

THE CARDINAL AND THE CALCULUS: ARTS AND SCIENCE

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DID JOHN HENRY NEWMAN study Calculus as a young Oxford undergraduate? The question has more than historical interest. In fact, it touches upon the most important educational problem of the present day, namely, the relationship of the arts and sciences. For the great English Cardinal is often pictured as the supreme product of a liberal education, as having formulated in his *Idea of a University* the blueprint of a liberal arts college. Now Calculus is clearly a scientific tool: indeed, it is still possible to obtain a degree in Mechanical Engineering without possessing more mathematical knowledge than Differential and Integral Calculus. If Newman pursued this subject, then the possibility that liberal education is not solely of a literary nature must be entertained. It may even be that "Science is one of the liberal arts" as President Lee DuBridge of the California Institute of Technology has asserted.¹ President James Killian of the Massachusetts Institute of Technology expresses his similar "deep conviction that the liberal arts cannot be liberal without including science."² Since one may judge these as biased witnesses, it is well to cite other testimony. Historian E. Harris Harbison observes: "we sometimes forget that science is just as integral a part of a liberal education as art and literature, history and philosophy."³

The point may be pressed further. In 1820 when Newman at the age of nineteen took his degree, Newton and Leibnitz (who had independently and simultaneously discovered Calculus) had been dead less than a century. Whatever progress had been made in the mathematical physics in that century was couched in terms of the calculus. Indeed, virtually all mathematics that ex-

isted at the opening of the 19th century was reducible to a single type, the hypergeometric function.⁴ Thus, to be conversant with calculus was to have all the current wares of modern science open to easy inspection. If the liberally educated Newman had easy access through calculus to the scientific thought of his day, can he be called liberally educated who today is ignorant of the same calculus, to leave unmentioned the non-Euclidean geometries of Bolyai, Lobachevski and Riemann, the set theory of De Morgan and Boole, all of which are more than a century old?

In April 1819, Newman declared his intention to stand examination in classics and mathematics.⁵ He evidently understood mathematics in a wide sense, for his list consists of the calculus, conic sections, algebra, trigonometry, geometry, hydrostatics, astronomy, mechanics, optics and sections on Newton's *Naturalis Philosophiae Principia Mathematica*. It is noteworthy that "this list was neither more nor less than was usual."

His list of classics is equally instructive.⁶ It consists of the dramatists Aeschylus and Sophocles, the poets Vergil and Horace, the historians Thucydides, Herodotus, Xenophon, Polybius and Livy and finally the Ethics, Politics and Rhetoric of Aristotle. The last two groups, the historians and the works of Aristotle deserve special attention.

Newman's age approached the Greek and Latin historians in a mode that is difficult to appreciate today but which must be kept in mind. It must be recalled that exhuming of the past had barely begun, archeology was in its infancy: the Rosetta Stone was uncovered just two years prior to Newman's birth. Thus, while the classic historians were not the sole witnesses to the ancient world, they were by far the most common sources for such knowledge. To consider the classics as exercise books in Latin or Greek prose is to misjudge their educational function in the early 19th century: Newman's copy of the Stagirite's Ethics, while it was printed in Greek and Latin, has his personal annotations in English⁷—a clear sign that the realities occupied his attention more than the language in which they happened to be expressed.

Concerning the Aristotelian works that appear on the list, two facts should be recalled. The first touches the subject matter of the books. The Rhetoric contains the elements of the forensic art, but it also holds Aristotle's longest technical analysis of the human emotions and various physiological states. The Ethics deals with the dynamic integration of an individual's emotions,

intellect and will. The Politics discusses the family, the state and some imperfect societies. In short, these books correspond to the modern sciences of psychology, personality integration and sociology. The second fact concerns the authority of Aristotle in these fields. The Philosopher was still the acknowledged master. The statistical approach to sociology that is so common in our age had not yet begun: Laplace had recently published his classic essay on probability and Comptes, only three years older than Newman, had not, of course, begun publishing. Thus, reading Aristotle in these fields was considered as productive of scientific knowledge as studying a modern text book in these areas.

In summary, Newman studied Aristotle where the Stagirite still held sway; in fields where Aristotle was thought to have been eclipsed, he studied more modern theories, even the classic work in the mathematical physical sciences, Newton's *Principia*. The future Cardinal had a detailed acquaintance with all the scientific processes of his age.⁸

Newman's education is merely a single example. It is therefore desirable to approach the relationship of the arts and sciences to the college in more general terms. Such is the task of the present paper. Modern opinions of the liberal arts college will be indicated (Part I) and analyzed in the light of the Aristotelian-Thomistic tradition of education (Parts II and III). Subsequently, certain difficulties against this doctrine will be raised and answered (Part IV); its modern application will be briefly considered (Part V).

PART I: Art and/or Science

Only Catholic educators and a small minority of other modern educators consider the liberal arts when formulating policy.⁹ The topic is a dead letter for the vast majority who seem uninterested in traditions prior to John Dewey and seem ignorant of educational matters that antedate Pestalozzi. This is an unfortunate attitude for it isolates them from a tradition that was two thousand years in the making. Further, it promotes the instability so evident among such educationalists: lacking firm foundations, these theorists constantly oscillate in their attempts to adjust the school to each passing impulse that society undergoes. Plato has already portrayed them and vividly detailed their baneful effect in several of his dialogues.¹⁰

In an age that is manifestly scientific, educators concerned with the liberal arts find themselves in a dilemma, one that is all

the more cruel because it is essentially a false one. It appears to them that they must either join the swing to the sciences, a swing given additional impetus this past year by orbiting satellites, or stand their ground with the increasing isolation this entails. Since the former seems to repudiate all the traditions they uphold, naturally they have optioned the latter course still convinced that their position is correct.

If their argument is stripped of all rhetoric, it can be stated in a polysyllogism.

The sound basis of Western education has always been the liberal arts college. And the liberal arts curriculum includes history, literature, the plastic arts and language; it excludes the sciences. Therefore the soundest basis of Western education includes literature, etc.; exclude the sciences. And these subjects are the liberal arts curriculum. Therefore the best colleges, even in an age of scientific specialization, is the liberal arts college.

The argument unfortunately equivocates on the word "college" in such a way that the major premise is useless. This will be shown in Part II. The exclusion of the sciences from the liberal arts involves a second equivocation (Part III). Finally, equating the liberal arts to the plastic arts, literature, history and language threatens to preserve an accidental and temporary configuration of the arts while casting aside the traditional and substantial enumeration: it is throwing out the baby while keeping the bath (Part IV: a and b).

PART II: Liberal Arts Colleges

Institutes of higher education have not always been termed colleges: Plato named his school the Academy, Aristotle named his the Lyceum. It is noteworthy that these terms which once signified the Hellenic equivalent of the Institute for Advanced Studies at Princeton are now applied only to secondary schools. This process of denominating one object by either the best or most familiar in that class of objects is very common. Evidently, denomination can occasion confusion and, if the nature of the original object which gave its name to others is forgotten, it can cause equivocation. Such seems to be the case with the word "college."

The universities which arose in the thirteenth century consisted of various *Nations*, or dormitories in which students from certain geographical areas resided.¹¹ The name "college" was applied to the Nations. They were not unlike the North American

College in Rome or the English College in Valladolid. A great number of students in one Nation necessitated additional dormitories. Each of these appropriated the word "college" and often enough some name linked to the dormitory. The Colleges of Oriel, Balliol and Magdalen at Oxford University exemplify this second process. At first these colleges held a certain independence in a university: they frequently offered their own lectures. Yet their influence subsided as education gravitated to central administration by the Faculties of arts, philosophy, theology, law and medicine. Each of these faculties styled itself a "college." It is in this sense that the word is used today.

But between the college of today and that of the past, there are two important differences, namely the age of the students on entrance and the relationship among the various colleges in a university. Neglect of these differences has occasioned equivocation.

Today the American student generally enters college at the age of 18. He may enter the college of engineering or that of commerce, or the arts, or science. None of these need be completed before entering another. Only the colleges of law and medicine demand that the student have finished his studies in another college, that of arts or science. Since relatively few students matriculate in law or medicine, the fact that one college can demand as condition for admission the completion of another is forgotten. Thus the term "college" is uniquely applied to the education one undertakes at age 18 in one faculty of a university.

All this was different in other lands and in other times. In the 13th century, students ranging in age from 12 year old youths to mature men lived in the colleges: all of them were rightly termed "college students." Since the vast majority were destined for the priesthood, they followed a prescribed course of studies: first the arts, then philosophy and finally theology. Students electing the medical or legal professions followed the same series but entered the college of law or medicine in place of theology. St. Thomas Aquinas, for example, began his arts at Monte Cassino, continued them at the newly erected University of Naples in the Arts college when he turned 14.¹² At 16 he began philosophy in the same place. Although his family's objections to his vocation resulted in one interruption and his religious novitiate occasioned a second, still he completed theology in Cologne before he was 24 years of age. This youthful entry into college must not be ascribed to St. Thomas' brilliance: it was the normal

procedure in his age and in later ages. Thus, St. Ignatius of Loyola, writing in 1550, prescribed the following course of studies for all colleges conducted by the Society of Jesus.¹³ Grammar's highest class should be finished by 12. After that, the student entered the lower arts faculty to study Rhetoric, poetry and history. At 14 he passed to logic, physics, metaphysics, moral philosophy and mathematics. At 17 or 17½ the student was qualified to elect a curriculum in law, medicine or theology. After a four year cycle in theology, he was eligible for priestly ordination at 21; after two more years study he was granted the doctorate in theology.

This program did not disappear in St. Ignatius' age. For the education of the American Founding Fathers¹⁴ was in accord with the tradition to which St. Ignatius is a witness. Saint Pius X who was ordained in 1858, began his higher arts at the college of Treviso at 15, his philosophy at 17 and his theology at 19.¹⁵ Once again, although St. Pius possessed great intellectual gifts, this was not different than the normal age for commencing the various collegiate studies in his native Italy.

The conclusion is patent. The word "college" should not be used as if it always applied to an educational agency such as an American student enters at 18 years of age: for centuries it was applied to the agencies which accommodated students ranging in age from 12 to 23 years. The lowest of these agencies was the liberal arts college. Thus the liberal arts college was the basis for all education only in the sense that an American high school is the basis of education: insofar as (1) the students in it were young and (2) its completion was a prerequisite for later studies.

PART III: Science and Education

It was stated above that the exclusion of the sciences from the liberal arts colleges involved an equivocation. To show this it is necessary to briefly set out the Thomistic doctrine of science and education.

According to Aristotle and St. Thomas, philosophy and science are interchangeable terms.¹⁶ Science or philosophy means true and certain knowledge, i.e., knowledge proceeding from principles that are true to a conclusion which can be held with certitude in light of the first principles.¹⁷ Thus, science is the optimum intellectual knowledge man can obtain. Knowledge grounded in mere opinion or in persuasive illustrations inclines the mind to accept a particular conclusion without removing fear

of error. Evidently since the intellect does not enjoy certitude in such matters, subjects concerned with this type of conclusion are inferior to science. Since education should produce the optimum intellectual conviction that a student can enjoy, science specifies the optimum education.

Such knowledge can be achieved in a variety of fields. These are the special sciences. Each of the special sciences requires a certain degree of experience and mental maturity for real comprehension of the matter it treats.¹⁸ Evidently this variation in requisite maturity can be used to set up an organized plan of education. This order is natural since it follows the natural unfolding of the human intellectual powers; it is artificial since it builds on nature.

According to this plan, serious education will begin with the studies that require least experience but still produce science. These are mathematics and the subjects which apply mathematics to simple problems.¹⁹ Traditionally these have been identified as the Quadrivium. They are geometry, arithmetic, astronomy and music; the last subject would perhaps be more correctly titled "physics of sound" or "theory of vibrating strings."²⁰

These sciences presupposed some intellectual training; this was instilled by the Trivium, grammar, rhetoric and logic.²¹ Even the trivium assumed some knowledge, the ability to form letters and read.

The Trivium and the Quadrivium are the seven liberal arts. The subjects of the Quadrivium are sciences properly so called: in geometry one demonstrated properties of triangles, in astronomy the rotundity of the world is demonstrated.²² In the Trivium, only logic can be considered a science. Yet rhetoric is a part of logic and grammar is instrumental to rhetoric.²³

The Trivium came to be called "lower arts" and its study was undertaken in the earliest scholastic agency. By denomination, the Trivium came to be called after their lowest member, Grammar.

The Quadrivium, although constituted of sciences, was named the "higher arts" and was taught in the college of arts. Thus, the faculty which taught only the higher arts accepted by denomination the name proper to all the seven arts. These sciences were completed by students 15 or 16 years of age.

By St. Ignatius' time, some slight changes had been introduced.²⁴ The higher arts (which were still completed by 16 years of age) still numbered mathematics from the Quadrivium. Logic,

which had developed greatly in the 14th century, was advanced from the Trivium. Physics, moral science and metaphysics (virtually the entire philosophical curriculum) were added; music seems to have been dropped. Evidently the arts college was really the college of philosophy and the terms were used interchangeably. St. Ignatius "used the terms arts or liberal arts as the name of the branches taught by his higher faculty of arts: logic, physics, metaphysics, moral philosophy and mathematics. He prescribed the doctrine of Aristotle to be taught in these branches. He placed Latin, Greek, Hebrew and other languages under the faculty of language and named them *litterae humaniores*; later on he put rhetoric, poetry and history under the same head." The faculty of languages or lower arts was to be completed by 14 years of age; the higher arts or philosophy then began.

It is therefore difficult to see how modern advocates of the liberal arts college avoid equivocation when they seek to exclude science from the arts curriculum. If the term is used in St. Ignatius' sense, the arts were the entire philosophical or scientific courses then known. If the arts are equated to the Quadrivium, they are the elementary science as has been indicated. Elimination of science from the liberal arts college leaves little more to be studied than what was formerly assigned to children under 14 years of age.

PART IV: Problems

Several objections suggest themselves.

- a) Granted that this is the Thomistic position, can it be represented as traditional?
- b) Other subjects such as language, history and literature which were not considered by Aristotle and St. Thomas have lately assumed great importance and must be included.
- c) Catholic liberal arts colleges do not exclude science as it is an alternate name for philosophy but only modern sciences.
- d) It is neither possible nor desirable to study the numerous modern sciences.

(a)

Since the solid doctrine of St. Thomas Aquinas was adopted by his brother Dominicans soon after his death and has been championed to this day, it is evident that the Thomistic position would have authority wherever Dominicans taught. The influence

of the Friars Preachers prior to the Reformation, is universally acknowledged. Even in the late 15th century when nominalism was tilling the dark soil from which sprang Luther, the Dominicans preserved the tradition of St. Thomas. Its fecundity may be judged by the impact that such men as Cardinal Cajetan, Luis of Granada and Bartolome de Las Casas had on their age.²⁵

After the Reformation, the traditions which influenced Catholic education can be considered most quickly by examining the position of the Society of Jesus.²⁶ For the Jesuits are important not merely for their personal contribution to education, but also because of the influence they exerted upon numerous religious congregations which were modeled upon their Constitutions.

This task has been greatly facilitated by the recent work of Father Ganss, S.J., the Director of the Department of Classics at Marquette University, entitled "St. Ignatius' Idea of a Jesuit University."²⁷ Father Ganss recalls that St. Ignatius "had the Dominicans of the Convent of the Rue Saint Jacques as his teacher in theology. . . . The eighteen months of theological study are without doubt the origin of the strong preference for St. Thomas which Ignatius showed later on when he organized the studies of his universities and wrote his Constitutions on education. . . . What he prescribed was a sequence of theological courses lasting throughout four years with St. Thomas Aquinas' *Summa Theologiae* as the chief textbook. . . . (Ignatius made) Aristotelian *philosophy* the main constituent of the entire program of *arts* in the universities he was to found." In a revealing comment on the humanist movement of his age St. Ignatius wrote that "for ourselves the theology itself would be enough without so much of Cicero and Demosthenes."²⁸ St. Ignatius served his age in the accents it cherished but he always preserved scientific knowledge in his curriculum.

The Thomistic tradition lingered on in the countries separated by heresy from its chief proponent, the Catholic Church. Inevitably, the tradition declined in these countries although it occasionally experienced a brief renewal, as in Newman's Oxford.²⁹ But the general trend in England and Germany ran counter to science. It is then unfortunate that these two countries greatly influenced the vast expansion of educational agencies in the United States throughout the 19th century; the traditions that were active among the Founding Fathers deteriorated and surrendered to this counter scientific trend. Thus, a predomi-

nantly literary education emerged in the United States at the very time that England and Germany moved to scientific education.³⁰

(b)

Aristotle and St. Thomas did not number language, literature and history among the subjects for adult students. Yet they were neither ignorant of such matters nor scornful of their value. Aristotle composed literary works that drew high praise and close imitation from Cicero; his *Poetics* remain the cornerstone of dramatic theory and aesthetics; his *Rhetoric* was copied by Quintillian and Cicero.³¹ The writings of the historians were familiar to him and he personally conducted research into history as even a cursory reading of the *Politics* and the *Constitutions* of Athens reveals. St. Thomas possessed poetic gifts of a high order as the Eucharistic hymns he composed indicate. His knowledge of classical drama was subject to the limitation of the age in which he lived; further, the specialized purpose of his writings precluded a display of literary and historical erudition. But his accomplishments in these fields may be inferred when in his *Summa Theologiae* alone he draws upon Terence, Virgil, Horace, Ovid, Livy, Caesar, Sallust and Josephus as necessity demands.³² His knowledge of the Roman moralists, the Greek and Latin Fathers is very well attested.

Evidently, it cannot be prejudice that caused Aristotle and St. Thomas to omit listing these subjects for adult students. More likely they understood the nature of these subjects and so placed them among those that are studied before a student is capable of scientific pursuits. Perhaps they applied St. Augustine's dictum that some subjects should be learned at a youthful age and quickly or not at all.³³ The Stagirite would soften the last phrase, encouraging the pursuit of these matters for recreation. His view is in accord with common experience, for most educated men *do* choose literary or historical works for relaxation; rarely are scientific works read in recreational periods even by the greatest scientists: Einstein played the violin, Von Braun listens to chamber music, etc. This suggests that colleges should teach men those subjects in which self-education is so difficult that it is never attempted in later life and touch lightly those in which self-instruction is evidently undertaken.

The following considerations attempt to indicate the noetic status of language, literature and history according to the opinion of Aristotle and St. Thomas. Some recent opinions on these

matters are analyzed because they support college curricula that are at variance with the traditional theory.

1.

The practice of learning one's native language in school seems so obvious that there would appear no point in mentioning it. Indeed, Aristotle presupposed it for his rhetoric. Yet the language of the classroom has not always been that of the fatherland: true to a degree in the Rome of Cicero when Greek was spoken in the schools, this was truer still as the national languages emerged out of Latin in the middle ages. As late as St. Ignatius' era, boys of 5 to 9 years of age studied Latin but not their native tongue.³⁴ There was no subtle reason behind this: Father Ganss notes "Latin had the same function which is today possessed by English in American elementary, secondary and even lower university education."³⁵

With the demise of Latin and Greek as classroom languages, the native tongue was taught from the earliest grades. Yet the foreign languages were still begun early: Newman studied both Greek and Latin before he was nine, the mathematician Bertrand Russell understood German and French at ten, kept a diary in Greek before he was 14 years old.³⁶ Elements of this tradition continue to the present. Foreign languages are ordinarily begun in European schools before the student is 11 years old, Russian students start in the 5th grade.³⁷ There are sound reasons why this practice became traditional and has remained so. Modern psychology has indicated the extraordinary aptitude children enjoy in assimilating languages. The classic examples are "English youngsters born in India who learn not only one vernacular but speak with every native servant in whatever happens to be his dialect."³⁸ Linguists insist that students beyond 14 years of age have great difficulty in learning the pronunciation and therefore will seldom speak that language correctly. Since American students ordinarily begin foreign languages in the 9th grade at 14 years of age, the results of such instruction can be safely predicted and are disappointingly accurate. A late start in languages has other repercussions: it crowds the curriculum at a time when the student is becoming capable of the easier sciences.

The inception of foreign languages in the American college is even more subject to these criticisms. It also occasions others. Devoting attention to a language at this late stage might suggest to a beginner that knowledge of languages is the ideal of educa-

tion. Fluency in several languages is a highly useful intellectual asset, yet it cannot be seriously proposed as the ultimate object of the human intellect nor of education. English, French and German students each of whom understand the proofs for the existence of God in his native tongue know precisely the same doctrine. If one can read the proofs in another language, he has not increased his knowledge at all. In brief, if education concerns reality and not words or sounds, languages should be studied at a youthful age when they can be learned quickly and do not interfere with more important matters.

While the study of languages should be promoted, it should not be advocated for false reasons. Father Ganss cites a common fallacy: "the teachers of Latin, in their efforts to defend its place in the curriculum, pointed to it as an effective means of imparting mental training. Their effort greatly promoted the disciplinary theory of education which held that the important thing in education is not what is learned but the shaping of the mind in the process of learning. The theory vaguely implies that the pupil will somehow acquire the wide knowledge or content of his education after graduation. This theory found perhaps its clearest and most influential expression through John Locke and Christian Wolff. Especially during the 19th century, Catholic educators in America drew heavily from this theory in formulating their philosophy of education. . . . In spite of all that the defenders of Latin have said, the populace at large has remained convinced that the training of mind it wants can also be procured with greater ease and efficiency, through other subjects such as mathematics, modern languages or sciences. As we shall see, the most recent scientific experiments of the psychologists have confirmed this opinion. The populace at large has also persisted in its opinion that cultural content, including literary form, can be obtained from subjects treated in the vernacular."³⁹

2.

Rhetoric held an important place in the traditional plan for early education. In learning the forensic art, speeches delivered by famous orators or drawn from the dramatists were used to great advantage, as Aristotle's *Rhetoric* attests.⁴⁰ In time, the declamation and imitation of classical pieces naturally expanded to include a study of particular authors. In St. Ignatius' program, students each year from their 10th to 14th year read one poet and one prose stylist whose writings were carefully selected and

edited if good taste demanded it.⁴¹ All this is in accord with Aristotle's principles. He had stated concerning painting (and it is therefore applicable to the other representational arts, namely, music, sculpture, drama and poetry) that "young men should be taught to look not at the work of Pauson (who pictured men as worse than they are, i.e., depraved) but at those of Polygnotes or any other painter or sculptor who expresses moral ideas."⁴² Interestingly enough, this pagan levies demands in art at which our age balks "the director of education should be careful what stories or tales children hear." Further, "since indecency of speech leads soon to shameful actions, the young especially should not be allowed to repeat or hear anything of the sort. . . . And since we do not allow improper language, clearly we should also banish pictures or speeches from the stage which are indecent. . . . The legislator should not allow youths to be spectators of (immoral) comedy until they are of an age to sit at public tables and to drink strong wine; by that time education will have armed them against the evil influence of such representations."⁴³

Concerning music, and by analogy the other representational arts, the Stagirite observes that its "study is suited to the stage of youth, for young persons will not, if they help, endure anything which is not sweetened by pleasure and music has a natural sweetness."⁴⁴

Aristotle's full opinion on the educational position of the representational arts can now be seen. All representations have a recreational value; they also "have some influence on man's character."⁴⁵ Stories, books and paintings are carefully screened and then used to engender sound moral opinion in the young. As children mature, the representational arts are removed gradually from the school curriculum; they increasingly become extra-curricula activities. They are replaced by the moral and physical sciences which the educated adult will bring to bear on his entire life, including his recreation: he is "armed against the evil influences of (immoral) representations" and capable of appreciating the good imitations of art. Thus, it is enough for Aristotle that adult students have the opportunity to hear concerts, visit museums, see plays and read the poets in their leisure. For adults, unlike children, are expected to direct their activities to other ends than relaxation; their moral character is supposed to be more or less determined; finally they are expected to have certitude rather than opinion in matters where certitude is possible for them. All this does not have the love of science as its motive,

but the love of man. If man is capable of achieving moral science and does not do so, it is always possible that stronger impressions will impinge upon his untutored sensibilities, dissuading him from his former opinions. Moral science requires a certain familiarity with natural science and psychology; the first step to these sciences is mathematics.⁴⁶

3.

Since Aristotle held that literature is more philosophical than history, his opinion on the latter's educational importance for adults may be easily inferred.⁴⁷ Since it is a commonplace statement that history is a science, it seems that the Stagirite's opinion is incorrect.

In his standard work "Guide to Historical Method," Father Garaghan, S.J., states:

History . . . (includes) not only the reporting of particular facts, but also interpretation and generalization on them. The general truths which history can formulate are of two kinds: those not restricted to place and those thus restricted. Examples of the first kind are: Material prosperity tends to beget moral decay; extreme governmental repression provokes rebellion. An instance of the second kind is the statement that the Romans were skillful administrators. It is within the province of history to establish and state such generalizations. In fact, it is mainly from such broad, comprehensive truths that history derives whatever practical utility it has.⁴⁸

Christopher Dawson uses slightly different terminology but he repeats much of this and makes a valuable addition.

"What (the pure historian) wants to know is what actually happened at a particular time and place and what effect it had on the immediate future. Nevertheless, one must admit that if history had been left to these pure historians, it would never have attained the position it holds in the modern world. It was only when history entered into relations with philosophy and produced the new types of philosophical historians . . . that it became one of the great formative elements in modern thought. . . . The academic historian is right in insisting on the importance of the techniques of criticism and research. But the mastery of these techniques will not produce great history. For this something more is necessary—intuitive understanding, creative imagination and finally a universal vision transcending the relative limitations of the particular field of historical study . . . partaking more of the nature of religious contemplation than of scientific generalization."⁴⁹

There are then three elements: the facts, the generalization based on these facts and the unity given the whole study. Daw-

son leaves no doubt of their relative value: he praises Gibbon for the "supreme architectonic power with which he disposes of his vast material and creates out of the shapeless mass an ordered and intelligible whole."⁵⁰

The triangle drawn by Euclid when he proved that the angles of a triangle total 180 degrees has disappeared, so has Euclid. But there is this difference between the geometrical and historical singular: a new triangle can be drawn and its properties shown. Conclusions about Euclid himself must depend on the testimony of others. About geometrical conclusions there is certitude; the conclusions about Euclid are not held with certitude: the fear that new evidence may overthrow the credibility of present data always exists. History produces opinion, science gives certitude: Dawson observes that "each age makes its own past";⁵¹ each age does not make its own Euclidean geometry.

The kind of general truths not restricted to time and place which history produces seem to be identical with conclusions reached in Ethics and Politics. The corrupting power of money can be gleaned from reading the morning papers, from considering the action of men clad in gray flannel suits, from introspection, even from reading Shaw's *Major Barbara*. Revolutions against oppressive governments are a commonplace in the past decade. If it is from truths like this that history derives its utility, Aristotle was well informed of its worth.

The second kind of general truth has historical elements. It is a conclusion and must be the product of a syllogism. The minor premiss is obviously that "the Romans did actions A, B, C and D. The major is that "all who do actions A, B, C and D are skillful administrators." It is true that history establishes the minor; but the major premiss is formulated with no more recourse to history than the truth that "material prosperity begets moral decay." This merely indicates that every historian must be learned in moral and political sciences. If he is not, then holding the major premiss of such general truths by opinion only, the historian cannot have certitude concerning his conclusion. The example of the Romans' administrative skill is a very easy conclusion to draw because the major premiss is readily obtained from induction. But an historical truth such as "the Greeks reached the high point in philosophy" shows more clearly the necessity for science. The major premiss involved would be "all who demonstrate the existence of a First Cause and the immortality of the human soul have achieved the high point in philoso-

phy." Such would involve a thorough grasp of physics, psychology and metaphysics.

The citation from Dawson underlines the need history has of science. If it bases its universal vision on opinion, it is apt to err. This is precisely the fault that Dawson uncovers in Toynbee, Spengler, Gibbon and Wells.⁵² Further, some have doubted whether the knowledge Dawson describes is possible for man: it seems to resemble the knowledge of Divine Providence which God has reserved for Himself.⁵³ Thus, since history has need of science, it is upon the latter that the college curriculum should be based.

(c)

Catholic colleges have steadfastly maintained philosophy in the curriculum in the face of pressure exerted by other interests. But the question is whether the inclusion of modern science demands the exclusion of philosophy. Again, since the subject matter of some modern sciences seems the same as some parts of philosophy, should a parallel set of courses be established. To raise these questions is to raise the problem of the relation between Aristotelian and modern sciences. This has been debated elsewhere at great length.⁵⁴ The following considerations indicate the direction of such discussions.

A conclusion of Aristotelian science that St. Thomas cites as certain is the rotundity of the planet on which we live.⁵⁵ The Stagirite provided several proofs for this.⁵⁶ Two of them can be described briefly. When the earth interposes itself between the sun and the moon (which is illumined by the sun), the shadow that is cast on the moon is always circular. Again, some constellations visible in Greece, gradually slip over the horizon on successive nights as one journeys to Egypt. Since only the surface of the earth itself could interfere with the line of sight to the stars, and the constellations *gradually* disappeared from view, the earth's surface must be nearly spherical. A modern observer could repeat Aristotle's proofs in a more sophisticated way. He could notice the appearance of the Southern Cross in the night sky as he flew from Canada to Chile; he could check the visual images transmitted from a satellite orbiting 2000 miles above the earth's surface for indications of curvature. While seated before a television set in Florida and viewing an outdoor program originating from California, he could notice the shadow cast by a flagpole there differs from the shadow now being cast by a vertical object in his backyard. This difference could only be ascribed to a different

angle of incidence of the sun's rays, therefore the surface of the earth is curved. Other means devised since Aristotle's time prove the same conclusion.

It seems clear that if such demonstrations were included in the astronomy of the liberal arts college of the past, newer proofs should not be absent from their modern equivalent. Further, just as the course based on Ptolemy's *Almagest* contained much data that could not provide a certain conclusion,⁵⁷ modern data that are presently unproductive of certitude should not be excluded from the curriculum of the liberal arts.

(d)

It is true that sciences such as minerology and geology, are of little importance for general education. Still, caution should be exercised in excluding individual sciences, for as Aristotle notes about the lower biological species,

if some have no graces to charm the sense, yet even these, by disclosing to intellectual perception the artistic spirit that designed them, give immense pleasure to all who can trace the links of causation . . . it would be strange if mimic representations of them were attractive, because they disclose the mimetic skill of the painter or sculpture, and the original realities themselves were not more interesting, to all at any rate who have eyes to discern the reasons that determined their formation."⁵⁸

The necessity and hence desirability of every student pursuing moral science has already been indicated. Since this entails a study of natural science (particularly psychology) and logic (the instrument of all science), these subjects are also desirable for general education.

The multiplicity of the other physical sciences can be reduced to order in another way. The Stagirite has provided the key:

Every systematic science, the humblest and the noblest alike, seem to admit of two distinct kinds of proficiency; one of which may properly be called scientific knowledge of the subject, while the other is a kind of educational acquaintance with it. For an educated man should be able to form a fair off-hand judgement as to the goodness or badness of the method used by a professor in his exposition. To be educated is in fact to be able to do this.⁵⁹

Thus, for students who do not intend to specialize in chemistry or physics, an educational acquaintance with them suffices; the chemist and physicist must, of course, search for all demonstrations in his field, even those that seem jejune, since certain knowledge is never unimportant.⁶⁰

The education acquaintance that the general student desires can be most easily obtained through study of mathematics. For example, a single differential equation finds analogous application in Newton's mechanics, in the theory of sound and in Maxwell's electromagnetic equations. Statistics forms the chief tool of the molecular distribution laws of Boltzman. It is also highly useful in sociology, psychology and biology as well as in commercial subjects. The non-Euclidean geometries are the key to Einstein's relativity theory and the astronomy of Hoyle and Gammow. Boolean algebra finds application in modern logic as well as in the electronic computing machines so widely used in commercial enterprises today. Careful selection among these and other topics would thus bring the general student up to date in a vast number of disciplines: he would be equipped to form a fair judgment on the methods of science in the age in which he is living. Evidently it would promote the unity of communication so sorely needed by the complex commercial, cultural and scientific ventures which are so common today.

PART V: Applications

While there are several current movements in education that are not unlike certain aspects of the medieval arts program, there is only one that is a conscious attempt to organize the entire school program along the lines of the Thomistic theory indicated in Part III.

Most of the agitation concerns the elementary and high schools.⁶¹ The Council for Basic Education favors a return to solid intellectual disciplines like history, literature, mathematics and languages in place of the social adjustment education that has spawned such courses as co-ed cooking and marketing for the home. The Council's recommendations are remarkably like the Quadrivium. Some attempts are underway to reorganize the mathematics of the high school. The formula of algebra, geometry, trigonometry and solid geometry is several centuries behind modern developments. It seems possible to regroup the matter in accord with later theories and to insert more recent discoveries. On the collegiate level, Dartmouth University has thoroughly revised its basic mathematics in the freshman and sophomore years. The Massachusetts Institute of Technology has undertaken a complete study of the physical and mathematical sciences offered in all levels of schooling. It has prepared a series of texts that incorporate elements of Einstein's relativity theory

in the high school course; it has also devised a series of laboratory experiments that illustrate basic physical laws without requiring expensive laboratory equipment. Early admissions to college have been tried under a Ford Foundation grant over a six year period in twelve colleges with gratifying results. On the other end of the academic scale, youthful initiation to language studies has underlined the wisdom of past ages.

But few of these agencies try to completely renovate the entire curriculum; none of them take a stand about the possibility of certitude in man's knowledge of the world and of himself. This is termed an "epistemological problem" and left to philosophers who, in turn, are left to themselves. The Xavier Plan for Liberal Education tackles both.⁶² Years before Americans became conscious of the Russian 10 year school, the Religious Sisters of Mercy and the Dominican Fathers of the Albertus Magnus Lyceum advanced their own 10 year school: 6 years devoted to subjects analogous to the Trivium, 4 years for studies similar to the Quadrivium. Students enter college at 16 years of age and, without omitting study of non-scientific disciplines, they seek demonstrative knowledge in an integrated series of natural sciences. Theology is the crown of the Xavier plan, drawing upon the student's previously acquired science to increase his knowledge of what Almighty God has gratuitously revealed of Himself and His Providence over creatures. It is of course true that persons innocent of learning know through God's Revelation truths that the keenest minds could not attain unaided, but students by their vocation are called to an orderly study of reality and may not leave aside any of the tools fashioned by the labors of centuries to assist their inquiry.

¹ Cited in "Education in Review," New York Times, Sunday, November 17, 1957.

² Cited in "Sports Illustrated Magazine," February 27, 1958, p. 27.

³ E. Harris Harbison, "Liberal Education and Christian Education," *The Christian Idea of Education* ed. Edmund Fuller. (New Haven: Yale University Press, 1957) p. 66. See also Jacques Maritain, *On Some Typical Aspects of Christian Education*, *ibid.*, p. 182, 192.

⁴ W. W. Sawyer, *Prelude to Mathematics*, (Baltimore: Penguin Books, 1955), p. 29, 61, 63.

⁵ A Dwight Culler, *The Imperial Intellect: A Study of Newman's Education Ideal*, (New Haven: Yale University Press, 1955) p. 16; 80.

⁶ *Ibid.*, p. 16.

⁷ *Ibid.*, p. 2.

⁸ *Ibid.*, p. 116, 80.

⁹ Cf. The Harvard Report, *General Education in a Free Society* (Cam-

bridge: Harvard University Press, 1945): "We think it would be serving no good purpose to require every student to take a course in philosophy," p. 209. The relation of philosophy and the liberal arts will be evident in Part III. The attitude of Ivy league colleges has perhaps altered somewhat in the past decade, but that of state colleges has not significantly changed in this regard.

¹⁰ Protagoras, the Sophist and the Republic Bks. II, III, VI, VII. See A. E. Taylor, *Plato, the Man And His Work*, (London: Methuen, 1952, 6th ed.) on these dialogues. Also John Wild *Plato's Theory of Man*, (Cambridge: Harvard University Press, 1946) especially chapters 2, 5, 7.

¹¹ *Rashdall's Medieval Universities*, I. p. 318, ed. Powicke and Emden, (London: Oxford University Press, 1936) George E. Ganss, S.J., *Saint Ignatius Idea of a Jesuit University*, (Milwaukee: Marquette University Press, 1954) p. 11, 50.

¹² Angelus Walz, O.P., *Saint Thomas Aquinas*, (Westminster: Newman Press, 1951) p. 21, 42, 53, 57, 124.

¹³ Ganss, S.J., p. 11, 50.

¹⁴ James J. Walsh, *Education of the Founding Fathers of the Republic*, (New York: Fordham University Press, 1935) p. 15, 20, 65, 101, 175, 331.

¹⁵ Igino Giordani, *Pius X*, (Milwaukee: Bruce Publishing Company, 1954) p. 7, 11. Hieronymo Dal-Gal, *Pius X*, (Westminster: Newman Press, 1954) p. 10, 11.

¹⁶ "Tres sunt partes philosophiae theoricæ, subicet mathematica, physica et theologica" (Comment. in Metaph. VI, L.1; also Comm. Phys. L.1, 1.) Quoted by Pierre Conway, O.P., and George Friel, O.P., in "Farewell Philosophy." *New Scholasticism*, October, 1950, p. 368. The authors state "For them [Aristotle and St. Thomas] philosophy and science are simply two different names for the same thing." *Ibid*.

This tradition remained until Newton's time as the title of his great work indicates. Also, Cardinal Newman frequently used the terms interchangeably. See John Henry Cardinal Newman, *The Idea of a University* (ed. Charles Harold) (New York: Longman, Green and Company 1947) p. 260, 264, 313, 318, 381, 382, etc.

¹⁷ *The Basic Works of Aristotle* ed. Richard McKeon, (New York: Random House, 1941). Nicomachean Ethics Books VI, ch. 3, 6, 1139 b. 14—35; 1140 b. 31—1141 a. 6. Hereafter all citations of Aristotle will be taken from this volume (unless otherwise indicated). Only the Bekker pagination will be given. The commentaries of St. Thomas Aquinas on Aristotle will not be indicated but perusing them on the passages cited from Aristotle is of great assistance in understanding the Stagirate's cryptic sentences.

¹⁸ *Ibid.*, 1142 a 12; 995, 2, 12.

¹⁹ H. I. Marrou, *A History of Education in Antiquity*, (New York: Sheed and Ward, 1956) p. 182. Rashdall 1, 441, 444, 462; III, 352.

²⁰ "Summa Theologica Sancti Thomae Aquinatis, Ia, q. 1, A. 2 corp. "music proceeds from principles known through arithmetic." Marrou, *op. cit.*, p. 181. James V. Mullaney, "Liberal Arts in the Aristotelian-Thomist Scheme of Knowledge," *The Thomist*, Oct. 1956, p. 483.

²¹ Marrou, *ibid.*, p. 177. Mullaney, *ibid.*, 496.

²² *Summa Theol.*, I, q. 1, A. 1, A. 2. Also cf., f.n., 56.

²³ *Arist.*, *op. cit.*, 1354a 1; 1355a 5. Also St. Thomas Aquinas *Comm. in Post. An.*, L. I., n 6.

²⁴ Ganss, *op. cit.*, p. 58.

²⁵ For Cardinal Cajetan see Philip Hughes *"A Popular History of the Reformation"*, (New York: Hanover House, 1957) p. 121-2. For Luis of Granada see "Introduction" to *Summa of the Christian Life*, Vol. I, trans. Jordan Aumann, O.P. (St. Louis: Herder, 1954. For Las Casas see Lewis Hanke, *Bartolome De Las Casas*, (Philadelphia: University of Pennsylvania Press, 1952).

²⁶ Quickly but not, of course, completely: Scores of new groups such as the Brothers of the Christian Schools have exerted great influence, older institutes have not ceased functioning, e.g. the Dominican University of Saint Thomas at Manila, P. I., founded in the 16th century and still flourishing.

²⁷ See f.n., 13.

²⁸ Ganss, *op. cit.*, p. 12-17; 157.

²⁹ Archbishop Whately was the center of Oxford's Aristotleanism in Newman's era. Even John Stuart Mill acknowledges Whately's ability (*System of Logic*, Introduction to 3rd edition). An inspiring teacher, Whately taught Newman logic and accepted his student's assistance in preparing a text in that subject. (Culler *op. cit.* p. 384) Also see Victor Lyle Dowdell, *Aristotle and Angelican Religious Thought*, (Ithaca: Cornell University Press, 1942) ps. 27-84.

³⁰ Culler, *ibid.*, p. 99.

³¹ Cicero cited Aristotle as a "flumen orationis aureum" (Acad. 2, 38, 119), Quintilian was equally liberal "eloquendi suavitas" (Inst. 10, 1, 83). These referred to Aristotle's (lost) Dialogues. One of them—the Protrepticus—was the model for the Hortensius of Cicero which so moved St. Augustine (Conf. Bk. III, ch. IV). *"The Works of Aristotle"*, Vol. XII Select Fragments ed. David Ross, (Oxford: Clarendon Press, 1952) p. 1-5; 27-56. Also Sir David Ross *Aristotle* 5th ed. (London: Methuen, 1949) ch. 1, IX.

³² *Omnia Opera Sancti Thomae Aquinatis* ed. Leonis XIII, Tomus XVI (Rome, 1948) p. 207, 217, 219, 223, 225, 226.

³³ De Doctrina Christina, L, IV. c. 3.

³⁴ Ganss, *op. cit.*, p. 48.

³⁵ Ganss, *ibid.*, p. 49, 163.

³⁶ Bertrand Russell, *Education and the Good Life*, (New York: Boni and Liveieglit, 1926), p. 273. *The Philosophy of Bertrand Russell* ed. Paul A. Schlipp (Evanston: Northwestern University, 1944) p. 8. For Newman see Culler p. 2.

³⁷ George S. Counts, *Challenge of Soviet Education*, (New York: McGraw Company, 1957) p. 77.

³⁸ Susanne K. Langer, *Philosophy in a New Key*, (New York: Pelican Books, 1948) p. 99.

³⁹ Ganss, *op. cit.*, 219.

⁴⁰ Aristotle, *op. cit.*, 1397b1, 1398b1, 1400b5.

⁴¹ Ganss, *op. cit.*, p. 58.

⁴² Aristotle, *op. cit.*, 1340a36, 1449a5.

⁴³ *Ibid.*, 1336a30—b24.

⁴⁴ *Ibid.*, 1340b15.

⁴⁵ *Ibid.*, 1340a6.

⁴⁶ *Ibid.*, 1139a1-35, 1142a15, 1025b18—1026a30.

⁴⁷ *Ibid.*, 1451b5.

⁴⁸ Gilbert Garraghan, S.J., *A Guide to Historical Method* (New York: Fordham University Press, 1946) p. 39.

⁴⁹ Christopher Dawson, *Dynamics of World History* ed. John J. Mulloy (New York: Sheed and Ward, 1956) p. 287-8.

⁵⁰ Dawson, *ibid.*, p. 332, 394.

⁵¹ Dawson, *ibid.*, p. 352.

⁵² Dawson, *ibid.*, ps. 400; 376, 378, 381; 346; 367; 466.

⁵³ Francis Kearney, O.F.M. "On Cassirer's Conception of Art and History," *Laval Theologique et Philosophique*, 1945. ps. 145-149. Also Charles De Koninck "The Nature of Man and His Historical Being," *Laval Theologique et Philosophique*, 1949, p. 277.

⁵⁴ Benedict Ashley "The Role of Philosophy of Nature in Catholic Liberal Education," *Proceedings of American Catholic Philosophical Association*, 1956. p. 62-80. Conway and Friel, *op. cit.*

⁵⁵ *Summa Theol.*, I, q. 1, A 1, Ad 2, I, 1, 1, 2um.

⁵⁶ Arist. *op. cit.*, 297b20. William A. Wallace, O.P. "Some Demonstrations in the Philosophy of Nature," *Thomist Reader*, 1957, p. 99, 105.

⁵⁷ *Summa Theol.*, I, q. 32, A 2, Ad 2.

⁵⁸ Aristotle, *op. cit.*, 645a8.

⁵⁹ *Ibid.*, 639a1.

⁶⁰ Wallace, *op. cit.*, p. 114.

⁶¹ Since the elements mentioned here are easily verified by consulting current literature, it seems sufficient to group them under this single citation. Council of Basic Education, *The Bulletin*. Walter C. Michels, "The Teaching of Elementary Physics," *Scientific American*, April 1958. E. P. Rosenbaum, "The Teaching of Elementary Mathematics," *Scientific American*, May 1958. Sister Mary Gabriel Phelan, S.S.J., "A Classroom Teacher Looks at Televised Instruction," *Bulletin of the National Catholic Educational Association*, February 1958. Dartmouth Alumni Magazine, October 1956, October 1957.

⁶² Benedict Ashley, O.P., "Sacred Doctrine and Natural Science," *Proceedings of Society of Catholic College Teachers of Sacred Doctrine*, 1957. p. 24-28, 47-57. For a more detailed account of Xavier plan see Ashley *op. cit.* p. 80-85. This also contains a general bibliography of the Xavier Plan (p. 81) until 1956. See "The Saint Xavier Plan," by John Burke, O.P., in this issue.



Scientific progress cannot, as such, disturb the believer, who rather takes pleasure in serving it and who hails in every discovery a shining manifestation of the wisdom and grandeur of the Creator (PIUS XII).