Dean's Statement of Educational Policy and Program 2010

The Place of Modern Natural Science in the St. John's Program

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From the beginning of the New Program, one of its important ambitions was to find a place for modern science in what was in most other respects seen as a revival of a traditional liberal arts education. By claiming that Harvard president Eliot introduced the elective system in the late 19th century "in order to absorb and assimilate the natural sciences to the liberal arts tradition," the first statement of the St. John's program even lays at the feet of modern science much of the blame for the departure of undergraduate colleges from their proper mission of liberal education. The ambition to include modern science within the liberal arts is reflected in the New Program seal, in which seven books, representing the late classical and medieval enumeration of the liberal arts, surround a laboratory balance, representing the arts involved in the experimental approach regarded as characteristic of modern science. In the early days of the New Program, the great books concerned with the understanding of nature, ancient as well as modern, were read in seminar, while the work of the laboratory was organized in other ways. "In general, the main themes are mathematical constructions, the instruments and techniques of measurement, repetition of crucial experiments, and the combination of scientific findings in concrete problems." (38-39 Catalogue, p. 33)

Starting with the second Statement of the St. John's Program, in 1938-39 (and persisting in somewhat modified form through the current version), modern natural science, along with modern mathematics, was characterized as the result of a "Cartesian revolution," called "perhaps the greatest intellectual revolution in recorded history," and one of the tasks of the Program was said to be the understanding of this revolution and its formative consequences for the modern world and for the liberal arts themselves (38-39 Catalogue, p. 26).

If we bring together these two passages from the early Program Statement, we can sharpen the paradoxical nature of the task set for the New Program. The education provided by the traditional liberal arts college focused on the study of classical languages and literature and understood the skills to be acquired in terms of a list of liberal arts predating the "Cartesian revolution." As a long term result of this revolution, there emerged a reorganization of higher education in the form of the "research university," reflecting the new understanding of science as a progressive and collective enterprise requiring an extensive infrastructure and an army of professional investigators. These investigators became the authorities in their areas and hence those charged with initiating others into the expertise required to carry out the ongoing project of modern science. Other areas of human thought and inquiry were reconceived along similar lines, so that "scholarly research" in specialized fields became the primary task of professors at research universities, followed by the task of training new apprentices to replace themselves. Seen in this larger context, Eliot's introduction of the elective system at

Harvard was a step in the assimilation of the undergraduate liberal arts college to the ideal of the research university. It is this demise that the New Program was meant to undo.[1]

One might easily argue, and critics of the New Program have not failed to do so, that the demise of an old-fashioned idea of liberal education is the natural and appropriate consequence of the Cartesian revolution. In introducing modern science, this revolution rejected ancient and medieval understandings not only of science, but of philosophy, the liberal arts, and the meaning of education. The demise of the liberal arts college was simply a long overdue consequence of the working out of this revolution.

It is not clear that it is a sufficient reply to this kind of argument to say that the specialization demanded by the modern research university must be confined to graduate school, while undergraduate education should be founded on the same premises that governed it prior to the Cartesian revolution. If our modes of understanding the world have been radically altered by this revolution, why shouldn't our approach to undergraduate education be altered to take account of this?

In response to this argument, it is important to note two important respects in which the New Program differs from the program of liberal arts colleges of the preceding centuries. First, the books whose study forms the heart of the New Program are not confined to Greek and Latin classics, but include not only the books that helped to initiate the Cartesian revolution, but many of those which played out its consequences in shaping our modern world. Second, the New Program does attempt to engage with the modern sciences that grew out of the Cartesian revolution and with some of the modern mathematics that has made this science possible. Together, these two differences suggest that the New Program can be defended against this kind of critique only to the extent that it does engage with the Cartesian revolution and its consequences, and moreover, does so in the mode of critical examination. In other words, it must not simply accept it as a given, but as a live and unresolved question. At the same time, it seems problematic to presuppose that the list of liberal arts inherited from the pre-Cartesian understanding of things can simply be relied upon as a guide to understanding what a post-Cartesian liberal education should be. The New Program seal, with the seven pre-Cartesian books, and the post-Cartesian balance, does not represent an achieved synthesis, but a deep and perplexing question. It is the centrality of this question in the New Program that prevents it from being either an attempt to retreat from the modern world or a propaideutic to an uncritical, specialized engagement with it.

There are thus, from the beginning, or at least near the beginning, a number of tensions in the New Program's approach to science: first, the tension between scientific inquiry and understanding as something embodied in great books and accessible to seminar reading and discussion, on the one hand, and as something essentially involving special techniques of observation, measurement, and experimentation that need to be

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[1] This brief sketch is based in part on Frederick Rudolph, *Curriculum: A History of the American Undergraduate Course of Study* (San Francisco: Jossey-Bass Publishers, 1977).

practiced in the laboratory, on the other hand; second, the tension between seeking to understand a great book in its own terms and seeking to see how some, but perhaps not all, of its claims are incorporated into the collective edifice of modern scientific theory; third, the tension between these techniques understood as a new liberal art that can simply be added to the traditional liberal arts and these techniques understood as enmeshed in a radically new way of understanding the world that calls into question the old understanding of the world in which the traditional liberal arts operated; fourth, the tension between emphasizing the continuity in the efforts to understand nature within the western tradition and emphasizing the revolutionary discontinuity between pre-modern and modern science, reflected in the radical critique of the former made by the founders of the latter.

As the Program has developed over time, the first of these tensions has led to the abandonment of the attempt to read books about the inquiry into nature in seminar, with a few exceptions: among the ancients, we read Aristotle's *Physics* and Lucretius' *De Rerum Natura*; among the moderns, we read philosophical works about the founding of modern science: Bacon's *Novum Organum*, Descartes' *Discourse on Method*, and some of Leibniz's writings on dynamics.

This shift has, on the one hand, resulted from an acknowledgment that most of these books cannot be read profitably in the mode of seminar, but require the more structured and sequential approach of a tutorial. On the other hand, it has in most cases brought the mathematics tutorial and the laboratory into the project of studying great books and has rescued them from reliance on text books which take the modern organization of the sciences for granted. Furthermore, it has posed for our mathematics and laboratory classes the task of dealing with the second tension mentioned above.

Aside from the few foundational works read in seminar, the task of coming to grips with scientific inquiry in a way appropriate to liberal education has fallen largely to the four years of the mathematics tutorial and to the (since 1976) three years of laboratory. The mathematics tutorial spends the equivalent of a year, spread out over freshman, sophomore and junior years, following one science, astronomy, from its ancient to its early modern form, studying texts from Ptolemy, Copernicus, Kepler, and Newton. In addition, it follows the transformation of the concept of number from its ancient to modern form, a transformation that Jacob Klein thought to be crucial to the possibility and the character of modern physics. The three years of laboratory, on the other hand, are divided into segments that closely correspond to conventional divisions of scientific subject matter, especially in the junior and senior years: mechanics and dynamics, electromagnetism, beginnings of quantum mechanics, evolution, genetics, and their synthesis and molecular basis. At least within the physics sequence as a whole and within the senior biology sequence, the topical organization also follows a roughly chronological sequence. In the freshman year, the segments are somewhat less conventional for various historical, structural and pedagogical reasons: observational biology, measurement and statics, and atomic theory.

What is the proper place of the study of natural science within a liberal education? In his 1975 statement of educational policy, Dean Curtis Wilson argued that we should aim to learn something about nature and nature's laws, as well as about our knowing of nature's ways. What we should know about nature should include some of the most fundamental conclusions of modern science, but we should not accept them as mere conclusions, but be aware of, and to some degree participate in, the kinds of inquiry, intellectual effort, hard work and luck that went into their discovery. He warned against devaluing modern science by subordinating it to either mathematics or philosophy.

While these goals are admirable and indispensable, I want to argue that they must, after all, be subordinated to questions about the philosophical status and implications of modern science, both as an overarching project and in its particular claims. If the deepest sense of liberal education is the raising of radical questions, then modern science, like anything else, finds its proper place in liberal education as the subject of radical questioning. I believe that this would be the case even if science in its present form were as old as poetry, mathematics and philosophy rather than the result of what the 38-39 catalogue called "the greatest intellectual revolution in recorded history," one which occurred a mere four centuries ago. There may be room for dispute about the extent to which the causes of this revolution and the shape that modern science ultimately took are to be located in the thinking of certain philosophers. It may be that Descartes and Bacon were arrogant and presumptuous in claiming to be the founders of this new enterprise and in thinking that their intentions would govern its development. Nonetheless, this very claim is one that we need to take seriously and to examine critically.

It does seem to me indisputable, however, that the emergence of modern science coincided with, whether as cause or effect, or both, a radical revolution in how people thought about what it means to know, what kinds of beings there are to know, what kind of beings human beings are, how we think about the human good, and how we should or should not think about what there might be beyond the nature investigated by science. While these questions are taken up in many of the modern philosophical texts we read in seminar, our ability to read and to evaluate the claims made in these texts is to a crucial extent dependent upon a responsible and thoughtful examination of the evolving claims to know made by the scientific enterprise which played such a big role in the revolution that spawned the new ways of thinking about these questions. In other words, if a responsible reading of the texts of modern philosophy is an intrinsic part of a liberal education, then a critical and responsible engagement with the fundamental claims of modern science is no less essential. Hence the success of at least the seminars of the Junior and Senior years are to an important degree dependent on the success of our engagement with modern science in the laboratories and in the mathematics tutorials.

The way in which the Cartesian founding of modern science shapes the subsequent development of modern philosophy is a familiar and oft-told story. The following is my own attempt at a rough-hewn version. Descartes was able to project the idea of a mathematical science of bodies by denying the ancient premise that living bodies were distinguished from non-living bodies by the presence of soul. While for the ancients, soul had the two-fold function of animating living things and making possible sensory and intellectual awareness of the world for some of them, Descartes confined it to the realm of human awareness, "thinking" in a broad sense, while insisting that all other functions of living things must be accounted for by the science of the motion of inanimate bodies. The resulting "Cartesian dualism" left a quandary for philosophers who sought a unified understanding of the knower (non-bodily thinking) and the known (non-thinking body). Since the science of non-thinking and inanimate body came to be understood as the science of nature, the thinking which achieved this science, among other human enterprises, came to be seen as something outside of nature and hence outside of the competence of natural science. Among the other human enterprises left outside the sphere of science were ethics and politics, or any attempt to understand the human good.

On the epistemological and ontological level, the course of modern philosophy can be roughly characterized as the attempt by each side of the Cartesian dualism to absorb the other. Either human thinking had to be explained as just a complicated outcome of the motion of bodies or the motion of bodies had to be explained as deriving its intelligibility, and perhaps even its being, from human thinking, whether understood psychologically or transcendentally. In the meantime, the principles underlying the understanding of the human good were sought in various places: the most basic passion(s), sentiment, the conditions of legitimate government, autonomous reason, reason as embodied in a teleological history, and will to power, to name a few.

Meanwhile, as the Cartesian mathematical science of body was developed by others, it went through many transformations in its conception of its object, leaving behind the simplicity of Cartesian extended substance in motion for ever more complex conceptions, until finally nothing commensurate with the human imagination (or even with the human intellect?) seems to be left to be the object of the mathematical formalism of modern science.

While the central role of the emergence of modern science in the development of modern thought and the modern world is widely acknowledged, this role has been the subject of special critical examination by two thinkers closely associated with St. John's College: Jacob Klein and Leo Strauss. Klein was dean of the college for a decade or more and his interpretation of the emergence of modern mathematics out of ancient mathematics, and the role of this modern mathematics in modern mathematical physics, has had a powerful influence in shaping at least the mathematics program at St. John's, if not the laboratory program. Strauss was for most of his career associated with the University of Chicago, and only came to St. John's late in his career to the position of Distinguished Scholar in Residence on the Annapolis campus, which Klein contrived for his sake. Strauss's influence has been less direct, working mostly through the numerous members of the faculty who have studied with him or with his students, or have read his books. Because of the powerful influence that their interpretations of the project of modern science have had on the treatment of science in the St. John's program, I think it worthwhile to attempt a brief sketch of those interpretations.

What is common to both interpretations is the raising of fundamental questions about the project of modern science, Klein focusing on its epistemological grounding, Strauss on its entanglement with a questionable political project, and both asking whether its wholesale rejection of ancient thought was justified.

In his book, *Greek Mathematical Thought and the Origins of Algebra*, Klein tries to give what he regards as the first precise account of the ancient concept of number, how the modern concept of number emerged as a transformation of it, and why the modern concept is problematic in itself, and hence in its necessary role in modern physics. Klein's project overlaps and intersects in complex ways with some of the late work of Edmund Husserl, particularly as expressed in two texts, *The Crisis of the European Sciences* and *The Origin of Geometry*. I will first sketch Husserl's critique of modern science and his proposed remedy, and then turn to Klein's more specific contribution.

Husserl believes that modern science is heir to the Greek philosophical ambition of a comprehensive and securely founded knowledge of the whole, but that it has squandered this inheritance through certain crucial misunderstandings and that he, Husserl, has a way to recover this inheritance and bring it to fulfillment. According to Husserl, modern science attempts to understand nature through mathematical constructs that are the result of an idealizing process accomplished by the subjectivity of the investigating scientists. Most practitioners of modern science make a fundamental mistake in interpreting their own accomplishment. This mistake is to identify these mathematical constructs, as elaborated in hypotheses confirmed by experiment, with the true being of nature, while either leaving out of account the workings of their own subjective accomplishments in constructing these concepts, elaborating these theories, and conducting these experiments, or, turning around and trying to explain the subjectivity which created these constructs in terms of the "true beings" established by its own activity. We are left with either an incomprehensible dualism of the "psychic" and the "material" or with an untenable attempt to reduce the "psychic" to the "material." Husserl's attempted solution is to assert the ultimate priority and foundational character of the "psychic," when properly understood, by means of the "transcendental reduction," as "transcendental," i.e., the ultimate source and ground of all worldly significance and being, rather than as itself a mere piece of the world.

In the essay entitled *The Origin of Geometry*, Husserl elaborates a feature of scientific activity that he only hints at in the *Crisis*, and which becomes of particular importance to Klein. Any given science has a developmental sequence such that certain "later" elements necessarily presuppose certain "earlier" ones. (The scare quotes indicate that Husserl does not wish to identify this developmental priority with factual historical priority.) For example, Euclidean geometry cannot get off the ground as a demonstrative science unless the work of idealization has already been accomplished, yielding the objects familiar to us (yet ever strange) from Euclid's definitions: the partless point, the breadthless length, the depthless surface. In its turn, Galilean mechanics presupposes the prior accomplishment of Euclidean geometry and Euclidean theory of ratio and proportion. And finally, as Klein will argue, modern physics presupposes the development of algebra and the modern number concept that it involves.

Husserl goes on to point out a crucial implication of this developmental sequence of the sciences. When a new scientific development, such as Galilean mechanics, builds on a prior scientific achievement, such as Euclidean geometry, there is a tendency, Husserl claims a necessary and inevitable one, to take for granted, and thus to lose sight of, the evidence involved in the prior science while building the subsequent one on it. We experience a simple example of this as we work our way through Euclid's *Elements.* As we proceed to later propositions in Book I, we tend to forget about our struggles with the definitions and our doubts about the proof of I. 4, the use of Postulate 5, etc. Likewise, as we proceed to use ratios and proportions in Book VI and beyond, we tend to forget about our struggles with and doubts about the meaning of the definition of same ratio. We come to take I. 4 (side/angle/side as proof of "congruence" of triangles) and same ratio for granted, without reactivating the evidence for their justification, assuming it was ever active in the first place!

As Husserl sees it, Galileo takes Euclidean geometry as given, and forgets that it is the result of a process of idealization. Hence he can think of nature as a book written in mathematical characters, forgetting what Husserl sees as the subjective origin of those characters. As another example, if Galileo himself does not lose sight of the nature and limitations of the Euclidean theory of ratio and proportion as he applies it to the magnitudes involved in mechanics, his successors soon do, as do we, as students in Junior Laboratory. Husserl coins the term 'sedimentation' to describe this tendency to let slip into oblivion a prior evidence when building a new one on top of it. In his view, the history of science, to the extent that it progressively builds on previous results, both presupposing them and failing to reactivate them in evidence, is essentially and necessarily a history of repeated sedimentation. The implication of this is that current practitioners of science will often not have a clear awareness of the sedimented layers of evidence that underlie their current practices, unless they have made a special and strenuous effort to unearth them. Therefore, they are not always the best guides if one wants to get back to the original evidence at the root of any given science. To the extent that we are persuaded by it, Husserl's understanding of sedimentation provides an important, although for many of us, largely sedimented, justification for our reading of original texts in our mathematics and laboratory classes.

Returning to Klein, we can now see that his effort in *Greek Mathematical Thought and the Origins of Algebra* can be characterized as an attempt to "desediment" the modern concept of number, and consequently its use in modern physics, by showing how it arose as a more or less conscious modification of the ancient concept of number. I will venture a brief and crude sketch. For the ancients, 'number' always meant a definite multiplicity of definite, discrete objects. Hence only the natural numbers starting with two were included in this meaning of number. Number was thus sharply distinguished from the various kinds of magnitude (length, area, volume, weight, etc.), which were all distinct from one another and each continuous rather than discrete, even though the Euclidean theory of ratio and proportion had a generality that enabled it to handle all different kinds of magnitude and was such as to provide operations with magnitudes and their ratios analogous to certain operations with numbers and their ratios.

The modern concept of number replaces this direct reference to determinate multiplicities with what Klein, borrowing from the scholastics, calls a second intention: a modern number sign intends directly no determinate multiplicity, but only the concept of multiplicity, allowing it either to blur or to overcome the distinction between multiplicities of discrete units and continuous magnitudes. (It is matter for interpretative debate whether Klein intends to say that the modern concept of number is finally incoherent, because it retains an unacknowledged dependence on the ancient concept of determinate multiplicity to ground its operational rules, while extending those rules to something continuous, or whether he leaves open the possibility that either Descartes himself, or some successor (Dedekind?) has succeeded in giving genuine internal coherence to the modern number concept.) At any rate, Klein certainly meant to suggest that for modern science as practiced at the time of publication of his book, and there is no reason to think this has changed, the whole question of the status of its use of modern mathematics is thoroughly sedimented and in need of examination if it is to be understood on the basis of evidence.

Thus Husserl and Klein both raise fundamental questions about the epistemological grounding of modern science, as well as pointing to desedimentation as a crucially necessary element to any attempt at investigating these questions. They differ, however, in that Husserl thinks modern science can be incorporated within a totality of accomplished knowledge achieved through the founding science of transcendental phenomenology, while Klein seems doubtful that the mathematical mode of expression of modern science can ever be made sufficiently intelligible for it to count as even a partial knowledge of the world, even if the rest of Husserl's ambitious foundationalist project could be accomplished.

Leo Strauss's critique of modern science (my summary is based largely on Strauss's essay "The Three Waves of Modernity"[2] and has also drawn on Henry Higuera's 2003 lecture[3]) claims that its rejection of ancient science and philosophy originated not with epistemelogical, but with political, dissatisfaction (the contrast in this form, is stated more clearly in Higuera's lecture), as found first of all in the work of Machiavelli. One of the key features of ancient philosophy and science almost universally (Is Leibniz an exception?) rejected by the founders of modern science is the notion of a final cause, i.e., that an important way of understanding natural things is to understand that for the sake of which they come to be what they are (Higuera, 7). According to Aristotle, things by nature have a principle of motion within themselves, and this principle is their nature or essence, that which determines what kind of thing they are. Their primary natural motion is their development into a mature instance of this kind of thing. Other natural motions include those characteristic of this kind of thing and those involved in reproducing others of its kind. Hence an acorn develops by nature into a mature oak tree, puts down roots, grows xylem and phloem, puts out branches and

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[2] In Hilail Gildin (ed.), *Political Philosophy: Six Essays by Leo Strauss* (Indianapolis: Bobbs-Merrill, 1975).
[3] Henry Higuera, "The Moral and Political Foundations of Modern Science," a lecture delivered at St. John's College, Annapolis, MD, January 24, 2003.

leaves, nourishes itself through photosynthesis, grows to a mature height, and produces acorns, which then continue the cycle. The nature of anything thus represents a kind of standard or measure of the perfection of that thing. An oak tree that failed to produce leaves or acorns would be judged to be stunted or imperfect, falling short of fulfilling its nature.

The fundamental concern of the political thought of the ancients was to say what kind of regime, or political ordering, would best conduce to the fulfillment of human nature, of man's perfection or final cause (Strauss, 84). It is this concern that Machiavelli rejects, on the ground that it is at best useless for, and at worst a hindrance to, the achievement of practical political goals, somewhat loosely understood as some combination of security, freedom, prosperity, and glory. Hence, Machiavelli rejects the notion of a final cause given by human nature in the political realm, not directly on theoretical grounds, but on the practical ground that it is useless or harmful in guiding efforts to achieve the goals that he regards as humanly important (Strauss, 86). This rejection of a naturally given human final cause brings with it, albeit somewhat less explicitly, the rejection of the notion of a human nature. Not only is human nature not a standard of perfection, but human capacities and behavior are, to a larger degree than previously believed, malleable, capable of being molded and changed by a founder, legislator, or prince. Human beings become the material on which a ruler works, not the standard that guides his work (Strauss, 85, 87). Finally, if the course of human events and the circumstances which affect them are not determined by nature, then it seems that they are a matter of chance or fortune. But chance or fortune can be forestalled or overcome by human art and foresight (Strauss, 87). Machiavelli gives the example of building dams and dikes to prevent the damage that would otherwise come with floods, whose occurrence is beyond our control. To summarize, Machiavelli rejected, as a debilitating restraint on the power of a ruler to effect political goods, human nature not only as a final cause setting a standard of perfection but even as a limit to what can be done with human beings regarded as material. Moreover, he suggests that political power can also be used to control the effects of non-human events, described under the rubric of fortune.

Bacon and Descartes lay the basis of modern science on these Machiavellian foundations. The Machiavellian goal of mastery of fortune becomes the Baconian/Cartesian goal of the mastery of nature for the relief of man's estate (*Discourse on Method*, Part VI; *Novum Organum*, I, 129). If knowledge of nature is to serve this goal, it cannot consist in learning about the goals or final causes of natural beings. Instead, it must consist in understanding how natural beings work, so that we can make them work for us. For Descartes and Bacon, this takes the form of understanding the laws that govern their operations, although the two of them may differ somewhat in their conception of these laws and of the character of the beings governed by them. These laws cannot be discovered by simply observing or contemplating nature; rather, we must pose our own questions to nature and make it answer them through "the vexations of art" (*Novum Organum*, I, 98). This questioning and vexation requires instruments, which become more and more elaborate and expensive, as the sciences develop. More hands and more funds are needed than any one individual, no matter how smart or how rich, can supply. It is necessary that the enterprise receive massive public funding, so there is need of a public relations campaign to persuade those in control of the public purse strings that the benefits will be worth the cost (See *Discourse on Method*, Part VI). The development of modern science into a collective technological project requiring a massive infrastructure is implicit in its founding and anticipated by the founders.

If this analysis is correct, the epistemological parameters of modern science were set by the political goal, mastery and control of nature for the relief of man's estate, and never had any theoretical warrant or justification beyond their efficacy in achieving this goal. These epistemological parameters, founded on the rejection of human nature and final cause, exclude the ancient mode of inquiring about and trying to achieve knowledge of the human good. Strauss sees much of the rest of modern thought, summarized briefly in the remainder of the "Three Waves" essay, as an attempt to come to terms with this problem, by finding alternative ways of thinking about the human good. It seems to be his conclusion that they all fail, leading to what he calls, in many of his writings, the crisis of modernity. He himself turned back to the ancients, to see if their way of thinking about the human good could be revived and understood as viable, given that its rejection by the moderns was not initially made on any theoretically compelling grounds.

These analyses of modern science and its relation to ancient and modern thought by Klein and Strauss are controversial and based on premises that can and should be questioned. I thought it worth rehearsing them for at least two reasons.

First, whether or not we agree with the ways they frame their questions about modern science, we are indebted to them for calling our attention to the importance of raising questions about it and for offering us some powerful ways of thinking about it. The following claims seem to me not only independent of the particular analyses of Klein and Strauss, but simply true: the epistemological path adopted by modern science makes it difficult to provide an understanding of the human good that is compatible with an understanding of the achievements of modern science, much of modern thought is occupied with this problem, and its success in resolving it is doubtful. There are various ways of responding to this situation, including questioning the terms in which the problem has been posed, thus attempting to dissolve it rather than solve it. Nonetheless, the necessity of facing this situation and thinking it through is to my mind the most important justification for the essential place of the study of modern science in a liberal education and in the St. John's program.

Second, insofar as their critiques have shaped the very form of our academic program, we as a teaching faculty and as stewards of that program have a responsibility to be aware of that shaping, to keep it from becoming sedimented, and to be willing both to attempt to understand and to question the presuppositions behind that shaping.

In conclusion, I would like to raise two questions along these lines about the design of our program. First, if it is correct that our study of modern science ought to confront its origins in the Cartesian revolution, how thoroughly should our program be shaped by this and how explicitly should it be framed in these terms? Second, how should we determine the level of technical detail that our students should be asked to engage in their study of mathematics and science?

Framing the Inquiry?

At St. John's, we have always refused to frame our sequence of seminar readings in terms of the historical-cultural epochs (classical, Hebrew, Hellenistic, medieval, renaissance, enlightenment, romantic, etc.) widely used in conventional academic "Western Civilization" courses. This refusal is based on a number of distinguishable grounds: 1) a desire to minimize the imposition of interpretive filters between students and the texts they are reading; 2) a concern that the belief in the reality of such historical-cultural epochs is a sedimented inheritance from Hegel, and ought not to be presupposed; 3) a concern that reference to such epochs brings with it a predisposition to believe that the books we read are primarily or even merely the "products of their times," rather than the work of thinkers who are making a claim, worthy of our consideration, to speak the truth for all times. Strauss and Klein both understood that their return to the ancients in pursuit of wisdom required a rejection of the historicist understanding that a thinker cannot transcend the limitations of his place in history.

On the other hand, I have just argued, developing a claim present in the college catalogue for over 70 years, that our consideration of modern science must be fundamentally oriented by an awareness of its origin in the Cartesian (or Machiavellian) revolution. Furthermore, this focus on the "Cartesian revolution," built into our curriculum and explicitly acknowledged in our catalogue, seems to divide the works and thinkers we study into two eras, the pre-Cartesian and the post-Cartesian. Moreover, our selection of seminar books also emphasizes the quarrel between the ancients and the moderns by devoting an unusually large (in comparison to other Great Books sequences) proportion (two sevenths) of our seminar readings to classical Greek texts. Are we guilty of a self-contradiction?

Let us consider each of the three reasons for not framing our studies according to historical-cultural epochs as they relate to the presentation of science in the mathematics tutorials and laboratories.

1. The selection and organization of materials, more so in the mathematics tutorials than in the laboratories, is done with a view to allowing the contrast between ancient and modern mathematics and science to emerge and to be thought through. In that sense, there is something of an interpretive filter. On the other hand, we do not have courses entitled "The Transition of Astronomy from An Ancient to a Modern Science" and "The Transformation of Mathematics from Ancient to Modern," but only four years of mathematics tutorials. Indeed, the two thematic threads interrupt one another or interweave with one another. Still, one might object that we are only thereby dissembling

our thematic filter and making it more difficult than necessary for students to see what we think is at issue. In the end, however, our students still encounter the texts directly and through discussion, so that it remains up to students what to see or not see in the texts they are studying. Still, I think our ambivalence about whether or not we are and should be framing the issues for our students, reflected in the different degree to which we do so in mathematics and laboratory, merits further discussion.

2. Speaking of a "Cartesian revolution" need not necessarily imply that we are understanding pre-Cartesian and post-Cartesian thinkers as the expression of Hegelian epochs. We need not believe that post-Cartesians embody a "new spirit" that has emerged "behind their backs." They may be regarded simply as thinkers who have adopted a project that Descartes (and/or Bacon and/or Machiavelli) initially proposed and have continued to wrestle with its implications. The success of the project has, however, shaped the world in which we live and resulted in the widespread adoption of a set of beliefs based on that success. Our students often bring such beliefs with them, in unexamined form, when they enroll at St. John's.

3. The presupposition of our study of these things, however, is that we can come to understand both pre-Cartesian and post-Cartesian thinkers and make a considered judgment of their respective claims. Moreover, we must also be willing to consider the possibility that modern science can be liberated from "modernity," i.e., from the self-understanding rooted in the Cartesian revolution.

Nonetheless, even if we can defend ourselves against self-contradiction, there remains a question worth discussing about the desirability of the degree and kind of framing of the questions that we have incorporated in the structure of our mathematics and laboratory program.

How much technical detail?

Junior and Senior mathematics tutorials and laboratories are acknowledged by students and tutors alike to be more difficult than the mathematics tutorials and laboratory of the first two years. This fact about our academic program is one of the main justifications for the process of enabling that students must undergo at the end of the sophomore year. This difficulty comes in large part from the attempt to understand material that is couched in a modern mathematical formalism that is more sophisticated, difficult to acquire facility with, and difficult to have insight into than the more geometrical mathematics of the first two years. Questions are sometimes raised about whether the level of mathematical insight and facility we expect from students in these classes goes beyond what ought to be contained in a "liberal education." The premise of this questioning seems to be that this kind of mathematics has a "technical" character which is somehow "illiberal."

There appear to me to be two ways in which our work in junior and senior mathematics and laboratory can be liberal. In the first way, we want to examine the elements and starting points of any kind of mathematics, being open to reflective questions about the nature of the enterprise and its relationship to other human possibilities. In the second way, we may need to follow the use of mathematics in science in order to raise and pursue reflective questions about the nature of these sciences and the implications of their claims to know. Sometimes there can be a tension between these two kinds of liberal use of mathematics. It may be necessary to bracket some of the questions we have about the mathematics itself in order to make use of it as a tool to open up the questions in a scientific investigation. There may be a moment (in the Hegelian sense) of illiberality in this bracketing.

On the other hand, mere difficulty does not make a subject matter illiberal. Nonetheless, concessions have to be made to what it is possible to do effectively in an all-required liberal arts program. We must thus balance the aspiration to do the mathematics required to gain access to important questions in science, against the capacity of our students to learn this mathematics in a liberal way. This is a difficult balancing act, and one that we continually struggle with, both in curricular design and in pedagogical practice. Nonetheless, I would urge that the importance for a liberal education of a serious encounter with modern science weighs against the temptation to lower our expectations in areas where an understanding of mathematics is important to that encounter.