St. John’s College Graduate Institute
Convocation Address
Fall 2013

On the Mathematics & Natural Science Segment

Welcome, new students, returning students, and tutors, to St. John’s College, and to the Graduate Institute. Today each of you is beginning, or resuming, your membership in a community of learning, at a College that dedicates itself to inquiry: to asking fundamental questions, and to pursuing answers to these questions. As members of such a community, we must from time to time shine the light of inquiry on ourselves. On this occasion I mean to do so by examining the readings of the Mathematics & Natural Science segment.

The subject of this convocation address – the second of five, each treating one of the segments in the graduate Program – is informed by a claim that I made in an earlier address, delivered in Spring 2012, titled ‘What is a Segment?’ I said then that the program of the Graduate Institute is a homogeneous whole, and that its segments represent arbitrary divisions of that whole into parts. Accordingly, I claimed that the titles of these segments should be taken as compressed questions in need of answers, and as opportunities for wonder, rather than as names that determine the distinct subject matter treated by the readings in each segment. Now I hope to make good on these claims in detail. So what, then, are the wonderful questions raised by the segment title ‘Mathematics & Natural Science’? And before I proceed to answer my own question, I should caution that the threads that I mean to follow for the next few minutes – threads that run through the tutorial and seminar readings of the segment, and that are connected to threads that run through other segments – are by no means the *only* ones worth following. I only insist that these threads are present in the segment readings, and that they *are* truly worth following. So again, what are the wonderful questions raised by 'Mathematics & Natural Science'?

At the risk of becoming predictable, let's begin once again with the least promising word in the segment title: the coordinating conjunction 'and' – or, more precisely, the ampersand. As it did in the Philosophy & Theology segment title, the ampersand implies that there is something double about the subject matter of the Mathematics & Natural Science segment. And once again, this implication is borne out by a cursory glance at the reading lists of the segment's seminar and tutorial. In seminar, we begin with Lucretius' bittersweet poem about atoms, *On the Nature of Things*; then we turn to Plato's dialogue about the musical making of the world, the *Timaeus*, followed by Aristotle's discussion of the four causes of natural things – things that have a principle of rest and motion in themselves – in the *Physics*. In tutorial, by contrast, we begin with the definitions, postulates and common notions found in Book I of Euclid's *Elements*; and we continue by demonstrating and discussing each of the forty-eight propositions in Book I. So in what we might mischievously call the 'Natural Science' seminar, we begin by considering the principles – which is to say, the *causes* – of natural things: whether they be atoms, the Same and the Other, or form and matter. In what we might call the 'Mathematics' tutorial, by contrast, we begin by considering points, lines, and figures – magnitudes and their parts – and by convincing ourselves that if some truths be given, other truths must follow by necessity. What, then, is the meaning of the ampersand that joins these two inquiries, into causes and into magnitudes, in our segment title?

It will help to consider here the meaning of the two parts of the title 'Mathematics & Natural Science.' 'Natural Science' seems easy enough: 'science' is another word for 'knowledge' – it consists of the things we know – and as for 'nature,' well, let's leap over an abyss and just agree with Aristotle that it consists of the things that have a principle of rest and motion in themselves, and so come to be and pass away. 'Natural Science,' then, amounts to what we know of such things, especially concerning their causes. 'Mathematics,' on the other hand, is a little trickier. Our English word is related to the ancient Greek noun *ta mathēmata*, which in turn is related to the ancient Greek verb *manthanō*, meaning 'I learn,' 'I perceive,' or 'I understand.' So *ta mathēmata* are the characteristically learnable, perceptible, understandable things. We can see the bearing of this etymology if we consider the chief content of mathematics, according to our ordinary understanding: namely, proofs about magnitudes and multitudes, figures and numbers. Such proofs are characteristically learnable because they bring with them the certainty of logical necessity, and because they hold for all time and place. For example, once we have learned how to demonstrate the Pythagorean theorem – proposition 47 from Book I of the *Elements* – we know that it will prove true on Earth and on Mars and in the Andromeda galaxy, and that it will hold true for all future time as it did for all past. This characteristically knowable quality leads some to translate the ancient Greek word for the knowable things, *ta mathēmata*, with the English word 'science.'

Now before we rush to conclude that our segment title, 'Mathematics & Natural Science,' really just means 'Science & More Science,' let's recall that abysmal word 'natural.' We said, following Aristotle, that natural science in particular consists of knowledge about the causes of things that *change* in time and place. But mathematics, by contrast, consists of characteristically knowable things that do *not* change in time and place. And with this contrast, a wonderful question hidden inside the ampersand of our segment title comes to light. Is it possible that the characteristically knowable things, namely magnitude and number, *are* the causes of the natural things? Is it possible that the things that do not change in time and place are the causes of the things that do? Let's pause for a moment to savor and shudder at the magnitude of this question. If the answer is yes, then natural science deserves the name 'science,' because the causes of natural things are fully knowable. If the answer is no, on the other hand – if we mean by 'cause' something other than magnitude or multitude – then either this thing must prove as knowable as the objects of mathematics, or we must resign ourselves to a nature that is to some degree unknown and unknowable.

Some of you might have noticed that, in describing the readings of the Mathematics & Natural Science seminar and tutorial, in each case I stopped after the first few readings. It turns out that our first wonderful question in the segment readings – the question of whether the mathematical things are the natural causes – equips us to understand a change that happens in the middle of each reading list. In the seminar, this change is marked by the triumphant title of Francis Bacon's *New Organon*. The newness of Bacon's organon comes from his sense that neither the natural causes nor the natural things themselves are what ancient philosophers – like Aristotle, author of the old organon – thought they were. It is a mistake, Bacon argues, to try to deduce the causes from the things themselves, because nature loves to hide: neither the causes nor the things themselves are apparent. The organic – which is to say instrumental or methodical – character of the *New Organon* follows from this claim: if there are natures and natural causes, but they are hidden, what is needed is a reliable way to force them into the open. This forceful way is the method of experiment. After Bacon's *New Organon*, we turn in seminar to a work by René Descartes with the deceptively sober and technical title of *Discourse on Method*. Among many other interesting things, Descartes suggests in that work a standard by which to measure the certainty of knowledge, such as the knowledge gained from scientific experiment. This standard is clarity and distinctness; and it is brought over to natural science from – you guessed it – mathematics.

So if we take the *New Organon* and the *Discourse on Method* together, they seem to announce not just a break with the ancient study of natural science, in their self-consciously new focus on method, but an answer to our question about whether the mathematical things are the natural causes. Yes, Bacon and Descartes say, the natural causes can be known; and yes, they can be known with the clarity and distinctness of mathematics; which is almost the same thing as saying that yes, the mathematical things – and especially number – are the causes. The color red, we might explain in this Baconian-Cartesian spirit, is nothing more than light with a wavelength of 700 nanometers, while violet is nothing more than the same with a wavelength of 400. To make red violet, indeed to make any color into any other, is merely a matter of changing a number – proof that in this case, as in every case, number is the cause. Whatever ancient philosophers like Lucretius might have known about the causes of natural things, the proof of the superior knowledge available through the modern experimental, methodical, mathematical natural science is the superior power of that science – power exercised, unlike the paltry power of ancient natural science, for "the relief of man's estate." Isaac Newton's *Principia* makes its own new beginning to display what can be achieved in the field of mechanics by this modern natural science, and in so doing argues that the natural world extends infinitely further than Aristotle admits – that the natural world is in fact the world simply, and natural science, science simply. Darwin and Jung follow the Baconian-Cartesian path, each in his own, sometimes questionable way, extending modern science from what we now call physics to the fields of biology and psychology. And with each new advance in knowledge comes an increase in power:

modern physics can put human beings on the Moon; modern biology can shape living things to our needs; and modern psychology can make human beings more useful.

Let's turn away from this vision of a secular heaven on earth to look at the readings of the 'Mathematics' tutorial, and the change that happens from Euclid's geometry to that of Lobachevski. It does not diminish the signal knowability of mathematics, nor that of Euclid's geometry in particular, to notice that it is founded on a handful of postulates; but this does raise some questions. While definitions isolate and name certain geometrical possibilities – or even, if you wish, certain geometrical impossibilities – and common notions spell out the necessary logic of mathematical proof, postulates set the limits of geometrical possibility itself. But the word 'postulate' comes from the Latin verb *postulare*, which means 'to demand'; and the corresponding word in Euclid's Greek, *aitēmaton*, means much the same: a thing asked for, begged, or demanded. A postulate, then, is precisely not a name, nor something that must be granted for logical proof to be possible; rather, it is something would not jeopardize the possibility of logical proof if it were otherwise.

But if mathematical proofs would be possible even if one of the postulates were not granted, or if a different postulate were granted in its place, then mustn't *ta mathēmata*, the mathematical or characteristically knowable things, *include* the conclusions demonstrated by such proofs? This question puts us on the road to different, non-Euclidean geometries, including the geometry of Lobachevsky – not to mention different arithmetics, such as the arithmetic of imaginary numbers. And this road leads to a mathematics that consists of a set, perhaps a limitless set, of alternative geometries and arithmetics, each corresponding to postulates that there might be good reason to grant. Moreover, if the knowable things consist of sets of such geometries and arithmetics, and the knowable things are the causes of the natural things, then mustn't these alternative geometries also be causes? *This* question puts us on the road to discovering the use of non-Euclidean geometry in Einstein's general theory of relativity, and the use of imaginary numbers in Feynman's account of quantum electrodynamics.

Now the discovery of such correspondences should not make us Pollyannaish. It would be terribly useful, and a great boon for the prospect of knowledge in the fullest sense, if it should turn out that the things we are most suited to know are also the things themselves. But the very utility and appeal of this situation should make us suspicious. Could the correspondences we have discovered, between the knowable things and the causes of the natural things, instead be due to the form our mind necessarily gives to everything it perceives and knows? Have we merely discovered a gift that we have made for ourselves, and hidden from ourselves, without knowing it? If so, perhaps we should expect a correspondence between every possible arithmetic or geometry and some possible being, but at the cost of suspecting that behind every being for us could lie a being in itself, to which we have no access. The very perfection of our knowledge of the beings for us would rule out our knowing the beings in themselves – presuming that the beings in themselves are any concern of ours.

It could also be the case that the Baconian-Cartesian equation of knowledge with power is incorrect, and that in fact we only know things to the extent we do *not* have power over them. Take the limit case of the modern scientific project, in which human beings acquire the power to turn anything into anything else. What would remain of knowledge about the objects of these transformations, if nothing about them were durable, let alone unchanging in time and place? If the miraculous power of a god, which must be ruled out for both mathematics and natural science to be possible, reappears as the goal of the modern scientific project to relieve man's estate, then this project seems to aim at its own self-destruction. Here we see the questions we have been following through the Mathematics & Natural Science segment touch on the themes of Philosophy & Theology.

Finally, there is the more present and clear danger of treating the mathematical things, and especially numbers, as the only knowable things just because they are the easiest things to know. For the same reason that 700 nanometers is not equivalent to the color red, and eighty-five percent is not equivalent to learning, knowing the magnitude and multitude of a thing might not be enough to know it, or even its causes, fully. Every science requires that one be able to count its objects, but to determine the unit in each case needs more than skill at counting. This danger should especially be heeded in an egalitarian democracy: the regime that most of all seeks to reduce questions of justice to problems of arithmetic. Here we see the questions that we have been following through the Mathematics & Natural Science segment touch on the themes of Politics & Society.

In conclusion, I would like to announce that there will be three Graduate Institute-hosted study groups this term. One group will study Plato's *Laws*, while another will study T.S. Eliot's *Four Quartets*. Both of these groups will meet on Thursday afternoons from 3:30 to 5:00, beginning on August 29. A third group will meet to learn Italian, and to read Machiavelli's *Prince*. Schedules and meeting places for all three of these groups will be circulated by email. Lastly, I would like to invite you all to take part in the refreshments provided at the back of the Great Hall, before going to tutorial.

The fall 2013 term of the Graduate Institute is now in session. *Convocatum est.*

Jeff J.S. Black
Annapolis, Maryland
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