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NOTICE TO AUTHORS

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Manuscripts of NEWS ITEMS should be sent to the NEWS EDITOR: Rev. Bernard M. Scully, S.J., Boston College, Chestnut Hill, Mass.

THE DEVELOPMENT OF PHYSICAL IDEAS FROM ARISTOTLE TO NEWTON

Francis X. Quinn, S.J.

One of the most technically involved riddles in the history of human thought, one which baffled men's minds for almost twenty-three centuries, is the problem of motion. It was a riddle which was never quite disposed of by the penetrating minds of Copernicus, Kepler or Galileo. It is the history of this involved riddle—this problem of motion—which will help us to sketch briefly the disintegration of Aristotelian physics and to point out the development of the new synthesis of scientific thought under Sir Isaac Newton. This paper, therefore, is divided into three parts: the Aristotelian concept of physics—especially with respect to its basic idea of motion, the gradual disintegration of this concept and the contribution of Newton to physical scientific thought.

It was in the old Ionian tradition of research *de rerum natura* that Aristotle, his colleagues and his disciples devoted their time to the discussion of physical questions. Aristotle divided the physical world into two essentially different parts: the part above and the part below the moon. Above the moon movements were regarded as perfectly simple, regular, eternal, and therefore circular. Below the moon movements were considered compulsory and violent whenever they contradicted the ordinary tendency of what we call gravity. Such unnatural motion depended on the operation of a Mover.

To understand more completely this sublunar world of Aristotle's we must consider more closely his astronomy—his supra-lunar world. To the Peripatetic astronomer, all but seven of the heavenly bodies seemed to move daily from east to west. The seven planets, clearly visible to the naked eye, appeared to move in periods of unequal length from west to east. The scientific astronomical observations of Eudoxus and Callipus gave rise to the opinion that these seven planets (including the moon and the sun) were imbedded in the crystalline shell of a hollow sphere while the pivotal point for all concentric hollow spheres was the Earth.

The region around the Earth was divided into four levels; each level being the natural habitat of one of the four elements: earth, water, air and fire. These four elements are precipitated up and down to their proper place. If they are moved from their *ecological niche* they tend to return to it in a straight line. Earth and water were supposed to be heavier and therefore move downward. The elements of air and fire were exactly the reverse and moved upward. When an apple fell to the earth it was supposed that something within it made it aspire to move downward.

The material energy required for these sublunar movements was transmitted ultimately from the outermost heavenly sphere—from the *Primum Mobile* down through the network of concentric minor spheres —to the Earth. The Primum Mobile receives its movement from a Being that transcends the physical universe and is immaterial. This is the Prime Mover, thought of thought, who moves without in any way being moved. Thus the description of the origin of movement is synonymous with the gradations of existence ascending from the first formless matter to the *Primum Movens*. This fourfold intermingling of the elements made for a lively and negotiable explanation of motion.

The genesis of Aristotle's idea of motion began with his rejection of the concept of vacuum. For Aristotle, motion was inconceivable in emptyness, since such motion would have infinite velocity. When he considered the motion of bodies it was always in a resisting medium. On the basis of observation he concluded that the speed of a body is proportional to the force pushing it and inversely proportional to the resistance of the medium. In other words, velocity is equal to the motive force divided by the resistance. Again, Aristotle observed bodies falling in accelerated motion and attributed this fact to a motive force as well as the fact that the body was nearing its natural level in the universe—its *ecological niche*.

The importance of the idea of motion for Aristotle should be obvious. His Physics is nothing but an inquiry into its nature. Everything that happens does so because of at least one type of motion. So far, we have mentioned but local motion which is the most important and without which other kinds of physical change are impossible. However, all change cannot be reduced to local motion. Bodies act and react in very determined ways and they do so because of very determined principles of activity and rest which are the natures that constitute them what they are. The discovery of the natures of terrestrial bodies added to the knowledge of the heavenly bodies' influence upon them gave Aristotle the explanation he sought of all physical phenomena.

But Aristotle was more than a physicist; he was also a metaphysician. It is an all too common error to say that he confused the two sciences, or to say that his metaphysics must be rejected since his Physics and his concept of motion are found wanting. That the description of what is observed and the attempt to formulate these descriptions quantitatively are procedures quite different from the search for ultimate causes underlying the phenomena, was as clear to Aristotle as it was to Newton. And Aristotle appears to have been more aware than Newton that certain basic metaphysical postulates are assumed in even the simplest scientific descriptions.

The problem of intrinsic change or what is required that intrinsic change be non-contradictory is as important a problem today as it was in the fourth century B. C., when Parmenides' dilemma created a crisis for human reason. To this problem Aristotle the philosopher gave a definitive solution.

Aristotle had been quite successful in dialectical sciences like logic, as well as in biological descriptions and classifications. Why then should he be less successful in combining observation and deduction in physics? Did his essentially qualitative treatment of matter which entailed a cleavage between both natural and unnatural motion as well as between celestial and terrestrial phenomena constitute a barrier to further progress? Can we call it an inaccurate observation which led Aristotle to posit the principle that a constant force produces a uniform velocity? These are questions associated with the deterioration of Aristotelian Physics and the rise of a new science.

With the passage of time the original beauty of the Aristotelian position with its aetherial substances moving perfectly and without friction became less attractive. Astronomy achieved remarkable advances, and in the early Christian era the complications of the Aristotelian system became obvious. Contrary to the traditional system, planets were seen to change course, approach and recede from the Earth, altering their speed. Yet however irregular such motion might appear in the perfect heavens, still celestial behavior must be reduced somehow to uniform circular motion—at least, so they thought. Additions and intricacies were added to the system in order to save it.

But the fact remains that Aristotle's explanation of motion in the universe was accepted for at least another thousand years. Dante's astronomy was essentially that of Aristotle which employed the notion of concentric spheres. Heavenly bodies were not subject to physical laws that govern the sublunar world, nor were they subject to change and corruption. But ordinary matter in the sublunar world was composed of the four elements which made it subject to dissolution and decay. Since Aristotle's astronomy did not account for the newly discovered phenomena, other spheres were added to the system to keep it intact, as for example, the sphere postulated by Dante to explain the course of the planet Venus—in the words of the poet, the sphere on "which Venus sits like a Jewel" reflecting the light of the sun.

The Aristotelian system was modified; concentric spheres up to the number of eight were added to save the theory. Controversies concerning these celestial spheres became more frequent. A number of disturbing and new discoveries agitated the world. In 1572 a new star appeared—one which shone with particular brightness and then disappeared again two years later—a thing which ought to have been impossible since the skies and the heavenly bodies were supposed to be incapable of change, incapable of either generation or corruption. Five years later in 1577, a new comet appeared high in the heavens and it became impossible to maintain credence in the supposition that comets existed only under the moon. The comet was seen to cut a path through that series of crystal spheres which had been supposed to be impenetrable. There was a demand for a general renovation of astronomy which would entail a complete revision of the concept of motion.

In the main there were two major defects in Aristotle's approach to an explanation of the universe: his assumption that there was an essential difference between celestial and terrestrial motion and the conviction that motion is proportioned to motive force and resistance. The latter defect, strange as it might seem, was due to a too close adherence to observation and not to *a priori* considerations. Motion was much more complex than Aristotle imagined and a high degree of abstractness was required to isolate what was essential and to discover the notion of inertia.

As the seventeenth century approached, the minds of men examined and re-examined the different inaccuracies in the system, reconstructing it now this way, now that, but never quite succeeding in a satisfactory arrangement of the parts. Copernicus' revolutionary conception of the Earth as one of the smaller planets of the solar system, the Cartesian doctrine of inertia and Kepler's laws of motion made it necessary to find another reason for the movement of the heavens. Each of these scientists, as well as men like Tycho Brahe and Galileo, grasped a strategic piece in the riddle of motion, but none quite realised that all the elements of a solution were already available.

It was during this period when men were confused by the apparent chaos in the heavens that young Newton began his schooling at Cambridge as Huygens was analysing the pull which a stone exerts when it is swung around on the end of a string.

No great scientist stumbles on his discovery by pure chance. He has been conditioned over a period of time to recognize the value which a given circumstance may offer. So it was with Newton. His ability to synthesize the discoveries of Copernicus, Galileo and Kepler was no chance operation. Newton read, studied and evaluated the work of his predecessors and in 1623 decided to exercise his own physical insights, his mathematical inventiveness and his great experimental and constructive skill. Any one of these qualities in the degree he possessed them would have made him famous. The combination of all of them made him unique. His physical insight led to the successful definition of dynamics and the theory of gravitation. His mathematical inventiveness led to the discovery of integral calculus, essential to the development of dynamics. His experimental and constructive skill led to the creation of optics as an experimental science. As we shall see, the study of optics was his first love and remained his greatest interest until his death.

Newton's scientific method took a geometrical form. He started with definitions and proceeded with both mathematical and experimental proofs to conclusions of greater and greater generality. In the formation of scientific propositions he would always urge economy, uniformity, universal causal explanations and empirical balance. He was always ready at any moment to modify or even scrap the most magnificent extension of his principles should the evidence require it. To entertain the possibility of such a revision shows how deep was the empirical requirement of Newton.

Like most of his contemporaries, Newton was at his wits' end trying to understand the motion of the stars in the complexity of the traditional system. One day as he walked in his orchard . . . We are acquainted with the legend of the falling apple. In any event, for a time Newton's experiments turned skywards from optics. He was led to question whether the force which operates so tangibly here at the Earth's surface might not extend its influence out beyond the Aristotelian barrier into the depths of space. Obviously some force pulls the moon constantly towards the Earth, otherwise that body would fly off at a tangent and never return. He made a calculation to test the moon's attraction to the Earth. He found that the moon's acceleration was in the ratio of the inverse squares of its distance from the center of the Earth. He proved his conclusions with mathematical rigor and then put them in a notebook—this at a time when men were wondering what was the reason for the apparent disorders in the traditional system and would have been extremely interested in Newton's theory of universal gravitation.

Thirteen years later Robert Hooke wrote and asked if he had anything he would like to communicate to the Royal Society. He refused to go in person but could not resist a suggestion for an experiment on the rotation of the Earth. This suggested experiment greatly interested the Royal Society, but unfortunately it contained an error, and Hooke, with evident pleasure, pointed it out publicly. This embarrassment stung Newton into activity, and he returned once more to gravitational problems.

The final stimulus came when Edmund Halley, discoverer of Halley's Comet, made a special visit to Newton to ask a question concerning Kepler's third law of planetary motion. Newton then began to collect his notes on gravity and coordinated them in such a way as to constitute a series of lectures under the title of *De Motu Corporum*. He began by showing that an inverse square law of motion would account for Kepler's laws. Newton presented a harmonious system in which the heavenly bodies all contributed to govern one another in a greater or less degree. The satellites of Jupiter leaned or reacted on one another as well as influencing the planet itself, while Jupiter, in turn, had a still more powerful hold upon them. Crystalline spheres and the lunar borderline disintegrated. Then having established several theorems, he set out to destroy the Aristotelian astronomical conception by extending the notion of gravity to all particles in the universe.

Three years later he published his definitive work on the laws of motion. The *Philosophiae Naturalis Mathematica Principia* which is commonly described as the greatest work in the History of science was the title of his book. It abolished the two thousand year reign of Aristotle's *Physics* and for more than two hundred years formed the basis of all astronomical and cosmological thought. Its stupendous achievement was to show in detail how the same principles of gravitation and the same laws of motion apply to the smallest particles of celestial matter. It explained the consistent irregularities of the celestial bodies as well as the seeming irregularities of tidal movements and wandering comets. It was the work towards which all of Aristotle's physical observations were pointed. Newton, however, insisted on leaving his gravitational discussions and returning to his first love—optics. Thus we meet with the paradox of Newton's scientific career: he was a genius of the first order at something he did not consider to be of the first importance.

History is made rapidly when the great man and his opportunity appear simultaneously. In the case of Aristotle and Newton there is evidence of just such a coincidence. They both were common heirs of important and fruitful developments in the history of science. It was Aristotle's great contribution to give precision to the problems of physics, while to Newton we owe the mathematical application of the concept of inertia to the heavenly planets. He substituted the moon for the stone at the end of Huygen's string and worked out the pull which was necessary to hold the moon on its course.

TOPICAL BIBLIOGRAPHY ON MASS WINES

Rev. William E. Donnelly, S.J.

Items 1 to 64 inclusive of the following contribution have been collected by the late Rev. William E. Donnelly, S.J., formerly Professor of Moral Theology at Alma College of the Province of California. Father Donnelly died suddenly in July 1955. It was through the kindness of Fr. Albert F. McGuinn of Boston College, who had been corresponding with Father Donnelly before the latter's death, that we retrieved this bibliography. We think that it should be published here, since the compilation is a goal that is attractive to many of *ours,* that is undertaken by only few, and that is seldom carried to substantial completion.

Items 42, and 65 to 96, have been inserted by the editor. Items 1 to 58 have been rearranged in more or less chronological order; 59 to 64 did not show dates in the manuscript. It is hoped that additional items will be called to the editor's attention for possible supplementary publication.

Items 65 to 96 comprise a mechanical analysis according to topics that appeared in the titles and in Father Donnelly's annotations to them. They do not pretend to offer an exhaustive index of contents. It is with the kind permission of the Very Reverend Carroll M. O'Sullivan, S.J., Provincial of the Province of California, that this sample of Father Donnelly's legacy can here be published. *Editor.*

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95. Turbidity: items 20, 41.
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THE SCIENCE COURSE IN THE JESUIT HIGH SCHOOL*

JOSEPH D. CIPARICK, S.J.

As a complement to Father Mulligan's presidential address, I thought that some reflections of a more particular nature might be appropriate. These are the thoughts of a neophyte of three years experience, and there are many areas that need development. However, there might be food for thought for both older and younger men in what I have to say.

The science course should be, as was stated in the address, a humanistic course, designed to fit in with the rest of the curriculum. This means that science no less than any other subject should build up the character of the student, and give him a correct outlook as a Christian—and more particularly in the case of leading students, as a Catholic Apostle.

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* During *regency,* Mr. Ciparick was a science instructor at Xavier High School in New York City. His contribution recalls the observations of most of us at this stage of our work, though we may have homogenized his suggestions in the mill of experience. Accordingly this paper is published in the sincere spirit of recollection which it breathes. Mr. Ciparek has contributed to *Demonstration Abstracts* which appears regularly in the *Journal of Chemical Education.*

In general, science is relegated to the *information* section of the curriculum, along with mathematics and perhaps even history. There seems to be less religious value to the science course, outside of a few reflections on the providence of God and the order of the universe. I do not believe that these should be the sole areas of religious application. In fact, they are areas that tend to become rather sentimental (I have a particular Catholic text in mind with the introductory phrase *God in His Providence. . . .*) . Rather, there is the broader area of solid intellectual training that forms one in a realistic way for the practical problems of the Catholic in the pagan world.

The first problem is to convince the student that he has talent and must use that for the greater glory of God. This, after all, is the reason we are teaching him, and we might as well start right off with the principle. The notion of *just learn this* and the complete lack of Christian application seems hypocritical. There must be the conviction on the part of the teacher that these men are going to be primarily apostles, and then men of science. Their science will be the means they will use to gain others to Christ. It will be the best instrument they can use if indeed they are interested in the subject and somewhat proficient in it. Once this foundation has been established, then we can go on into the more practical details of becoming a scientist. Too often these ideas might be taken for granted. Too often also, these ideas are rejected as being too lofty. Well, if they are not our ideals, what are? I have received various answers which I would hesitate to print at present. Be that as it may, these will be the fundamental ideals held here.

The next problem concerns the selection of matter to be studied. For men of greater talent, a concentration on the theory (In Chemistry) rather than on a lot of practical applications seems more profitable. However, the fundamental approach will be through the senses (as is obvious) and through a complete appreciation of the things about us. It seems profitable to take time out in the beginning to show the value of appreciation, and the necessity of observation. The neglect of the common-place is prevalent among the more sophisticated, and we must attract the student to make those child-like observations once more. This observation, appreciation and joy over real simple things is a definite help to any soul. Certainly an appreciation of nature and of things is akin to the joy of the poet, and necessary for real poetical inspiration.

A link between the poetical, religious and scientific observation can be made here in one or two classes, with quotations from say the Ethics of Elfland (Orthodoxy, Chesterton, where he talks of the fatalism of the scientist and the imagination of the poet) and a general exhortation—replete with scientific examples—to look and see!

Since this looking is the beginning of any scientific work, the scientific method either in outline or in practice can be easily presented. All the work with things, and the conclusions we make and the questions we ask, all reflect man's great curiosity, desire to know and power of synthesis. Certainly the insights presented in the great theories of science are akin to the creative work of the artist, and again we can pause to make some comparisons.

All these pauses do not take away from the content of the course. They are a necessary part to the understanding of real science. To appreciate the creative work of a scientific genius one must know science as well as be able to recognize creativity. This ability to recognize is akin to the appreciation of poetry, which is a virtue we certainly want the students to have. To divorce science and poetry seems foolish to begin with, but let us admit that it is either actually done or that the opposite is never really shown as a reality.

There will be plenty of time for the drilling of valences and equations, and these are indeed hard tasks. But even here, a real grasp of the basic theory will make the brute memory a minimum. These are the tools the scientist uses to express his ideas. He must also use language and here we have another important point of integration.

The scientist must communicate, and this communication demands words. The use of words to express ideas, the *eloquentia* of the course, can be taught here as well as in English or Latin. A reading habit can also be encouraged. Assignment of articles from *Scientific American,* for instance, where the technical details are usually clearly presented, will give them practice in scientific reading. If the article is in English, and the terms are explained somewhere in the article, then the student should be able to *translate* so to speak, and get some meaning. He should also be trained to eliminate details he cannot understand at all (such as mathematical equations) and see if he can understand the conclusions. This is not to make him superficial, but to train him in the understanding of the unadorned English rather than the mathematics. That will come in time.

The most stimulating part of the course comes when the imagination is severely taxed in the explanation of theories. Here we progress from the observables to the theoretical, and the transition is rather difficult. It is almost impossible to completely appreciate the atomic theory without a good imagination. Le Compt de Nuoy remarks somewhere that the reason we do not have enough great scientists is because this imagination the great scientist needs is often lost in the years of concern over details, and when the details are mastered, the imagination is dry and theory is lost with it.

This test of going beyond the observable, of trying to picture what goes on in a chemical change is as challenging as trying to imagine the image of the poet or the idea behind the abstract painting. Certainly here we have a great opportunity to stress the study of literature and the appreciation of all things about us in order to keep our imaginations alive.

This effort to keep alive is sometimes more the teacher's than the student's problem! Nevertheless, an effort must be made to prevent the dead grovelling in facts. This is easier to teach, easier to test, and sometimes the collection of facts is even a fascination for several students. I don't think it is the goal of our science course. Facts are necessary, but we must go beyond them.

The final test comes when the theory has been fairly well completed, and the time comes to test the validity of the theories and the methods. Here the science teacher has the supreme opportunity to help form the real intellectual, the real humanist and Christian apostle! In an atmosphere steeped with the results of scientific moralizing, we can well spend several hours on the validity of the scientific method, the application of scientific conclusions to other fields, and the future of the world built on science.

The idea of *law* and the amoral aspect of physical law as applied to 19th century economics is one area for discussion. The relationship between the scientific method and the conclusions of theology causes a great deal of discussion. The *proof* for the existence of God *scientifically* and the frustration one has trying to distinguish between the thinking methods of the scientist and the theologian can all be discussed with the student if the teacher is willing to make the distinctions clear in his own mind, and if he is able to contact the students without talking down to them.

The technological progress and the value of pure knowledge itself also present problems for the boys. Isn't progress inevitable? Why study something that isn't practical? Doesn't science make us happier? These are real questions, and as can be seen, there is material for several lectures in any one question.

Finally, their position as Christian leaders demands that they be technically competent. The enemies of the Church are often the scientists, and their methods of thinking must be known. We need the scientific leaders and competent followers as well to complete this part of the Christianization of the world. They will be respected for their knowledge and achievement. All this is but a means to an end, a means whereby they can bring others to Christ in themselves. These *must* be the ideals of the high school teacher. If we fall short, then we are at least at a higher level than if we propose some lower ideal. At this time of their lives if this is presented as a challenge and not preached to them, they will listen and discuss, they will argue and try to worm their way out of the responsibility, which is a sign of their conviction!

None of these ideas will be accepted if the rest of the course has been sloppy or unscientific. If the course is taught efficiently, from a theoretical point of view, with proper concentration on the appreciation of observables, and a correct evaluation of scientific method, then when the applications are made, they will seem to be logical consequences of the preceding. The mechanistic atom and the atom of quantum theory are different. If the difference in the point of view is not pointed out, the course will be incomplete. The possibility of explaining the origin of life chemically represents the valid work of methodological scientists. To make no application to our own view of life and evolution would be a crime.

It was mentioned once that when some of our boys get into the non-Catholic scientific courses, they are floored by the scientific method and the *refutation* of faith by the use of this method. If they have had no introduction to this in high school then perhaps their loss of faith is the responsibility of their science teacher! They cannot be given a full course in philosophy, but they are intelligent enough to grasp the basic principles, if these are explained and discussed intelligently.

Finally, we have the responsibility to produce the Christian Gentlemen, an apostle and saint and scholar. The appreciation of God's World, the insight into the human mind, the knowledge of creativity, all can be inculcated through the science course which can be technically correct as well as spiritually uplifting.

GRAVIMETRIC EXPERIMENTS IN FRESHMAN CHEMISTRY

Rev. Bernard A. Fiekers, S.J.

The commonest gravimetric experiment, found in the laboratory manuals of general chemistry, deals with the law of definite composition. It appears under a number of titles: the ratio of weights of components, percentage composition, combining or equivalent weights, the formula weight, where atomic weights have to be given, as well as determination of formula. Another such experiment, generally easier to perform, deals with water of hydration, emphasizing the formula of the hydrate and/or the percentage of water present. A few laboratory manuals (1) carry the determination of atomic weight through a pair of experiments, for example: a study of the law of DuLong and Petit, followed by the determination of equivalent weight. But in most procedures the atomic weight is given to the student *gratis* where required.

A few manuals carry the following topics: relative equivalent weights, copper to zinc for example in an EMF displacement series study (2, 3); the law of multiple proportions; and the thermal decomposition of carbonates and chlorates.

The various chemicals used in each specific type of experiment, the diversity of objectives in those generically based on the law of definite composition—one or many of the objectives listed above—, the very differences in title of the experiment and name of the law of (constant) definite composition (proportions)—, all of these add to the confusion of the *green* instructor, or of the experienced one using a new laboratory manual. Accordingly a review or survey of about two dozen laboratory manuals with respect to such gravimetric topics seems to be of sufficient value to be placed on the record here.

A majority of the manuals choose the synthesis of a copper sulfide for illustrating topics related to the law of definite composition. A known weight of copper is heated in sulfur (hood) and the excess of the latter is burned off. The weight of final product is determined. Required objectives are the formula of the sulfide and/or its percentage composition. A few manuals divulge the fact that the product should be cuprous sulfide and not cupric sulfide. Cuprous sulfide and cupric oxide contain approximately the same amount of copper (compare Cu_2S with CuO, recalling that sulfur has twice the atomic weight of oxygen). This observation gives some grounds to the suspicion that excessive roasting of the product would not alter the numerical results.

According to some manuals other metals can be substituted for copper in this experiment: nickel (4, 5, 6); iron (6) (#00 steel wool (8)); and lead (9).

The Holmes manual (10), which carries an unusual number of gravimetric experiments, includes one on the oxidation of magnesium in addition to that on cuprous sulfide already noted. This is also a *classic*, to judge by the number of manuals that carry it. It has certain difficulties, however. Atmospheric nitrogen reacts with magnesium. Magnesium nitride has to be hydrolyzed, entailing more time for the operations of drying and roasting, a real test of a beginner's technique. Further, limited access of air is required to control the reaction so as to prevent the magnesium from taking its oxygen from the porcelain of the crucible. Magnesium is not allowed to glow. Again, care has to be exercised to prevent the magnesium from reducing the gas from the flame and deposit carbon in the crucible to add to the weight of the product.

The direct oxidation of aluminum or silicon might be attractive pedagogically on account of the subscript bearing formulas of the products. But procedures for producing the oxides of these metals, direct or indirect, seem to be impracticable in the academic laboratory.

For the decomposition of oxides, potassium chlorate seems to lead the field. Not a binary compound, decomposition of it provides an apt method. The reaction is performed with (Fe_2O_3)[11], or without catalysis. Complete oxygen content of it is lost, as contrasted with only one-third oxygen content loss in KNO_3, making the latter unsuitable.

In this connection, Sisler and Stewart (12) have an experiment on the indirect analysis of potassium chlorate/perchlorate mixtures in which the student is to devise his own technique to be approved by the instructor (safety!). Scarlett (13) can be cited to show the versatility of decomposition reactions by using a pair of them, potassium chlorate and perchlorate, so that the second one illustrates the law of multiple proportions. Sienko and Plane (1a) however illustrate this law with a single substance, cupric bromide, serially to cuprous bromide and copper. The first step is achieved by thermal decomposition; the second by nitric acid oxidation to cupric oxide followed by reduction with hydrogen to metallic copper. Authors suggest that the law can be deduced without having to weigh the container. Sienko (1b) also has an experiment on the indirect analysis of mixtures of potassium chloride/chlorate. Sorum (11a) gives the reduction of cupric oxide by means of ammonia.

The binary compound, mercuric oxide is decomposed quantitatively according to Sisler and Stewart (12a), who also suggest the decomposition of freshly prepared mercurous oxide in order to extend the application to the law of multiple proportions. Carnog (5a) has the decomposition of mercuric oxide also. Decomposing oxides of heavy metals such as mercury and silver might be expensive unless conducted on the semi-micro scale. Weight differences, due to the loss of oxygen, are small and hence not ideally precise. There could be a hazard from mercury vapor.

More complicated chemical methods abound in the manuals. The oxide of tin is studied (1c, 9a) by treating the metal with nitric acid. Reduction of oxides by hydrogen and ammonia have been mentioned (1a, 11a).

In general there might be some pedagogical advantage in dealing with oxides of metals, rather than their sulfides, chlorides, iodides and the like, because of the direct comparison of equivalent weight to eight grams oxygen standard.

In order to study the weight ratio silver to silver chloride nitric acid is used to dissolve the silver, hydrochloric to precipitate the product and long evaporations are invoked for the procedure (2a, 10a, 14). Holmes (10b) has an interesting synthesis of silver iodide in which a weighed quantity of powdered silver is strewn over excess iodine in a tube. On heating reaction occurs and excess iodine is sublimed. Weight of the final product is taken.

Magnesium carbonate is readily decomposed at moderate temperatures (2b). Calcium carbonate's decomposition requires a much higher temperature (10c). This calls for the use of a Meker type burner with chimney attached.

Barium chloride dihydrate is very popular for the experiment on the dehydration of hydrates (7, 11b, 15). Markham (7) also suggests calcium sulfate hemihydrate; Ray (4a) suggests copper sulfate pentahydrate.

There is a decided tendency in recently published manuals (1, 15, 16) to call for instructors' *unknowns* in quantitative work.

Instructors' manuals thus become a necessary item. Data forms and calculation methods differ from manual to manual.

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DIFFERENTIABLE MANIFOLDS AND DIFFERENTIABLE FUNCTIONS

Andrew P. Whitman, S.J.

The concept of a continuous real-valued function defined over a topological space M is well known. However the treatment of differentiable functions, although equally well-developed for the professional mathematician, is not generally known. The purpose of the paper is to present the definition of a differentiable function.

Difficulties immediately present themselves in the attempt to give a generalized definition of a differentiable function. The classical definition of the derivative of a function at a point is by the limit of the difference quotient. In order for this quotient to make sense, since the numerator is a real number, so also must the denominator be a real number. This implies that the domain of definition of the function must be the real number system, R, or if partial derivatives are considered, M must be a Euclidean n-space, R^n. Certainly this is no generalization of the domain M. Fortunately, however, the definition of a derivative is a local definition. Thus all the structure that is needed on M is that each point possess an open neighborhood which is homeomorphic with an open neighborhood in R^n. With such a structure M becomes known as a topological manifold or a locally Euclidean space. However it follows immediately that M is locally compact, locally connected, locally simply connected, locally second countable, Hausdorf, etc. Thus M is not arbitrary but has a rather specialized structure with many pleasant properties.

With this locally Euclidean structure on M it makes sense to define a function differentiable at a given point. However the existence of a derivative at a point does not insure the existence of a derivative throughout the open Euclidean neighborhood of the point. Counter examples can be given. In order to avoid this pathological case the definition of a C^k differentiable function at a given point implies that it possesses continuous derivatives at all points in an open Euclidean neighborhood of the given point up to some fixed order k. The same is implied if the function possesses continuous derivatives of all orders, in which case the functions are said to be of class C^∞. Since real valued functions are under consideration, this last condition does not imply analyticity. The function $g = \exp -1/x^2$, $x > 0$; $g = 0$, $x \leqslant 0$, is of class C^∞ but it is not analytic at the origin.

However this result still gives only a local definition of a differentiable function. It is desired to expand this definition to the entire manifold M. In order to do this the counterpart of Urysohn's Lemma for continuous functions needs to be constructed for differentiable functions; that is, there exists a function defined over M with values between 0 and 1 which has the value 1 over an arbitrary closed subset of M and a value 0 over another arbitrary closed subset of M and which is of class C^∞ for each point of M. The above function g is used to construct such a function. By the use of such a function it can be shown that if f is a differentiable function defined in an open neighborhood V of a point p in M, then there exists a function h, differentiable at each point of M, which coincides with f in some open neighborhood of p. Thus it is passable to pass from the existence of a differentiable function defined locally to one defined over the entire domain. If real analytic functions were considered, such an extension could not be made.

With this conclusion established it is possible to give an intrinsic definition of a differentiable function and the domain set over which it is defined, called a differentiable manifold.

Definition: A Hausdorf space M is a differentiable manifold of class C^∞ if there exists a set of real-valued functions D(M) defined over M such that:

1) D(M) is local: If g is a function defined over M such that g coincides on an open neighborhood V of M with a function f contained in D(M), then g is also in D(M).

2) D(M) is complete: If F is a function of class C^∞ over R^m, then $F(f_1, \ldots, f_m)$ is in D(M) for any choice of m functions in D(M).

3) D(M) is locally Euclidean: For each p in M, there exists an open neighborhood V of p and n functions in D(M) such that for each q in V, the mapping of q to $(f_1(q), \ldots, f_n(q))$ is a homeomorphism onto an open set of R^n. Each function f in D(M) coincides with a certain function $F(x_1, \ldots, x_n)$ of class C^∞ on V.

The set functions D(M) is the set of differentiable functions of class C^∞ defined over M.

An important property of a differentiable manifold is the following. Suppose the locally Euclidean neighborhoods U and V of M have a non-void intersection. Then there is a homeomorphism v of U onto an open set of R^n. On the intersection of U and V one can define a function uv^{-1} of R^n into R^n (similarly for vu^{-1}). Thus it makes sense to speak of C^∞ derivatives for this function. Indeed it can be proven that this function is of class C^∞ in the case that M is a differentiable manifold of class C^∞. In fact the latter property could be made the definition of a differentiable manifold, which definition could be shown to be equivalent to the former one.

Note: Chevelly in his book *Theory of Lie Groups* (Princeton: Princeton University Press, 1946) gives an intrinsic definition of an analytic manifold, i.e., the functions are not of class C^∞ but are analytic. From the remark above this means that these functions can only be local. For class C^∞ manifolds the above intrinsic definition is found in Nomizu, *Lie Groups and Differential Geometry* (Mathematical Society of Japan, 1956). Whitney gave the second definition in his article "Differentiable Manifolds" (*Annals of Mathematics*, Vol. 37, 1936).

THE DIRECTION OF ELECTRIC CURRENT

REV. JOSEPH F. MULLIGAN, S.J.

The increased contact recently between college and high school physics teachers resulting from the large number of summer institutes for high school teachers has pointed up the fact that these two groups of teachers disagree radically on the convention they adopt for the direction in which electric current flows. Almost all college and graduate school textbooks[1] use the long-established convention that current flows in the direction in which positive electric charges would flow in an electric circuit. The new Physical Science Study Committee High School Physics Course goes along with this convention. Almost all other high school texts, however, favor the direction of electron flow as the direction of current flow, and high school textbook authors point to this feature as one indication of the *modernity* of their books.

The question is basically one of convention, and either convention

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[1] The only exceptions the author has been able to find among college textbooks is Harvey White's, *Modern College Physics* (Van Nostrand, 1956), and Smith & Wiedenbeck's *Electrical Measurements* (McGraw-Hill, 1959).

may be used if it is done consistently. The difficulty ultimately goes back to Benjamin Franklin who called *vitreous* electricity positive, and *resinous* electricity negative. If he had reversed these names, we would probably have unanimity about the current convention today. Because he unknowingly made a poor choice, however, and because electrical theory developed for many decades by considering the flow of a positive *fluid*, it is extremely difficult from a theoretical point of view to abandon the convention that the direction of current flow is that of positive charges without rewriting a large amount of the work of Kelvin and Maxwell, to say nothing of most modern advanced textbooks in physics.

It may be worthwhile just to summarize here some of the incongruities[2] which would result from changing to the electron-flow convention, while preserving Franklin's choice which makes electrons negatively charged, and protons positively charged.

1. If a current flows across a surface surrounding a volume, carrying charge into that volume, then the greater the current, the less would be the charge (algebraically) accumulating in the volume, for an increase of negative charge is equivalent to a decrease of positive charge. This leads to a basic diagreement with the equations of hydrodynamics, which were used as an analogue for the development of early electrical theory.

2. Since the direction of an electric field is, by convention, the direction in which a positive charge would flow, we would have current flowing in a direction opposite to that of the field, or flowing against the potential gradient, up hill as it were.

3. A current would give out energy when its direction is that of the electromotive force, and receive energy when its direction is opposite to that of the emf.

4. All vector-product conventions would have to be changed; right hand rules would become left-hand rules, etc.

5. The accepted explanation of thermoelectric phenomena would have to be modified. Thus in the Thomson effect the electrical current would flow in a direction opposite to that of the heat current. In other words heat would flow down a temperature gradient but the direction of current flow would be against the electric gradient produced by the temperature gradient.

These theoretical reasons are rather convincing. It might pos-

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[2] Some of the ideas here are based on Henry A. Perkins, *American Journal of Physics* 6, 280 (1938).

sibly be argued, however, that practical and pedagogical reasons make it valuable nevertheless to use the electron-flow convention. The chief practical reason given for its use is the fact that in metals and in vacuum tubes at low pressures the electrons carry almost all the current. It was this that led the armed services to adopt this convention in training their technicians during World War II. But it should be realized that metals and vacuum tubes represent only a small part of current-carrying materials in nature. In electrolytes and in gas tubes at low pressures positive ions are just as important as negative. In the comparatively new field of semiconductors conduction is due both to electrons and to "holes", which can be treated as positive charges. And it now appears that most of the universe is made up of conducting plasmas of positive ions and electrons in which the conduction is again shared by both types of charges. Plasmas are becoming so important that they have been called "the fourth state of matter", to be numbered along with gases, liquids and solids as the four basic states of matter in the universe.

From a pedagogic point of view the electron-flow convention certainly has an advantage in high school, where most of the electric conduction discussed is that in metals or vacuum tubes. But it may be asked whether the simplification introduced here is not more than cancelled out by the fact that the student who goes on to college has to learn the opposite convention there. Also there may be real advantages in showing the student that the direction of electric current in terms of very concrete electrons running around a circuit. The increased maturity that such an outlook brings may well be worth the time it takes to get it across to a student.

Of course, no one could argue with a thorough-going reformer who would be willing to go back and correct Franklin's mistake, call electrons positive and protons negative, and carry out the many changes demanded by this in the equations of electromagnetism. This would at least be logical and consistent, but the practical difficulties would be great. There is also the added deterring factor that if we ever get out far enough into space to find a galaxy made of antimatter, there we will find that in metals the positive charges, the positrons, do carry the electric current, and we will wish that we had retained the convention that current flows in the direction in which positive charges flow. Then our seemingly old-fashioned convention will prove to be much more modern that the so-called "modern" convention of electron flow.

SURVIVAL IN THE NUCLEAR AGE

REV. THOMAS J. SMITH, S.J.

The development of nuclear weapons and the widespread use of radioactive substances in research, medicine and industry presents a new problem to man in his struggle for existence. Mankind, as a result of scientific advances has learned to live with a whole litany of diseases and survive. It will have to learn to live with the hazards due to nuclear radiation. To do this there is required no small amount of technical knowledge regarding the physical characteristics of radiation and its biological effects upon the human body. This need is being met by the introduction of courses and training in what has come to be called Health Physics.

Over the last eight years we have trained on the instructor level some 150 people here at Holy Cross who have returned to the cities and towns in the area and become advisers to local authorities on radiological matters and instructors in the use of radiation detection instruments and the techniques of monitoring. Of the 74 cities and towns in Central Massachusetts 57 have at least one of these trained Radiological Officers and they in turn have turned out over 700 qualified monitors. Lectures on the hazards of radiation and the proper protective measures have been integral parts of some 15 Disaster Nursing courses and have been requested for senior undergraduate nurses at St. Vincent's Hospital during the last two years. In an attempt to interest and inform the general public we have appeared in town halls, at assemblies in high schools and several times on radio and television. Briefings on radiation problems in military service were part of the summer training program of the Air Force Reserve.

The demand for health physicists at research centers, hospitals, medical clinics, industrial plants and universities is continuously increasing. We are planning to introduce the basic information and techniques of health physics into many of the science courses here at Holy Cross in the near future. The new Science Building has provision for radioactive storage, a radioactive processing hood and a counting laboratory for radioactive measuring instruments all to be used jointly by the science departments. It is entirely possible that a specific course in the health physics field will be offered in the near future both for our students and for radiological personnel in the Worcester Area. The importance of this new field of study can be appreciated when we learn that the Atomic Energy Commission releases some 10,000 samples of radioactive isotopes per year for civilian use. Wherever these are used across the country the problem of radioactive protection is present. In our instructor course we emphasize the danger involved in emergency situations either while this material is being transported or used and the need for assistance to local authorities in coping with the situation.

Over and above the good public relations engendered and the commendation of the college by the Governor of Massachusetts for the public service rendered, perhaps the most satisfying result of our work has been the readiness of these men and women to sacrifice their time to prepare themselves to help others to save themselves from injury and death—to teach others how to help themselves. The old smug feeling that "it could not happen here" has apparently passed but in its place, in many quarters, an attitude of defeatism has appeared which would have us throw up our hands and sit quietly by to take whatever the enemy has in store for us. Recent research and several series of atomic and nuclear tests have shown that, except for the unfortunate ones caught in the area of total destruction surrounding the target, people can live through a massive nuclear attack-provided they take means to protect themselves. We feel that we are gradually succeeding in channeling down to the individual citizen the all important information regarding the nature of the radiation hazard and the protective measures to be taken and are convincing him that survival is possible.

It is impossible to exaggerate the radiation hazard following a nuclear attack. Persons located hundreds of miles from the site of the explosion in the remotest parts of the country are liable to be permanently injured or die. Moreover, it is slowly being realized that for a period of about two weeks following a widespread nuclear attack there will be no help available to the individual. He will be completely on his own to perish or survive. Whether he lives or dies will depend on how well he has absorbed the information we have tried to pass on to him and how well he makes use of it.

Thinking regarding protection measures has changed as weapons have developed from the first atomic bombs through the megaton hydrogen bomb to the nuclear warhead borne in the nosecone of the intercontinental missile. The missile with its 15 minute warning time and its uncertainty of aim has made plans for evacuating possible target areas all but obsolete. Under the same conditions large, costly shelter against the nuclear blast are more and more being considered impractical. Against the radiation effects of fallout, however, a shelter is very effective with varying efficiency all the way from the simplest dirch or culvert to the specially constructed outdoor underground refuge. Taken along with other simple precautions they are the best answer to date to the problem of survival. Here again it is up to the individual to use the information and advice he has been given.

Many people in many other places undoubtedly have made greater contributions but we feel that Holy Cross efforts are substantial, noteworthy in this area and something you would be pleased to hear about.

Abstracts

THE EFFECT OF NON-IONIZING RADIATION ON THE GROWTH AND DIVISION OF SINGLE CELLS

Rev. William D. Sullivan, S.J.

(abstract)

Most of us are inclined to consider growth as an increase in height and in mass. Yet, these two concepts are but the result of growth, a much more basic and fundamental scientific fact. Basically and fundamentally growth is to be found in the cellular level; in the physiology and biochemistry of individual cells. It is a concept which today has taken well below the power of the most powerful microscope. Here, in the submicroscopic world, activities are going on which result in the increase in height and mass.

Cell division, mitosis, is therefore a most basic and fundamental problem, and, despite the vast knowledge of what takes place, very little is known about the dynamics and trigger mechanism of this activity. Due to the recent investigation of isolating the mitotic apparatus during cell division, the study of the dividing cell is more easily accomplished. Analyzing the mitotic apparatus, it has been shown that the role of the sulfur and sulfhydryl compounds is a most important one. The gelation of protein, necessary for the spindel formation, is very much dependent on the behavior of glutathione-sulfur-protein cycle.

On the basis of this information and using the method of synchronous cell division, each stage of cell division was studied paying close attention to the role of the sulfur amino acids (methionine, cysteine, cystine, and glutathoine) in irradiated cells. *Tetrahymena pyriformis* W. was the single cell used in these investigations. The result of the experiments show that methionine in this organism plays the more important role during the division of the cell. The protection against ultraviolet radiation during cell division was noted to be more pronounced during mid-division than at any other time.

We are merely beginning. A great deal more must be done in order to understand one of the most basic concepts of life, cell division. This above abstract is a combination of two articles which appeared in the Transactions of the American Microscopical Society for April and July 1959.

FOSSILS IN THE GEOLOGICAL RECORD

Rev. James W. Skehan, S.J.

(abstract)

The pre-Cambrian rocks of the world are older than 500 million years and are sparsely fossilferous. They contain some Protozoan forms.

All invertebrate phylla are represented in the rocks of Cambrian age which are 500 million years old. Primitive fishes appeared about 350 million years ago. Dinosaurs and other reptiles became so abundant as to allow the Mesozoic era to be rightly called the "Age of Reptiles".

Modern mammals, flowering plants and flowering trees, as well as modern forms of birds first appeared after the Rocky Mountains were formed, 70 million years ago. The abundance of insects and birds over all other forms during the Cenozoic era is most striking.

The lecture was illustrated and given in the Biology Section at the September 1959 meeting.

DERIVATION OF THE TRIGONOMETRY ADDITION FORMULAS FROM COMPLEX NUMBERS

Rev. Bernard M. Scully, S.J.

(abstract)

Both personal study and teaching experience point out that the usual text-book derivations of the laws for addition of sines and of cosines is a complicated and unrewarding procedure. An easy and logical method has been pointed out by Prof. Donald Richmond of Williams College. Prof. Richmond's method is based upon laws of complex numbers.

Let a and b be two complex numbers. From the definition of a complex number it is known that: (if A is the angle between the abscissa of a and its radius vector and B is the angle for the same of b,) $\cos A + i \sin A = a$ and also $\cos B + i \sin B = b$. It is also known that the complex number formed by the *addition* of angle A and angle B is the product of ab. Then, multiplying the equivalents of a and of b gives angle A + angle B − $\sin A \sin B + i (\cos A \sin B + \cos B \sin A)$. This means that the angle formed the addition of angle A and angle B has for its cosine the real part of the above equation which gives the expression: $\text{Cos}\,(A + B) = \cos A \cos B - \sin A \sin B$.

Similarly, the sine of the sum of the two angles A and B is given from the coefficient of the imaginary number i. Thus sine $(A + B) = \cos A \sin B + \cos B \sin A$.

The other addition expressions follow directly from the above.

THE NEW LAND COLOR PROJECTION PROCESS

Joseph S. Rooney, S.J. and Thomas L. Cullen, S.J.

(abstract)

In early 1955 Edwin H. Land, president of the Polaroid Corporation, discovered a process by which he was able to reproduce a full color scene from two black and white transparencies. Fuller treatment of this experiment will be found in the May 1959 issue of *Scientific American.*

Two black and white transparencies of the same scene are taken:

one through a red filter, called the long record, because it accents the longer part of the spectrum; and, one through a green filter, called the short record. The long record is projected thru a red filter and the short by a white light (called long and short stimuli); these combine to give a full color image. Within certain broad limits the light sources used can be varied; the main limitation is that the long record is always projected by the longer of the stimuli used.

If a scale of brightness is established for each of the projected images the resulting colors of the combined image can be predicted if the values are plotted on log-log-graph paper.

MODERN PHYSICS IN THE UNDERGRADUATE CURRICULUM

REV. JAMES J. RUDDICK, S.J.

(abstract)

Today *modern* physics should properly mean quantum physics, for an appreciation of current-day physics requires an understanding of the basic ideas of quatrum theory. There is much discussion of the question, "Is it advisable to handle quantum theory in an undergraduate program?" For one group, it is extremely unreal to develop the various fields of physics for several years without any treatment of the fundamental theory of these fields. Even in courses in *atomic* physics, for instance, there is often little mention of the theories of the post-Summerfeld era. On the other hand, students often have an insufficient mathematical background for quantum theory. Furthermore, they find it difficult to grasp the many new ideas involved.

Quantum theory *should* be taught, but the right method must be found. This may mean a three-semester modern physics course that includes the usual matter of atomic and nuclear physics, but also treats relativity, quantum theory, and solid state. Or, it may be that the usual two-semester course in atomic and nuclear physics should eliminate much of the superseded background and devote an appreciable amount of time to more modern topics. Or, there may be place for a full course in quantum theory aimed directly at senior students and tailored to their mathematical background.

DISCUSSION OF NSF INSTITUTES

(abstract)

Mr. Eugene A. Zimpher, S.J., who in connection with an article he is writing for the J.E.Q. on the subject interviewed the national director of Secondary School Programs of the National Science Foundation, opened the discussion with a resumé of policy changes of these programs for 1960 and mentioned some features of the program not immediately evident from the written material available.

$1,600,000 will again be spent in the summer of 1960 on such programs at 106 centers in the U.S. The number of participants is expected to increase to almost double the 1959 figure, since in 1960 participants' costs will not be paid in full, but according to individual need (0-100%) at the local director's discretion. The majority of the staff of each program must be regular college or professional personnel.

Although some programs are designed for commuters only, no program can of policy limit itself to participants from one state. The region covered by one center usually extends for a radius of 300 miles, but travel allowance (to and from) may cover 1,000 miles ($80 at $.04 per mile). Subject coverage, though predominantly in Mathematics, Chemistry, Physics and Biology, extends to over 15 other special fields. The majority of programs are open to those who have completed the 11th grade, although there are programs open to 9th, 10th, 12th, and rarely 8th grade students.

Further details and suggestions for high school science counsellors who guide applications, as well as some points applying to other programs of interest for high school teachers and students will appear in the J.E.Q. article.

News Items

Boston College. The Biology Department received an AEC grant for undergraduate training in the amount of $7,000. Fr. William Sullivan, Department Chairman, is principal investigator for a Cancer Institute project grant of $5,500. The total grant from the Air Force is about $10,000. A National Institute of Health grant of $10,000 is being directed by Dr. Chai Hyan Yoon, a native of Korea, who graduated from Ohio State University. Robert A. Ortman, who earned his Ph.D. at the University of California has been appointed Assistant Professor of Biology. Last year's graduating class placed 30 students in medical schools and 18 in dental schools. The present freshman class has 115 Biology students.

The Chemistry Department has been placed on the NSF Cooperative Fellowship Program list. The department is now accepting applications for its Ph.D. program to begin September 1960. Dr. de Bethune is principal investigator for two projects on research in the chemistry of perspiration. One is from the National Institute of Health. The other is a $7,500 grant from the Cystic Fibrosis Foundation. Dr. de Bethune is also principal investigator for an investigation into corrosion sponsored by the Department of the Navy. Dr. de Bethune, Truman Licht and, Nancy Swendemen jointly wrote an article on Electrode Potentials for the July *Journal of the Electrochemical Society*. Dr. Timothy McCarthy wrote an article on Methionine Determination for the first volume of the *Biochemical and Biophysical Research Communications*. Dr. Raymond Bogucki, Holy Cross, 1953, and holding the Ph.D. from Clark University, was added to the staff as Assistant Professor of Chemistry. Dr. Joseph Bornstein is principal investigator for an American Chemistry Society Petroleum Research Fund grant of $2,000 on fluorides. He spoke on this work at a chemical meeting in Birmingham, England in July.

The Physics Department is engaged on an Air Force project investigating Aurora Spectra. Over 30,000 spectrograms from IGY records have been microfilmed and studied. Fr. Guidon is the director of an Air Force grant which now totals about $150,000 for studies of High Magnetics and Gaseous Plasma. The Department is planning a several thousand volt positive ion accelerator. Dr. Robert L. Becker, a Ph.D. from the University of Wisconsin, joined the staff as Assistant Professor of Physics. Dr. Robert Carovillano who earned his doctorate at Indiana University, is a new Assistant Professor of Physics.

The Mathematics Department received an NSF grant for $200,000 for the Academic Year Institute which will have 40 participants. The NSF also alloted $13,700 for an In-Service Institute for 40 participants. Dr. Louis Kattsoff, Ph.D. University of Pennsylvania, author of 70 articles and four books, joins the staff as Professor of Mathematics. Dr. Paul Nesbeda, Mathematician in the Radio Corporation of America, formerly a member of the staff of the Institute for Advanced Studies at Princeton University has been appointed Lecturer in Mathematics. Dr. Joseph Sullivan, B.C. 1944, a Ph.D. from Indiana University comes to the Department as Visiting Professor of Mathematics. Miss Margaret Kenney has been appointed Instructor in Mathematics.

The Science Library now contains 10,500 volumes. The Library receives 370 different journals. There are over 5,000 bound journals. In the past year 2,500 science and mathematics books were circulated. The total number of *person-days* using the library is about 25,000.

Boston College has added to its Department of Physics Dr. Robert L. Becker as an Associate Professor and Dr. Robert L. Carovillano as an Assistant Professor of Physics. Dr. Becker had been an Assistant Professor at the University of Kentucky after completing his doctoral studies at the University of Wisconsin; his teaching and research work at Boston College will center around an experimental nuclear program in which a small accelerator is being built for the study of low energy nuclear collisions. Dr. Carovillano recently completed studies at the University of Indiana; he will continue his research work in nuclear theory.

Boston College High School. The Physics course is using the materials which have been compiled by the Physical Science Studies Group of MIT. Fr. Frank Buck has written a chemistry book which has appeared in mimeographed form. During the past summer Fr. James McCaffrey studied radiation biology at U.C.L.A. on an NSF grant. Fathers Philip Harrigan, Thomas Spillane and William Doyle studied mathematics on NSF grants at Holy Cross College.

Fordham University. Fordham chemists, interrupted in their research after a fire last winter destroyed the chemistry annex, were able to continue in a converted dining room in Dealy Hall.

The Mathematics Department received a NSF grant of $95,000 for a Summer Institute this past summer. An NSF grant of over $10,000 will be used for an In-Service Institute during this academic year. Fr. H. DeBaggis will teach Introduction to Topology and Prof. Frank Crippen will teach Linear Algebra. There will be 50 participants. Fr. DeBaggis is acting chairman of the Mathematics Department while Fr. Charles Lewis is on an NSF Science Faculty Fellowship at Harvard.

The Physics Department has been awarded $50,000 from the NSF for the purchase, maintenance and operation of a computer needed for research problems.

Dr. Alfons Weber, Assistant Professor of Physics at Fordham, has received a grant of $32,200 from the National Science Foundation to support his work on High-Resolution Raman Spectroscopy of Gases for a two-year period.

Rev. James McConnell, Professor of Physics and Dean of the Faculty of Science at St. Patrick's College, Maynooth, Ireland, will be a Visiting Professor of Physics at Fordham during 1959-1960. Father McConnell is well known for his many articles on the theory of the fundamental particle. He first developed the theory of the anti-proton, and wrote a review article on the subject for the journal *Nuclear Physics* after the production of the antiproton in the Bevatron at Berkeley in 1955. Father McConnell was a student of Nobel-prize winning physicists E. Schrodinger and W. Heitler at the Dublin Institute for Advanced Studies. He is on the editorial board of *Nuclear Physics,* and is the author of the recently published book, *Quantum Particle Dynamics.* While at Fordham Father McConnell will lecture in the graduate school on quantum field theory and fundamental-particle physics.

Three graduate students in Physics at Fordham, Rev. Benedict J. Monostori, Maurice Cotter, and Joseph Barrett were among the six students receiving National Science Foundation Cooperative Graduate Fellowships at Fordham for next year.

Recent publications from the department include Joseph Shapiro (with G. Breit of Yale), "Metastability of 2s States of Hydrogenic Atoms", *Physical Review* 113, 179-181 (1959).

The National Science Foundation has announced a grant of

$51,950 to the Physics Department of Fordham University, to provide a High-Speed Electronic Computor for use on four research projects being carried on by members of the Department. These research projects are under the direction of Professors Canavan, Shapiro, Weber, and Mulligan, and involve calculations of fundamental properties of atoms, molecules and nuclei.

Most of the grant will be used to purchase a Bendix G-15 General Purpose Electronic Computor, which will be installed in Freeman Hall on the University Campus. The computor will be available to other Departments of the University carrying out research work requiring computing facilities.

Professor Emeritus Victor Hess of the Physics Department was recently awarded the *Osterreichische Ehrenzeichem fuer Kunst und Wissenschaft* (Honorary Insignia of Art and Science) by the Austrian Government. The medal was presented to Professor Hess on December 7, 1959, by Dr. Karl Wolf, Consul General of Austria, at the Austrian Consulate General in New York. Professor Hess, Nobel Laureate in Physics, though retired from teaching, is still busily engaged in research at Fordham.

The second revised edition of *Quantum Particle Dynamics,* by Rev. James McConnell, visiting professor of physics at Fordham, has just been published by the North-Holland Publishing Co.

The Physics Department sponsored a dinner in the Keating Hall Mural Room for the Albertus Magnus Guild on Thursday evening, January 28. Fifty physicists, who were in New York for the annual meetings of the American Physical Society and the American Association of Physics Teachers, attended the dinner.

Father Joseph F. Mulligan, S.J., Chairman of the Physics Department, has been appointed to the Advisory Committee on Graduate Fellowships of the National Defense Education Act.

Dr. Bernard J. Dunn and Dr. Daniel F. McDonald, Assistant Professors in the Physics Department, have been awarded a $24,550 contract for basic research by the Office of Ordnance Research of the United States Army. Under this contract they will carry out basic investigations of the scintillation process in organic crystals.

Georgetown University. The members of the ASSOCIATION who attended the Jesuit Science Convention at Georgetown on September 3-5, 1959 were impressed by the hospitality of the University. Reverend Father Bunn, President of the University extended the greetings and best wishes of Georgetown. An interesting feature was a guided tour through the new Lawrence C. Gorman Diagnostic and Research Building.

College of the Holy Cross. Recent departmental publications in chemistry include no. 94, A. Van Hook (staff), F. P. Fehlner ('56), E. S. Roth (Scranton, '55; HCMS, '56), R. A. Rousseau (56 MS57) and W. A. Van Hook ('57), the Rate of Growth of Sucrose Crystals in Pure Solutions, *Internat. Sugar J., 61,* 167-171 (1959). The younger Van Hook and Rousseau are now doctoral candidates at Johns Hopkins University; Fehlner, finishing at RPI. This summer, Prof. Van Hook finished a monograph on Crystallization and hopes soon to see this *brain-child* in print. Other authors among alumni, of special interest here, include Fr. Gerard M. Landrey, MS '32, now stationed at Boston College, and Fr. Francis C. Buck, ex-'37, at Boston College High School, both of whom produce their own general inorganic laboratory manuals. Other items of alumni and joint interest include: the NSF summer fellowship in chemistry of Fr. Wm. H. McBride, MS '53, who worked at Bowdoin College in Maine; the awarding of an honorary degree by Loyola University, Chicago, (at the mid-year graduation) to Dr. James A. Shannon, HC '25, Director of Public Health Service, U.S. Department of Health, Education and Welfare; and Dr. F. O. Rice, HC honorary '58, retirement from Catholic University, and new affiliation as visiting professor at Georgetown University.

Fr. Martus spent the summer of 1959 in parish work in Martinez, Cal., so as to be near his aging parents. He took advantage of this sojourn sometime in August, to attend the first summer conference of the Pacific Southwest Association of Chemistry Teachers, held at Asilomar Park on the Monterey Peninsula. At this meeting he represented the New England Association of Chemistry Teachers, first in the Summer Conference field, of which he has been secretary for a number of years now. On returning East he attended the Atlantic City meeting of the American Chemical Society, at which he was in charge of the Crusader Chemist Luncheon, incidental to the event, having to arrive a few days in advance to sit with the A.C.S. Co-operative Examination Board, with which he is affiliated. He had also been active in these two events at the A.C.S. meeting held in Boston, in the Spring of 1959. Fr. Martus has recently been appointed college representative to the Woodrow Wilson Scholarship Foundation (for prospective college and university teachers) and he holds a corresponding position on the campus scholarship committee. Further, in March 1959 he previewed in part the Continental Classroom for chemistry in part and took part in the formal presentation of this monumental film collection to Dr. James R. Killian, Jr. then special assistant to President Eisenhower for Science and Technology, at a small gathering of Washington officials, educators, scientists and newsmen, being perhaps one of the few clergy representatives if not the only one.

College and ASSOCIATION were shocked on May 11, 1959 at the passing of Fr. Anthony J. MacCormack, S.J., Professor of Biology, and preceptor in the past of so many of *ours* at Weston College and at Holy Cross. He passed away during a coffee break in mid-afternoon. May his soul rest in peace. Fr. John W. Flavin, Asst. Prof. Biology, can fortunately be spared for leave to finish his PD-NSF fellowship in Radio-biology at the University of Michigan.

With the Atlantic City meeting of the A.C.S., Father Fiekers terminated membership on Council's Standing Committee on Chemical Education, as well as Council's Sub-committee on Teacher Affiliation Proposed Classification, both chairmanship and membership; tenure as councillor expected to go through 1960. In October, he contributed a page to the HC-Univ. Dayton Football Program, entitled *Football and the Crusader Chemist.*

Dr. A. Van Hook is chairman of the Central Mass. Section of the ACS this year. He is councillor with the Jesuit Research Council. Dr. Ralph Trese, its executive director, addressed the entire faculty here early in October. Grants here at present include the Petroleum Research Fund of the ACS and some support from the Sugar Foundation.

The record of alumni doctorates in chemistry divulges that there are 39 holding doctorates who graduated with the bachelor's degree here, 21 of whom hold our master's also; further there 14 who hold our master's only, bachelor's elsewhere, as well as 4 ex-men. Of these 57, two are deceased; and college and/or university teachers tally overall 16 of these. There seem to be 18 candidates for higher degrees among recent alumni. Since largely through our own fault, this item seems to have been garbled on certain releases, it is brought up to date and repeated here for the record. Our manpower contribution report for 1958 sagged somewhat, as it well may for 1959 also; but we hope to improve it again in the coming years.

Dec. 8th, 1959 marked the formal opening of our new science building, Haberlin Hall, with an academic convocation at which his Eminence Cardinal Cushing of Boston spoke on Science and Religion, and Fr. Daniel Linehan, S.J., Director of the Seismological Observatory at Weston College, was among those who received honorary degrees.

The new building with its approximately 70,000 square footage houses the departments of chemistry, physics and mathematics, along with some classrooms for general campus use and a science branch of the College Library where the holdings of interest to these three departments are housed together.

St. Joseph's College. The annual lecture of the Mendel Biology Society was delivered by Dr. John Tyler Bonner of Princeton. His subject was *Cells and Society*. Dr. Thaddeus Raines addressed the Collins Chemical Society on *Rockets and Rocket Fuels*. Dr. Raines, a St. Joseph's graduate of '39 is chief of the Propellant Evaluation Section for Reaction Motors.

Scranton University. The NSF awarded the University a grant of $7,990 for academic year In-Service Institutes in biology and mathematics. This summer the University ran a program for students who are going into their senior year in high school. College-credit courses in chemistry and mathematics were conducted.

The Weston Seismological Laboratory. The *Geo-Jesuit* erupted into print with volume I, no. 1 for April, 1959 from the pen, and under editorship, of Father Daniel Linehan of the Weston Seismological Observatory, who has taken on this assignment *pro tempore*. This seven-page multilithographed issue arose out of decisions passed at the conference of the Jesuit Seismological Association held at Spring Hill College in 1957. It gives some idea of what we may hope of it in the way of the history of this ancient Jesuit avocation and news story of what Jesuits are doing in geophysics, or, as the editor also adds, failing to do so.

Geo-Jesuit succeeds in bringing together under one cover news out of our geophysical apostolate that is otherwise difficult to collect. It must ever have been a problem for editors of the BULLETIN to give seismology the coverage that the voluminous activity of *ours* in that field warrants. Now we are relieved in this matter.

But this relief is only partial. When one reads therein: bread on the waters that came back like sponge cake—To many people, a seismograph is as much of any Jesuit's equipage as his brevairy—feel free to make any quotations from this paper (which we do), after you correct the English and change the Editor's style—the time of publications of each issue is like the earthquakes we study, unpredictable—talk of Penguin seismologists from the Antarctic—and the banana belt of that region, 40°F.—you will have read it yourself; we do not dare further to quote; it shows us up!

Seriously though, a new compass point has been found. We now definitely emphasize geophysics, of which seismology is but a part. *bafSJ*

Wheeling College. The Space Society held a symposium which was addressed by Fr. Heyden. He spoke on *Outer Space, Our New Frontier*. Fr. Duke attended California Tech. as a senior faculty fellow of the NSF this summer.

Varia

Recent Publications on Père Teilhard de Chardin have been reviewed in Bull. 47, ns, *Union Catholique des Scientifiques Francais*, Bimestriel-61, rue Madame Paris, 6^e, France, pp. 2-5. The titles are: Claude Guénot, *Pierre Teilhard de Chardin, les grandes étapes de son évolution*, Plon, Oct. 1958, 800 pp; Oliver A. Rabut, O.P., *Dialogue avec Teilhard de Chardin*, Edition du Serf, Oct. 1958, 209 pp., Collection Signe du temps, Science d'aujourd'hui, 630 fr; Pierre Leroy, S.J., *Pierre Teilhard de Chardin tel que je l'ai connu*, Plon, Nov. 1958, 66 pp; and Charles Journet, *Notes sur Teilhard de Chardin: "Le milieu divin": Teilhard et la phénoménologie*, Nova et vetera, Revue trimestrielle, Jul.-Sept., 1958.

Publication of Fr. E.P. Bertin, S.J. with I. Nakagawa, S. Mizushima, Fr. T.J. Lane C.S.C. and J.C. Quagliano: Infra-red absorption studies XIII., hexammine cobalt (II) halides and diammine mercury (II) halides, J. Am. Chem. Soc., *80, 525* (1958).

Publication of Robert D. Cloney, S.J. and John S. Dooling; Molecular Orbital Study of Be_4, (Cath. Univ.) J. Chem. Phys., 29, 425 (1958).

Motion Pictures

Beyond Uranium, 16 mm. b & w, 30 min., TV KQED, San Francisco, Cal., available from AV Ctr., Indiana Univ. This film is a sequel to one on the missing elements in the periodic table and documents the discovery of elements Z 93-98, to be followed by a showing of Z 99-101 incl. This documentary features the 1951 Nobel prize winners in chemistry, Dr. Edward F. MacMillan, co-discoverer of Neptunium, 93, and Glenn T. Seaborg, 93-96 incl., both of the Radiation Laboratory of the University of California at Berkeley. Dr. Bernard Harvey of the same laboratory outlines the applications of fission to produce power. Features of the film include a demonstration of fission in an ionization chamber, the argument for the parallelism of the actinides with the lanthenides, illustrations of nuclear reactions by adding and "boiling off" subatomic particles, chromatographic separation of transition elements to illustrate separation of certain actinides, historical exhibits of actual apparatus used in the chemical work and the first crystal of one of the elements, MacMillan's early investigation of fission products by separation in a book of cigarette paper, illustrations of the slow neutron fission, and the mouse trap illustrations of a chain reaction. Reasons for the names of the new elements are emphasized. There is profit for every witness of this film, from auditor background of the three R's to those who can interpret a nuclear balanced equation. Not to be overlooked is the fact that discoverers re-enact their discoveries essentially within allowed time limits. *bafSJ*

The Spectrograph, 16 mm. sound, color, 20 min., McGraw-Hill, 1954. Starting with the simple, ocular prism, spectroscope and what one sees in them, this film describes the *what*, *how* and *why* of spectrographs up the line to very special and modern ones.

In emission spectrography it is shown how increase of the size of prisms, the use of quartz and of the grating cumulatively enhance dispersion and even spectral range: visual to infra-red and over to ultra-violet and xray. The origin of spectra, atomic, and molecular or band spectra, are delineated with animated diagrams of electron leaps like "men on a chess board". Spectrograms of continuous spectra are shown. Absorption spectra (Fraunhofer dark lines) are explained through actual spectrograms and through apt illustrations.

Part two includes the uses of spectrographs and instances of their applications to biology and agriculture, industrial metallographic work, criminal investigation and astronomy. The Doppler effect provides proof of the rotation of the sun when the spectrograms from two edges are compared. Absorption spectroscopy in the infra-red region is briefly indicated. Optical, photographic and photo-electric sensing and recording are included in appropriate places. The narrative is done with a British accent. Criticisms might include the great variety of instruments that is packed into such a relatively short film, and the general omission of densitometers and internal standards for quantitative work—not that supplementary information on such points may now be given the more readily by instructors. On the credit side the treatment of emission is far less dense, though still emphatically qualitative rather than quantitative. For this reason, this film makes a good addition to any repertoire of films on instrumentation, since emission spectrographs are hard to come by in most undergraduate laboratories. *bafSJ*.

Weighing = Comparing, 16 mm., color, sound, ca. 10 min., Metteler Balance, produced by Condor Film Ltd., Zurich, with sound track in English; available from Fisher Scientific Co., New York and Pittsburgh. Constant sensitivity is achieved by constant load on this one-pan, two knife-edge design in which all weights are counterbalanced with a fixed weight and are subtracted from the pan to compensate for the weight of the object, with all but automatic recording.

The first half of this film constitutes an elegant demonstration of the way sensibility depends on load in the traditional analytical balance. The second half of the film describes this stream-lined *job*, emphasizing its accuracy and time-saving features. Naturally the first half of the show is very attractive at certain academic levels. It could supply good supplementary material to those films on the analytical balance that avoid and omit the topic of sensibility, an extremely difficult topic to teach. The second half is of interest in advanced work. *bafSJ*.