point here is that neither the contention that science's contribution to understanding consists of established truths, nor the contention that even if current science falls short, its ultimate objective is a network consisting exclusively of established truths is faithful to scientific practice. Some (such as Nagel (see 1986)) might insist that philosophers know better than scientists what science should be doing. But that seems arrogant, particularly since science, as scientists do it, is an extraordinarily admirable human achievement. We seem then forced to recognize that science is epistemically estimable, despite its divergence from strict, literal truth. That being so, we have no reason to maintain that its divergence from truth excludes art from the epistemic realm.

Turn now to art. It is not unusual to emerge from an encounter with a work of art – a painting, a performance, a novel – thinking that we learned something. And what we think we learned is not just something about that work or its author – not just that Shakespeare had a big vocabulary, or that Whistler could achieve amazing effects by modulating shades of grey, or that Bach was really adept at the fugue – but something, maybe something significant, about the extra-aesthetic world. I think we are right to say such things. But that raises an important epistemological problem, for we gained few, if any, justified true beliefs about the extra-aesthetic world. Nor would we attempt to express what we have learned by articulating newly acquired justified true beliefs. What exactly we are saying? What entitles us to say it?

Very roughly, I contend, epistemically rewarding works of art reorient us, enabling us to see things differently from the ways we saw them before. This needs to be spelled out. To do so, I will highlight some parallels between art and science. Experiments and thought experiments, I will urge, parallel fiction. Static models parallel drawings. Dynamic models and simulations parallel performances. All function via exemplification.

Exemplification

Exemplification is the referential relation by means of which a sample, example, or other exemplar refers to some of its properties. (Goodman 1968, Elgin 1996). An exemplar highlights, displays, or makes manifest some of its properties by both instantiating and referring to those properties. Indeed, it refers via its instantiation of those properties. A swatch of herringbone tweed can be used as a sample of herringbone tweed. It is an instance of the pattern that refers to that pattern. A swatch of seersucker, not being herringbone tweed, cannot serve as a sample of herringbone tweed. A sample does not exemplify all of its properties. It can highlight some of its properties only by marginalizing or downplaying others. In its standard use, a fabric sample does not exemplify its shape, age, or origin. Exemplification is selective. In different contexts, the same object can exemplify different properties. Although they are not exemplified in a tailor's shop, the size and shape of the tweed sample might be exemplified in a marketing seminar, where the focus is on what features make a commercial sample effective.

My emphasis on commercial samples may make exemplification seem narrow. It is not. An object can in principle exemplify any property it has. So exemplification is versatile. Moreover, we can turn anything into an example simply by treating it as such. All we need to do is point

something out, and use it to highlight a property. Exemplification thus lends itself to intellectual opportunism. A naturalist can point out a plant as an example of, say, poison ivy. He might simply point to the plant. Or he might go on to identify its important properties, perhaps the shape and sheen of the leaves, the trifoliate leaf configuration, the capacity to cause a rash. If he is successful, his audience will now know how to identify poison ivy. He has given them epistemic access to it.

In this case, exemplification was effected by pointing out properties that were easily seen. Sometimes, however, the properties we seek to exemplify are subtle or are ordinarily overshadowed by more prominent features. Then considerable stage setting may be needed to bring the relevant properties to the fore. This is what happens in experiments. Let's look an example drawn from middle school science. To ascertain whether water conducts electricity, a science student does not attempt to induce a current in a vat of pond water or rain water or tap water. Such liquids contain impurities. If she were to detect a current in such a liquid, she would not be able to tell whether it was the water or the impurities that conducted electricity. Rather, she uses distilled water – water from which, as far as she can tell, all impurities have been eliminated. Then, in case the conductivity is slight (as it turns out to be), she runs her result through an amplifier. The result exemplifies water's capacity to conduct electricity. For our purposes, the critical point is that she distances herself from nature, operating on a substance (distilled water) not to be found in nature, subjecting it to a force (the amplification) greater than found in nature, in order to discover something about nature. Her result exemplifies something about not only pure distilled water but also about natural fluids such as pond water and rain water that are, in part, H_2O.

Because an item can in principle exemplify any feature it instantiates, the range of features it has the capacity to exemplify is vast and heterogeneous. Haydn's *Farewell Symphony* brings this out. It is famous for its finale. Each year, Count Esterhazy, Haydn's employer, removed his court, including his orchestra, to his remote summer palace. In 1772, he extended their stay, seemingly endlessly. The musicians desperately wanted to return home to their wives. Haydn's *Symphony 45* made their case musically. In the finale, as each musician finished playing, he got up and left the stage. The Count got the point. The following day, everyone was permitted to return home.

Manifestly the finale is an exemplar of the power of collective action. It could feasibly serve as the theme song for the American Federation of Musicians. It is also something of a joke, highlighting and making salient our expectation that, even if they have nothing further to play, orchestra members will remain on stage until a piece ends. But the finale is not just an editorial comment or a joke tacked onto the end of the symphony. It is an integral element of the work. *The Farewell* is, as far as we know, the only 18th century symphony in $F^{\#}$-minor. $F^{\#}$-minor is recognized as a difficult key, and the piece can be interpreted as exemplifying the difficulties. It is not a key in which one could feel musically at home. Further, the symphony exemplifies incoherence, instability, imbalance extended over time. Tonal relations are at odds with each other and with cadences. Chord progressions go unresolved. Sonic and rhythmic patterns fail to mesh. The piece thus exemplifies tempestuousness, chaos, a forward trajectory through a musical maelstrom toward an unseen but hoped for haven. There is a strange, beautiful, D-major interlude, where the basses drop out and the music seems to float, unmoored. It exemplifies a

promise of coherence, but that coherence is never achieved. The listener is left hanging. The journey continues. In the end, the various musical elements are brought into accord. But the resolution is itself strange. There is no grand finale – no victory fanfare. As one by one the musicians depart, the music grows softer, until only the two violins, playing ever more pianissimo, remain. The rest is silence. On one reading, the symphony thus suggests that we live our lives in $F^{\#}$-minor. With instabilities to balance, perils to traverse, incoherences to resolve, we seek a safe haven with no assurance of finding one this side of the grave. On another, it is a musical parallel to *The Odyssey.* Like Odysseus, we travel through tempestuous seas seeking not just a lovely interlude, but home (Webster 1991). A single symbol can exemplify any and many of its features, enabling the interpreter to forge a variety of epistemically valuable connections across a variety of domains. Background information (about the key of $F^{\#}$ minor, about *The Odyssey,*) may inform an interpretation. If so, that background information is crucial to the individuation and identification of the exemplars that interpretation draws on. Still, with the appropriate background, the insights are there to be found. And with different backgrounds, different features will be exemplified and different insights emerge.

Because they refer to some of their properties, if properly interpreted, exemplars afford epistemic access to those properties. By attending to an appropriate exemplar, we can learn to recognize herringbone tweed, poison ivy, water's conductivity, the ubiquity of unresolved tensions in human lives.

It might seem from my discussion so far that exemplification is simply a device for making manifest what is already known by some other means. If so, it would be a vehicle for conveying

insights, not for generating them. But, exemplification is not always a matter of making manifest antecedently known properties. As we have seen, an experiment is designed to make manifest features that are not antecedently known. Some sample taking functions similarly. A mining inspector collects a variety of samples in order to make manifest something no one yet knows – the distribution of gases at different levels of the mine. A political poll samples public opinion about a matter no one yet knows – perhaps the weight voters attach to economic factors in the upcoming election.

Something similar occurs in the arts. Merce Cunningham and John Cage were frequent collaborators whose method of collaboration strikes many as odd. Cunningham choreographed a dance while Cage independently wrote the music. All they agreed about in advance was the duration of the piece. Until the first performance, no one (not even the dancers, the choreographer, or the composer) knew what the work would exemplify. In some of their works and some passages of those works, music and choreography were mutually reinforcing; in others they pulled in different directions. Cage and Cunningham sought to exemplify the autonomy of the different arts. Even when writing for dance, Cage was not willing to make music subservient to the ends of dance. Nor was Cunningham willing to make dance a mere visualization of music. In cases like these, just what would be exemplified was not antecedently known. In other cases, works exemplify features that are at odds with what their authors intended. *Paradise Lost* was supposed to justify the ways of God to man. It does not succeed. Rather, it glorifies Satan, thereby exemplifying the importance of personal autonomy, self-respect, and not giving into bullies. It fails to exemplify what Milton sought to bring out.

Fictions in Science and Art

An experiment is no mere matter of bringing nature indoors. It is a controlled manipulation of events, designed and executed to make some particular phenomenon salient. Natural entities are multifaceted. Important properties and relations are often masked by the welter of complexities that embed them. In experimenting, a scientist isolates a phenomenon from many of the forces that typically impinge on it. To the extent possible, she eliminates confounding factors. She holds most ineliminable factors fixed, effectively consigning them to the cognitive background of things to be taken for granted. This enables the effect of the experimental intervention on the remaining variable to stand out. This strategy enables her to cast into bold relief factors that might typically be hidden from view.

Suppose a population of wild mice who were accidentally exposed to bisphenol-A subsequently exhibited a high rate of liver cancer. To conclude that exposure to bisphenol-A caused their disease would be premature. Those mice might have been peculiarly susceptible to liver cancer or been exposed to a carcinogen that scientists overlooked. To glean direct, non-anecdotal evidence of a connection between exposure to bisphenol-A and liver cancer, scientists place genetically identical mice in otherwise identical environments, exposing half of them to massive doses of the chemical while leaving the rest unexposed. The common genetic endowment and otherwise identical environments neutralize a multitude of genetic and environmental factors currently believed to influence the incidence of cancer. This blocks rival explanations that might be proposed for the elevated rate of cancer in the wild population. If the exposed mice show a significantly higher incidence of cancer than the controls, the experiment exemplifies a difference that correlates with exposure to bisphenol-A.

The result of the experiment exemplifies the difference (if any) in the incidence of liver cancer between the two groups of mice. It not only instantiates the difference, it also highlights that difference. If the difference is statistically significant, then the result exemplifies a correlation between exposure to bisphenol-A and the incidence of liver cancer. Although correlation does not imply causation, a robust correlation is often evidence of causation. In this case, the background assumption that moves us from a mere correlation to a causal judgment is the well founded conviction that the experiment was so rigorously designed and executed that nothing but the exposure to bisphenol-A could have caused the difference. That being so, the result may also exemplify a causal relation.

So far we are just talking about the particular mice in the experiment. But the goal of the investigation is not primarily to discover their medical fates. It is to use their medical fates to learn something more general. Since the mice in the experiment were chosen arbitrarily from the class of mice with particular genome, it is straightforward to project to other mice of the same strain. The experiment then also exemplifies the increased propensity of mice of that strain to develop liver cancer when exposed to bisphenol-A. Moreover, the mice function as model organisms, so there is reason to think that what holds for them also holds for the organisms they serve as models for – in this case, mammals, including humans. The inference from mice to mammals is a big jump. But if the background assumptions legitimating treating the mice as model organisms are sufficiently accurate and adequate, it is reasonable to treat the experiment as exemplifying a causal connection between exposure to bisphenol-A and cancer in mammals in general.

Thought experiment involves further distancing. Sometimes the imaginative rehearsal reveals that an actual experiment *need not* be carried out. The mental run-through itself discloses the relevant information. Even without physical implementation, Galileo's thought experiment discredits the Aristotelian contention that the rate at which bodies fall is proportional to their weight. Imagine a composite object consisting of a boulder tethered to a pebble. Being composed of two rocks and some rope, the composite object is heavier than either rock alone. If Aristotle is right, it should fall more quickly than the boulder. But since, according to Aristotle, the pebble falls more slowly than the boulder, once the two are tied together, the pebble should retard the boulder's fall. It should serve as a brake. Hence the rate at which the composite object falls should be between that of the boulder and that of the pebble. The composite object cannot fall both more quickly and more slowly than the boulder, so the Aristotelian commitments are inconsistent. By exemplifying the inconsistency, Galileo's thought experiment demonstrates that the Aristotelian account cannot be correct.

Sometimes an actual experiment of the sort envisioned *cannot* be carried out. It is impossible or impracticable. By imagining a person's experience while riding in a uniformly accelerating elevator in the absence of a gravitational field and his experience at rest in the presence of a gravitational field, Einstein shows the equivalence of gravitational and inertial mass. To actually run the experiment would require placing an unconscious subject in a windowless enclosure, sending him to a region of outer space distant from any significant source of gravity, restoring him to consciousness, and querying him about his experiences. This is morally, practically, and physically unfeasible. Still, the recognition that we cannot do a real experiment does not by

itself legitimate stopping short. Sometimes, the infeasibility of performing an experiment translates into the infeasibility of finding out a particular fact. The reason Einstein's thought experiment is effective is that it takes the form of a challenge: Suppose the specified conditions were met. How could a subject tell whether he was in one situation or the other? What evidence could he draw on? If our best efforts to identify a way to tell the difference fail, and fail for scientifically principled reasons, we have evidence of the equivalence. Collectively, our failures exemplify that, if our theories are close to correct, there is no difference to detect.

Like a scientific experiment, a work of fiction selects, isolates, and insulates, manipulating circumstances so that particular properties, patterns, and irregularities are exemplified. It may localize factors that underlie or are interwoven into everyday life, but that are apt to pass unnoticed because they are typically overshadowed by or interwoven with other, more prominent matters. This is why Jane Austen believed that ‘three or four families in a country village is the very thing to work on’ (Austen 1814). The relations among the members of the three or four families are sufficiently complicated and the demands of village life sufficiently mundane that the story can exemplify something worth noting about ordinary life and the development of moral personality. By restricting herself to a few fictional families, Austen in effect devises a tightly controlled thought experiment. Drastically limiting the factors that affect her protagonists enables her to elaborate in detail the consequences of the few that remain.

Writers like Tolstoy paint on a larger canvas. So grander, more panoramic themes are may be exemplified as well. Some exaggerate to bring particular features to the fore. Even if we will

never encounter as pure an instance of weakness of will as we find in Pierre Bezuhov, or as pure an example of malevolence as we see in Iago, encounters with those characters enable us to recognize the more mixed cases that we see in everyday life. In effect, the representation of particular episodes, characters, and features is literary counterpart of what Nancy Cartwright (1983) calls 'prepared descriptions' in science. Both distance us from phenomena in order to enable us to see them more clearly.

In *The Nicomachean Ethics* Aristotle suggests that we should call no man happy until he is dead (Aristotle 1953). He uses the example of Priam, the elderly king of Troy. Typically, students are unconvinced. Part of the problem is that 'happiness' is a less than adequate translation of 'eudaimonia'. 'Flourishing' would be better. But even then, the example is less than wholly convincing. After all, students insist, Priam evidently flourished throughout most of his life. It wasn't until the very end that things went badly for him. This is plausible. Priam is far from an ideal case. *Oedipus Rex* provides a more powerful exemplar of Aristotle's point. Unbeknownst to himself, Oedipus killed his father, married his mother, and thereby brought a plague on the city he ruled. Throughout most of his life, he seemed to be flourishing, but in fact he was not. On learning what he had done, he could not but look on his past with repugnance and disgust. He never actually flourished, even if it looked throughout most of his life as though he did. The suggestion then is that *Oedipus Rex* can be read as a thought experiment that exemplifies the plausibility of Aristotle's claim.

I've suggested that experiments, thought experiments, and works of fiction distance, isolate, and

purify. They set up circumstances, sometimes quite unrealistic circumstances, and see how things play out. They devise contexts, including and omitting as necessary to bring out the features they seek to highlight. They can be vehicles for discovery.

Still, it might seem that we would do better to face the facts directly and avoid the detour through fiction. I disagree. A sociological investigation of country villages would not be preferable to looking at Austen's three or four families. Nor would a biography of a real leader with a tragic flaw be preferable to *Oedipus Rex*. The features that stand out so plainly in the fictions might well be obscured in 'real life' situations where other factors obtrude. Moreover, in factual studies, objections can always be raised. Maybe other, unrecognized factors figured in the events we seek to explain. Was it really pride and prejudice that kept the two apart, or were there unresolved issues stemming from their childhood, or genetically based propensities, or complicated family dynamics that we failed to accommodate? Does the tragic flaw the biographer targets really explain the subject's downfall, or were other causal factors at work? Maybe he never was as admirable as the biographer makes him out to be. Austen and Sophocles block such objections by simply omitting the potential complications. And by the effectiveness of their stories, they show that their omission makes no difference.

The same point holds in science. It would not be preferable to drop things from towers rather than to do Galileo's thought experiment. For one thing, there is no need. Galileo's thought experiment is, in effect, a reductio of the Aristotelian position, in much the way that *Oedipus Rex* is a reductio of the idea that someone's seeming to flourish demonstrates that he is actually

flourishing. Moreover, dropping things from towers would muddy the waters by, introducing factors that need to be controlled for and inviting questions about, for example, how high the tower has to be, how different the weights of the objects have to be, how accurate the timers have to be, whether we have adequately accommodated the effects of air resistance, wind, and so forth. Galileo evades these questions by simply omitting the irrelevant factors. They make no difference. And the effectiveness of the though experiment makes their irrelevance manifest.

The same point holds for actual experiments. Simply charting the incidence of cancer in wild mice exposed to bisphenol-A would not make as compelling a case as an experiment. The experiment controls for genetic factors and accidental (that is, irrelevant) features of the environment. Because it does, the effectiveness of the experiment makes it manifest that those factors do not figure in the result.

Fictions, thought experiments and laboratory experiments exclude factors deemed irrelevant so that they can investigate the consequences of those that remain. They can go to the limit – perhaps a limit that is nowhere to be found in nature, but that illuminates mundane cases. Ahab is a representation of the limit of obsession. He exemplifies how an obsession can dominate and destroy not just an individual life, but the lives of others who are involved with the obsessed individual. A simulation that represents molecular interactions at increasingly cold temperatures – colder than can actually be realized – discloses that very near absolute zero, electrical resistance disappears.

In some cases, distancing is more than merely useful. It is essential for the exemplification of the features of interest. The Judson Dance Theater is a post-modern dance collective whose works exemplify everyday movement. The dancers (looking like ordinary people, wearing ordinary clothes) walk, run, climb, carry a mattress. The movements are utterly mundane. This raises a number of questions: Why call their performances dance? Why are we watching them? Why did we buy a ticket, given that we can see the very same behavior outside? Sally Banes maintains that such dances are devices for defamiliarization (2003). They make the familiar strange, contriving a context that prompts audiences to attend to features that they normally look right past. Carrying a mattress is actually an intricate, complex sequence of behaviors in which a person continually adjusts her position to accommodate changes in the center of gravity of the unwieldy load. It's quite remarkable, once you notice it. Normally, of course, you don't. You want to get the mattress moved. You have no interest in attending to the complex adjustments you make in your body to get the job done. Works like those the Judson Dance group performs, by moving ordinary activities into a new venue, change the context, refocus the lens and attune us to aspects of things that we ordinarily overlook. They bring mundane activities to exemplify features that are typically ignored. Most of us would not register or appreciate the complex physical intelligence that goes into moving a mattress if they simply saw a couple of guys schlepping a mattress down the street.

The Miller-Urey experiment begins with chemicals believed to be present on Earth in pre-biotic times. It involves a sequence of chemical reactions whose ultimate output consists of organic chemicals and amino acids. It thus shows how life could have emerged from non-living matter. For the experiment to work, the chemicals – methane, ammonia, hydrogen and water – had to be

pure. Any hint of contamination would discredit the result. Moreover, to insure that no organic material was accidentally introduced in the course of the experiment, the chemical processes had to be completely isolated from the environment. The very same sequence of chemical reactions might have occurred innumerable times since the advent of life on the planet. But because those natural occurrences were not isolated from living organisms and processes, they would not show how life could have evolved. They would instantiate the sequence of chemical changes, but not exemplify it or its importance. Although – indeed, because – the experimental components and conditions were unnatural, the experiment revealed something important about the natural world.

The effect of exemplification can be Socratic. Then a work of art or science unseats our complacency by exemplifying that we do not know what we thought we knew. Nabokov's Humbert Humbert is a notoriously unreliable narrator. He exhibits no understanding of himself, the nature of his desire, or the appallingness of his conduct. He is, moreover, a distressingly convincing character. It is not hard to believe that someone could be that clueless about himself. We may be brought to wonder, if Humbert Humbert can be that deluded about his own character and behavior, how confident should we be that we understand our behavior, or that other people understand theirs? Ought we take our, or their, sincere self-ascriptions to be even presumptively correct? Once the question is raised, we may become acutely aware that we don't know how to answer it. One effect of *Lolita* is Socratic. We come to realize that we do not know what we thought we knew.

Experiments with surprising results have a similarly Socratic effect. The Michelson Morley experiment was conducted to detect ether drift. None was detected. The first, quite reasonable,

response was to rethink the experiment. Was it well designed? Was the interferometer sensitive enough to detect small effects? Eventually, however, scientists had to conclude that the result was solid. The reason the interferometer did not detect ether drift is that there is no ether drift to detect. They did not know what they thought they knew – that waves require a medium of transmission. As is the case in the Socratic dialogues, the failure of their complacent assumption had far reaching consequences. It exemplified a serious flaw in their understanding of light.

Models

Scientific models are complex symbols that represent one thing as another (Hughes 1997). A gas molecule is represented as a perfectly elastic sphere. A harmonic oscillator is represented as a spring. Similarly, caricature involves representing one thing as another. Margaret Thatcher is represented as a dragon and Churchill is represented as a bulldog. Representation-as is a complex form of reference that involves both denotation and exemplification.

Denotation is straightforward. A name denotes its bearer. A predicate denotes the objects in its extension. A portrait, being the pictorial counterpart of a name, denotes its subject. A map denotes the terrain it applies to; and the semantically significant aspects of the map denote features of the terrain. A generic picture, such as the picture of a warbler in a field guide, denotes each of the objects in its extension – that is, each of the warblers. And so forth. Denotation is the '-of' relation. 'Shanghai' is the name *of* a city. This is a picture *of* my cat. Here is a map *of* the campus. Denotation, moreover, can be arbitrary. We can simply stipulate that a name denotes a bearer or that a red dot denotes a city with a population of 100,000, and it does.

Some symbols that lack denotations function as denoting symbols. They perform the same syntactic functions as symbols that actually denote. They are empty names or predicates, or pictures. Sometimes the lack of a denotation is an error. Scientists thought that there was such a thing as caloric – that is, thought that the term 'caloric' denoted a substance. Explorers thought there was such a thing as the northwest passage from the Atlantic to the Pacific – that is, that the phrase 'the Northwest Passage' denoted a sequence of navigable rivers. They were wrong. In other cases, however, denoting symbols are introduced with no expectation that they denote anything real. This is so for fictional symbols like the name 'Frodo' or the map purporting to show the route to Mordor. It is also the case, I suggest, for models like the harmonic oscillator or the ideal gas. The critical question is what gives such symbols their content?

Such symbols are denoting symbols – indeed often quite specific denoting symbols – even though they lack denotata. To explain how they function Goodman introduces the distinction between a *p*-representation and a representation *of p* (1968). A representation *of* a horse denotes a horse. A horse-representation need not denote any actual horse. It can be purely fictional. In calling a representation a horse-picture we classify it as belonging to a particular genre – a genre composed of all and only representations with a shared ostensible subject matter. The horse-picture genre consists of all and only pictures as of horses. Some are pictures of actual horses – Secretariat, American Pharoah and the like. Others are fictional.

The introduction of *p*-representations might seem like a dodge. If so, the only way to determine what belongs to such a genre is on the basis of an antecedent classification of their referents. In that case we have to know what the picture was of in order to know what genre it belongs to.

But this is simply false. We readily classify pictures as landscapes without any acquaintance of the terrain they ostensibly represent. Likewise, we readily classify maps as Middle-Earth-maps, and pictures as hobbit-pictures or Pagasus-pictures without comparing them to their denotata. We classify such representations on the basis of their relation to one another, not on the basis of their relation to their denotation.

The two devices – denotation and *p*-representation – enable us to explicate *representation-as:*

x represents *y* as *z* just in case *x* is a *z*-representation that as such denotes *y.*

In the famous portrait, Sir Joshua Reynolds represents Mrs. Siddons as the Tragic Muse. That is, he paints a picture of Mrs. Siddons that is a tragic-muse-representation. A physicist represents a spring as a harmonic oscillator when he uses a harmonic oscillator diagram or equation to denote the spring. Merely being both a denoting symbol and a *p*-representation is not enough. That is the force of the 'as such' requirement. Reynolds would not have represented Mrs. Siddons as the tragic muse if the painting just happened to be both a representation of Mrs. Siddons and a tragic-muse-picture. Nor would the physicist have represented the spring as a harmonic oscillator if his representation just happened to both denote the spring and be a harmonic-oscillator representation. The two functions need to be connected. Exemplification supplies the link. In representation-as a *p*-representation exemplifies certain features and ascribes them to the denotation. A certain sort of somber dramatically, characteristic of representations in the tragic-muse genre is exemplified by the figure in the portrait, and ascribed to its subject, Mrs. Siddons. A capacity for a distinctive mode of oscellation, characteristic of members of the harmonic-oscillator genre, is exemplified in the diagram and ascribed to the spring. That there is no such thing as the tragic muse and no such thing as a (pure) harmonic oscillator is irrelevant. The

portrait and the model function to make features of their referents accessible, by highlighting those features through fictional representations.

Where does this leave us? Experiments, thought experiments, and fictions contrive artificial situations to exemplify features that otherwise are likely to be epistemically inaccessible or overlooked. They make those features accessible and equip us to recognize them and appreciate their significance elsewhere. Models, like some works of art, represent one thing or one sort of thing as another. The representing symbol (the model, the picture, the diagram) exemplifying features that are instantiated by, but perhaps hard to discern in, the referent (the target of the model the subject of the picture or diagram). They too make the exemplified features and their significance epistemically accessible. This, I contend, demonstrates my thesis: the arts, like the sciences, embody, convey, and often constitute understanding.

Coda

Still, one might wonder, is there *no* difference between the epistemic functions of the arts and the sciences? I suggest that there are at least two significant differences. But rather than pertaining to the question whether the two disciplines advance understanding, they bear on how they do so.

According to a familiar stereotype, art is vague while science is precise. Actually the opposite is the case. Science intentionally sets limits on precision. A measurement is accurate only to a given number of significant figures. Any disagreement beyond that point is irrelevant. We can, to be sure, increase the accuracy of our measurements, the only limitations being the sensitivity of the measuring devices we can build and the needs of our inquiry. But there is always a limit.

Art, on the other hand, allows for unlimited precision. In principle every difference in certain respects – the thickness of line, extension of the leg, the timbre of the voice – can make a difference to what a work exemplifies or represents.

The second difference has to do with the value the disciplines place on agreement. Goodman maintains that the same configuration of ink on paper would function differently if it were interpreted as an EKG readout or as a Hokusai drawing (1968). Only two features matter in the EKG: the shape of the wave and the frequency with which it repeats. Both are measured only to a given degree of precision. As a result, two cardiologists reading the same EKG are apt to agree about how to interpret it. Or, if they disagree, they are apt to be able to clearly articulate what about the pattern is the ground of their disagreement.

In the drawing, any of a vast number of features may matter: the size, shape, color, and intensity of the line; the constitution, weave, material, colors of the paper. Differences, however subtle, in shading from one part of the paper to the next, and so on. As a result, two connoisseurs may disagree about how the drawing is to be interpreted, about what features denote, what features are exemplified, and to what degree of precision. Because an aesthetic symbol is relatively replete, and because every difference in certain respects can, in principle, make a difference, this difference may be interminable.

Moreover, in the case of scientific symbols like the EKG, which features are significant is settled in advance. A cardiologist may detect a subtle feature in the shape of the *p* wave that turns out to be important. But she would and should attach no significance to the fact that the line gets

lighter over time. That only indicates that the printer's toner cartridge needs to be replaced. It is not her problem. A connoisseur, on the other hand, might notice that, for example, the weave of the paper supports or plays against the flow of the drawing. That no one earlier had thought to take the paper's weave to be significant does not discredit her discovery.

The reason for these divergences, I suggest is this: Science places a premium on intersubjective agreement. Because scientists build on one another's findings by taking them as unquestioned premises, they want it to be determinate and determinable what those findings are. They are willing to trade off a measure of precision to get that agreement. Although artists are plainly influenced by one another, they do not proceed by taking previous works as unquestioned premises. Because artists do not build on one another's work in the same way as scientists, they do not have the same incentive to sacrifice precision. This leaves open permanent possibility of disagreement. Possibly connoisseurs will never agree about the significance of the paper's weave. Science then strives for symbols that bear univocal interpretations, while art welcomes symbols that bear multiple interpretations.

I suggest then that the difference between the arts and the sciences is more practical than epistemic. The two disciplines take different trajectories in their pursuit of understandings, use the insights of their predecessors and colleagues in different ways, and, as a result, place different values on intersubjective support.

References

Aristotle (1953). *Nicomachean Ethics.* New York: Penguin Classics.

Austen, Jane (1814). 'Letter to her niece, Anna Austen Lefroy, September 9' *Letters of Jane Austen.* Bradbourne Edition, <www.pemberley.com/janeinfo/brabit16.html>.

Ball, Philip (2005). *Elegant Solutions*. Cambridge UK: Royal Society of Chemistry.

Banes, Sally (2003), 'Gulliver's Hamburger: Defamiliarization and the Ordinary in the 1960s Avant Garde,' *Reinventing Dance in the 1960s*, Sally Banes, ed. Madison: University of Wisconsin Press.

Cartwright, Nancy (1983). 'Fitting Facts to Equations,' *How the Laws of Physics Lie* Oxford: Clarendon Press, pp. 128-142.

Dryden, John (1913). 'Annus Mirabilis' *The Poems of John Dryden*. <bartleby.com>.

Elgin, Catherine (1996). *Considered Judgment.* Princeton: Princeton University Press.

Goodman, Nelson (1968). *Languages of Art*. Indianapolis: Hackett.

Hughes, R.I.G. (1997). 'Models and Representation'. *Philosophy of Science* vol. 64 supplement: S325-S336.

Nagel, Thomas (1986). *The View from Nowhere.* New York: Oxford University Press.

Webster, James (1991). *Haydn's "Farewell" Symphony and the Idea of Classical Style.* Cambridge: Cambridge University Press.

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Dryden. 'Annus Mirabilis' clv.