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SCIENCE and PHILOSOPHY

HOLY FATHER SPEAKS ON MATHEMATICS

Address of the Holy Father delivered to the International Convention, Held at Rome, of those engaged in the Study of Higher Mathematics.

By Raymond E. McCluskey, S.J.

"It is our joy and privilege to respond cordially to your desire to come to Us, distinguished professors and academicians. The expression of this wish was made manifest to Us by the distinguished President of the convention which is being held at Rome; accordingly it is Our pleasure to welcome such a gathering of the most select and outstanding teachers and researchers of the higher mathematical sciences.

In you We admire the multiform rays and degrees of lights that emanate from that science which plants its sturdy substance upon reality, the source of every truth for human cognition. So does she manifest her sublimity in her Calculus, in her geometrical lines and configurations, in all that finds itself within the dominion of quantitative bodies. She descends from the loftiest heights of the macrocosm only to penetrate and burrow deeply into the infinite depths of the microcosm, discovering, weighing and considering the values of space, time, and quantity all of which are precontained in the mind of the Divine Architect Who ordered and fixed the harmony of the universe from the highest heavens to the lowest depths thereof.

The science to which you have dedicated your talents is a manifest proof of the reality and truth of the common values which are highly esteemed by the cultures of the human race, even by the remotest and most individual tribe or nation. Before mathematics reared her head at Athens or on the banks of the Tiber, she was deeply rooted in that region of the world which beholds the endless flow of the Tigris and Euphrates and also in the land bathed by the Nile. Primitive and simple though her methods were even in this crude stage, she produced astounding results. If indeed, shining as she did in the glory of her merits, Western Culture became debtor to the Orient, in no way does this fact diminish or obscure the glorious merits of the European mind, which has established the science of mathematics so high and secured her place firmly and permanently on the pedestals of science, competing with the other branches of science. But the acknowledgment of the common values of learning has today an all important aim or purpose which looks ahead to the future. The more conscious a nation becomes of the deadlock that exists in her vital progress because of her exclusive confinement to material interests and progress, the more apparent her struggle becomes, the brutal struggle for existence — so much the greater must the effort be to maintain in every creature, unshaken "by the blows of materialism", but still alive and vibrant with spiritual ideals, in the midst of an avalanche of hatred and discord, the consciousness of these values and a special insight, to the end that it may one day reestablish the spiritual touchstones and constants through a new understanding and a scientific and intellectual approach, both working hand in hand.

Mathematics is the science of peace and not of conflict. To Us it is a pleasant vision, the contemplating of great mathematicians and astronomers in the nocturnal quietude of their observatories, as their telescopes spy upon the most distant and peaceful constellations of the heavens. It is the measuring of the unlimited depths of the firmament; it is that sublime image and symbol of peace that the nations on the fact of the earth hope and desire may return to rule the world. Our hopes of such a vision are so high that We, even in the progress, in the research and decisions of your high and exact science, outstanding and brilliant as they have been in the course of your convention, place the peaceful hope that the numbers of peace-loving people increase and multiply, that the just needs of the nations are recognized and compensated for in due and satisfactory measure. The basis of justice is truth, this very truth that in your exact sciences seems to shed more lustre and light than the others; that truth which makes science all truthful, wherein all science lives in harmony and concord, never bickering but fraternizing amongst men and nations in peace.

Illustrious professors and academicians: The atmosphere of this Apostolic palace for the learned man is not strange and forbidding but familiar and welcoming.

The esteem which the Church holds for the natural sciences has rarely found a more universal, delicate, a more noble, more fluent and convincing expression than that depicted by the painting of the Umbrian artist "The School of Athens", which displays the most varied action, effervescence, scattered groups and the agitation of a scientific congress. In this group the place of honor is held by one of the most classic pioneers of mathematics. Bent forward you admire him as he traces some geometric figures with a compass, while four youths, fellow discipes follow him with awe and attention.

The sacred science, which at the service of faith, delves deeply into the mysteries of the Divinity and the divine plan on the redemption—and the profane science, which in its untiring strivings struggles for a vaster knowledge of things created, are not foes but sisters. The more hallowed nobility of the one determined as it is by the end proper to it, which end lifts it above the natural, does not belittle or diminish the importance, the magnitude, the necessity and worthiness of the other, which searches and discovers successfully in the universe the works of its Creator.

Wherefore We are most grateful for your prescence here — We invoke upon the results of your congress, your decisions, your discoveries, your academies and universities, your families those favors which exalt you and your science before God and men. May they be effective in helping you and sustaining you for paving the pathway for peace, since it is through you that the way of peace on which charity and justice will one day meet and embrace, can be built."

Because it is the statement of the Holy Father this tribute to the science of Mathematics should call forth an expression of gratitude from all those who have an interest in the study and teaching of Mathematics. It can hardly escape the careful reader of this address that through it all flows the thought that Mathematics is more than a tool for the scientist or the statistician, more than a necessitv for the airman or the seaman. In the present day when the demands of the emergency require that great stress be placed on the utilitarian and practical aspects of Mathematics, we can be thankful that the Holy Father has not let us forget that Mathematics is a branch of knowledge that has greater values than mere material ones, and that it has qualities that place it high in the ranks of worthy intellectual pursuits. Is not this a reminder to us that we should not lose sight of the possibilities of Mathematics as an apt instrument for educating the human mind, as an educative, formative, cultural branch of knowledge, and that in the selection of subjects that are suitable matter for a liberal education Mathematics can very fittingly be included?

The reasons that could be adduced in support of the inclusion of Mathematics in a program of liberal education are many. For the sake of order and brevity they can be grouped and considered under three headings namely its aptitude for mental development, its capacity for indoctrinating minds with order and certainty, and its suitability for moulding the character of the student.

That Mathematics as a study is calculated to develop the intellectual capacities of the student is quite evident. But in addition to the common intellectual nature of any branch of learning to make demands on the student's understanding, memory and imagination, Mathematics makes special demands on the student's ability to reason, to analyze and synthesize, to judge and evaluate, to discern the relevant from the irrelevant. It exercises him in solving problems, in appraising a situation and in arranging its varied circumstances to the end that an interpretation of the meaning of the situation may be made. The student of Mathematics is forced to take his general principles and apply them to specific cases and thereby is trained in a most difficult mental process, that of spanning the gap between the abstract order and the concrete order. He who enters the study of Mathematics is, as it were, entering a new world. He is going to learn a new language, the language of mathematical symbols. He is going to deal with new concepts, have his mental horizons widened, and gain entrance into hidden recesses of scientific research that are closed to one not a mathematician. He will become as familiar with the process of using logarithms, of utilising the methods of trigonometric computation, of applying the methods of the Calculus, that is, differentiation and integration, as the ordinary person is with addition and subtraction. To the mathematician the world about him will take on new meaning, his everyday life will be enriched, his surroundings will be clothed with new significance. His curiosity will be awakened, inert faculties will be called into action, stiff and rigid mental processes will be made more flexible and adaptable. In these and in many other ways his mental growth and stature will be cultivated as the study of Mathematics contributes to the formation of the educated man.

Scarcely a higher compliment could be paid to a course of study than to say that it is ordained to indoctrinating growing minds with patterns of certainty and order, to inculcating notions of truth and coherence at a time when these can be woven into the very fiber and framework of expanding minds in such a way that they will influence the whole mental life of the student and put at his command faculties that have been tempered into keen intellectual weapons and moulded in the forms of strength and reliability. Giving himself to the study of Mathematics the student brings his mind into contact with a system of thought that is the fruit of thousands of years of work on the part of many of the world's greatest minds. Such a one will make the acquaintance of a science that has been built up step by step on solid principles, advancing with unmistakable certitude into further realms of the unknown. In the construction of the edifice of mathematical theory rigid lines have had to be followed. There was no room for deviation from the truth because the false was so patently false and the true so undeniably true. In a world and an age that has so little use for absolute principles and truths, so given to scepticism and floundering on the shoals of expediency, the mind of the student can't but be enriched and strengthened by dealing with a branch of knowledge that is built up from universal absolute principles, whose conclusions are the right conclusions, known to be right, and known to be right forever. Studying the universe in the light of his mathematical training, observing the motions of the heavenly bodies as interpreted by his Mathematics, beholding the unity and the integration of the laws of nature operative in the macrocosm of constellations and the microcosm of the atom and molecule as manifested by mathematical computation the student will necessarily be impregnated with the ideas of truth and certainty.

In addition to the disciplining and conditioning of the intellect of the student the study of Mathematics has a contribution to make in the training of the student's character. There are, of course, the obvious attributes of any more difficult intellectual pursuit in demanding attentive study, concentrated application, hard work, and perseverance. All of these requirements go to make a well rounded character or to develop strength in weak characters. But in other ways more proper to itself the study of Mathematics lends itself to being directed in character building channels. The student who is diffident can be helped if he is assigned more easy problems and little by little as his confidence is built up he can be given more difficult work proportioned to his present ability. On the other hand the student who with little effort can keep up with the class and is not called upon to exert himself in the least with the ordinary assignment can be challenged with the more intricate problems that will put him on his mettle and bring out the best that is in him, saving him from the pitfall of mental stagnation. Again by making the student justify every step of his work and constantly driving him back to his fundamental principles, honest intellectual habits will be cultivated. In this way he will be taught not to jump to conclusions that exceed the bounds of his premises, to draw out of his evidence the conclusions that are justifiable and not the solution that best suits his prejudices. The trait of facing the facts and accepting the consequences of the facts can be brought home to the student in the concrete circumstances of a given problem. By careful checking and assigning of homework the youth can be taught to do his own work and not to rely on others but rather to despise the shirking of work and taking credit for the efforts of a fellow student. Surely no one will deny that there are character building potentialities in such training.

The statement of these considerations, stimulated by the address of the Holy Father and urged in support of the inclusion of Mathematics in a liberal education program because of its aptitude for mental development, for indoctrinating truth and order, and for building character lead to the expression of the hope that Mathematics may have a share in the shaping of a peaceful world order for the generations to come.

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(1) Translated from the Italian as published in the Irish Ecclesiastical Review, Nov. 1943. Cf. Acta Apostolicae Sedis, Vol. XXXIV Num. 12, p. 370, 23 Dec. 1942.

BIOLOGY

A FEW VITAMIN COMPLEXES (Cont.)[1]

By Rev. James J. Deeley, S. J.

VITAMIN C

Potatoes, a common item in the daily diet of most individuals, contain significant quantities of vitamin C. Vitamin C is a relatively simple chemical substance named ascorbic acid ($C_6H_8O_6$). Ascorbic acid has a high reducing power, is soluble in water and alcohol, and is readily destroyed by heat and oxidative processes. Prolonged boiling, drying, aging or storage of foods reduces or destroys their antiscorbutic properties. Thus potatoes, when mashed, lose much of their vitamin content because of the oxidation of this vitamin by air. Copper catalyses the oxidative process, so that the vitamin is destroyed more readily when foods are cooked in a copper utensil rather than when glass or aluminum vessels are employed. In general slow cooking, e.g., stewing, is more destructive of the vitamin than more rapid cooking at higher temperatures. Nevertheless, boiling milk even in an enamel vessel for five minutes destroys twenty percent of its vitamin C content.

The essential function of vitamin C appears to be the maintenance in a normal state of the intercellular ground substance in which the tissue cells are embedded and cemented together. The matrix of bone and dentine, the cement substance between the cells of the capillary walls and the ground substance of the general connective tissues are produced by the supporting or collagenous cells. Originally the material is liquid but after its production it becomes, under normal circumstances, transformed into semi-fluid gelatinous mass on which the cells are embedded. It is Wolbach's view that the gelatinous process and the maintenance of the gelatinous state is dependent on the action of vitamin C.

The richest sources of vitamin C are the citrus fruits. Fresh meat, cow's milk and other animal foods are very poor sources. In fact milk loses its vitamin C content when exposed to visible light. One half of the average sized grapefruit, or one over-sized orange or a three and a half ounce serving of strawberries, when in season, will give the total daily requirement of vitamin C. Its concentration in human milk is several times that of cow's milk. In the body the

(1) cf. This Bulletin. Vol. 21, 207.

greatest storage house of this vitamin is the adrenal cortex, where it exists in high concentration. The crystalline lens, the corpus luteum and the pituitary gland contain large concentrates of the vitamin.

Scurvy is the most prominent result of Vitamin C deficiency The essential pathological change in this disease is the weakening of the endothelial walls of the capillaries and the reduction of the amount of the intercellular substance. This leads to hemorrhages from the various structures, e.g., mucous membranes of the mouth and the gastrointestinal tract, skin, subcutaneous tissues, muscles and subperiosteal tissues. Redness, swelling, ulceration and, in severe cases, gangrene of the gums result. Some of the main features of the condition are: anemia; small cutaneous hemorrhages; pains in the bones and tender swellings, due to subperiosteal or muscular hemorrhages; separation of the epiphyses, especially in young children; great weakness and emaciation. One of the earliest records of the cure of scurvy by the administration of a substance rich in vitamin C is that describing an episode of Jacques Cartier's second voyage to Canada (1535). A number of the explorer's men had died from scurvy and most of the remainder were dangerously ill. These were cured by being given a drink prepared by a friendly Indian from the leaves and bark of an evergreen tree (probably a spruce). After the year 1795, the sobriquet "Lime Juicer" was given by other nations to the British sailor because concentrated lemon juice was rationed to each sailor in order to cut down the prevalence of scurvy in the navy. The government took this action years after Lind, a British naval surgeon, carried out an interesting and admirable clinical research on board the 'Salisbury', the results of which showed conclusively the antiscorbutic value of oranges and lemons.

The daily requirement of vitamin C for the adult is from 70 mg. up, but it varies considerably. Infections, rheumatic fever and other conditions tend to deplete the vitamin stores and therefore increase the amount that must be provided in the diet. Infants require much more relatively to their body weight than do adults. The vitamin stores with which a baby comes into the world are depleted within the first few days and even if breast fed it must receive extra supplies in the form of orange juice or tomato juice.

VITAMIN D

The search for the antirachitic vitamin makes one of the most interesting stories of modern biological science. In 1890 Palm first suggested that sunlight possessed an antirachitic property. Twenty-nine years later Huldchinsky successfully cured rickekts by the application of the ultraviolet rays from a mercury lamp. Two years later Hess and Unger demonstrated the truth of Palm's suggestion. At the same time Mellany had already published his results proving the antirachitic value of cod-liver oil, egg yolk and butter. Intensive research by several workers soon furnished the evidence necessary to link together the antirachitic effects of these and other articles of diet with those of radiant energy. First it was found that rats thrived as well as if they had been directly irradiated, if they, while on a vitamin D deficient diet, were placed in glass jars that had been irradiated by a mercury vapor lamp. This was due to the fact that the rats ate the irradiated sawdust in the jars. Goldblatt and Soames discovered that rat livers that has been irradiated with ultraviolet light acquired nutritive properties similar to those of cod-liver oil. Shortly after this four investigators independently showed that certain fat-containing foods acquired the power to cure ricets upon artificial irradiation. The next step was the discovery that cholesterol of animal tissues and sterols of vegetable foods gained antirachitic properties upon irradiation. These sterols were apparently the precursors of vitamin D. Thus the final link in the chain of evidence connecting the antirachitic effect of irradiating the body surface and that resulting from the ingestion of certain foods was forged. It was, however, later discovered that not cholesterol itself, but minute quantities of ergosterol with which it was contaminated were responsible for the antirachitic effects. Thus ergosterol came to be recognized as the precursor of vitamin D.

Ergosterol, obtained from yeast, when irradiated, yields a group of substances—lumisterol, tachysterol, calciferol and suprasterol. During irradiation these products appear in the order given, but their proportions in the mixture at any moment depend on the intensity and the duration of the irradiation. Calciferol is not the end result but at a certain stage the amount of calciferol formed is at a maximum beyond which it undergoes decomposition and toxisterol is formed. This product of over-irradiation is highly toxic, having a very pronounced effect upon calcium metabolism. Calciferol is regarded as the pure vitamin and can be isolated in crystalline form from the other products.

The ultraviolet rays effective in activating ergosterol are those which it absorbs, namely, those with wave lengths between 250 and 313 Mm. The maximum effect occurs at wave lengths around 280 Mm. Rays having wave lengths within this range falling upon the body surface are also effective in the prevention and cure of rickets. The antirachitic action common to irradiated foods and direct irradiation of the body surface thus received a simple but essential explanation, that is, ergosterol the provitamin was transformed in either instance into vitamin D. The latter when taken in the food is absorbed from the gastro-intestinal tract; when formed in the skin it is absorbed into the blood of the cutaneous vessels.

The shortest waves in sunlight have a wave length of about 290 Mm, whereas those from artificial sources are around 220. Dust, smoke or water vapor in the atmosphere, being opague to the shorter waves, markedly reduce the antirachitic effect of sunshine. Ordinary window glass filters out rays of the shorter wave lengths and thus destroys the antirachitic effect of sunshine.

The antirachitic waves are incapable of penetrating the skin to any considerable extent beyond a depth of a half a millimeter or so. About eighty percent of the rays are absorbed or reflected from the corneous layer; the remainder are absorbed by the Malpighian layer and the corium. The blood in the capillaries of the corium acts as a filter, none of the ultraviolet rays penetrating beyond.

The vitamin D formed by the irradiation of ergosterol is not identical with the one produced by the irradiation of the skin. Waddell found that cholesterol after irradiation has an antirachitic potency, when tested upon chicks, equal to that of cod-liver oil and therefore much greater than that of irradiated ergosterol. He concludes that the latter though it posseses a high antirachitic power is not the vitamin D of cod-liver oil or of mammalian skin. In other words, the provitamin which is associated with cholesterol and which undergoes activation in the skin is some substance other than ergosterol. Waddell's findings offer an explanation for certain discrepancies which have been noted in the past between the potencies of irradiated ergosterol and cod-liver oil. It has since been shown that 7—dehydrocholesterol present in small amounts in cholesterol is the provitamin of mammalian skin.

Halbut liver oil is one of the richest natural sources of vitamin D. Cod-liver oil and liver oils of bony fishes generally are other rich sources. The antirachitic potency of dairy products, egg yolk, butter, cream and milk, is as a rule quite low and depends upon the vitamin D content of the diet and the exent to which the animal has been exposed to the sunshine. Vegetable foods are very poor or lacking in this vitamin.

Vitamin D is indispensable to the normal calcification of bone. Its absence from the diet is followed by the development of rickets in the young and osteomalacia in the adult. Vitamin D deficiency is also conducive to dental caries.

The fundamental feature of rachitis is the disturbance of the calcium-phosphorus metabolism with consequent defective ossification and the development of various deformities, e.g., knock knees, bow legs, spinal curvature, malformation of the chest, contraction of the pelvis, and soft depressable areas in the parietal bones. The natural curvatures of the long bones are exaggerated. The enlargements of the costo-sternal junctions—"beading of the ribs"—causes a series of small swellings on either side of the thorax which is referred to as the rachitic rosary. Dentition is usually delayed. Sweating of the head is common. In a rachitic bone the layer of proliferating cartilage is greatly enlarged, being sometimes ten times its normal depth and the cells no longer show their regular columnar arrangement. This layer instead of being sharply demarcated from the zone of preparatory calcification sends out finger-like cellular prolongations into the latter which is almost free from mineral deposit. The trabeculae are malformed and have lost their regularity of pattern. They are composed of tissue very poor in or devoid of calcium (osteoid tissue). The cortex of the bone may also be partially replaced by the osteoid tissue, the extent to which this occurs varying with the severity of the disease.

The precise manner in which vitamin D exerts its effect upon the calcium and phosphorus metabolism is obscure. It has been thought that one of its primary effects was to increase the absorption of these elements from the bowel. Evidence of increased calcium absorption has been afforded by the study of the calcium balance in rickets. Nevertheless, the principal action of vitamin D is more probably the encouraging of the deposition of calcium and phosphorus in the bone.

VITAMIN E

Some years ago it was observed that rats reared upon a diet of whole milk were usually sterile. Evans and Bishop observed a failure of reproduction in rats fed upon a diet containing all the known vitamins and essential minerals. The addition of lettuce, wheat germ or alfalfa corrected the defect. The conclusion was necessarily the existence of a vitamin necessary for normal reproduction. This was subsequently called vitamin E.

In male rats the loss of fertility is a progressive process. In earlier stages of the vitamin deficiency the spermatozoa lose their motility; later germ fells fail to be produced. Finally the spermatogenic epithelium degenerates and the sex instinct is lost. In females, estrus occurs normally and when fertilization occurs implantation of the ovum is not impeded but the embryos after developing a short time die and are resorbed. Information concerning the applicability of the foregoing experimental results to the problem of human sterility is scanty. However, the administration of the vitamin in concentrated form has been highly successful in the treatment of repeated miscarriages.

There appears to be a relationship between the pituitary and the thyroid and vitamin E. The potency of extracts of pituitaries of female rats, on vitamin E deficient diets, to induce ovulation in rabbits is reduced; the power is restored by the administration of vitamin E. The thyroids of E deficient animals become hperblastic and the young born of rabbits on diets containing vitamin E in just sufficient amounts to prevent sterility are cretinous. Degenerative changes in the pituitary, involving both acidophil and basophil cells, have been described as resulting from vitamin E deficiency.

Vitamin E is a higher alcohol, soluble in fat and the usual fat solvents. Like the other fat-soluble vitamin, bile in the intestine is necessary for its absorption. Its chief sources are green vegetables, e.g., lettuce, peas, and the germ of various seeds. Wheat germ oil has a very high vitamin E potency and most ordinary vegetable oils contain it in fair amounts.

VITAMIN K

Chicks upon diets lacking in green stuff are subject to hemorrhagic disease which is traced to a lack of vitamin K. Investigators have demonstrated a relationship between vitamin K and the prothrombin concentration of the blood. The low value for this essential factor in the clotting mechanism prolongs the clotting (coagulation) time. Green leaves, especially of clovers, are rich sources of the vitamin; cereals, yeast and wheat germ contain it in small amounts. No hemorrhagic disease in man, so far as is known, is due to a lack of vitamin K. In fact it has been impossible so far to induce a hemorrhagic tendency in any of the mammals so far investigated. It has been shown that some synthesis of vitamin K occurs in the intestine of the chick as a result of bacterial activity, and it may be that mammalian immunity is due to a synthesis of vitamin K in a greater degree in the intestines of mammals than that which occurs in birds. Vitamin K is fat soluble. Little yet is known definitely with regard to its chemical constitution and properties.

This concludes a brief and inadequate discussion of one set of dietary essentials. Because of limits of time much of historical interest and many technical details and experiments have been omitted. However, it is to be hoped that in some slight way there has been indicated the tremendous advance in knowledge that has been made along these lines in the last few decades, to say nothing of the human ills that have been, if not totally, at least partially eradicated.

CHEMISTRY

POSTWAR PLANNING IN GENERAL CHEMISTRY

By Rev. Gerard M. Landrey, S.J.

In our increasing abundance of postwar planning, ideas for secondary school chemistry should not be out of place. In recent years there has been a tendency toward somewhat liberal, exotic methods in teaching chemistry in American high schools. It is to be hoped that the immediate future will bring a return to the conservative ideals of the Ratio Studiorum and of the early pioneers of chemical education in the United States.

Ira Remsen can be acknowledged as the father of chemical education in our country. His work was raised to new heights in the contribution to chemical education by Alexander Smith who was preeminent as a teacher in general and inorganic chemistry. To him must be accredited the first clear and logical presentation of the principles and applications of fundamental chemistry. The value of his work may be estimated by the wide popularity of his text-books in this country and Great Britain. His influence is reflected in the number of authors of text-books who have followed his method.

The order of Alexander Smith's classical presentation may be briefly summarized as follows: First, the fundamental grammar of chemistry is set forth. Then follows a treatment of the nonmetals beginning with the simplest and most common, oxygen. The nonmetals are first treated since they are the easier to understand. The metals are treated after the nonmetals. Interwoven with the presentation of the practical matter are the theoretical principles introduced according to the capacity of the student. From another standpoint it may be said that Smith's fundamental chemistry consists of a medulla or structure of theory logically and pedagogically developed in a body of descriptive chemistry divided into nonmetals and metals. It is true that the various editions of Professor Smith's texts and of those who followed his method of presentation were modified to meet developments in the science, but strict adherence to general principles was observed. The arrangement and presentation of topics is sound as is evidenced by the widespread reception of Smith's texts by non-author teachers of chemistry and by the reflection of his spirit in the works of teacher-authors who have modeled their works on that of the master.

Recent years have seen marked changes in general chemistry texts. Authors, influenced apparently by the desire for novelty, visualization, etc., have introduced texts which have departed from the standard set by Smith and at the same time from logical and pedagogical presentation. These texts have reverted in the direction of the hodge-podge of chemical knowledge from which Smith broke away in 1906. Clearness and interest must, indeed, be cultivated in text-books, but these qualities can be strained. The so-called desire to make chemistry a reality in the life of the student, the problem approach, chemistry in everyday life, and similar aspirations of authors with consequent unusual selection and arrangement of topics together with, in some cases, an almost extravagant style intended to capture the imagination of the student make these texts savor of modern comic books.

This criticism is not intended to be all-inclusive, for there are present day texts which are to be commended for their sober adherence to principle, and which at the same time do not lose sight of the appeal to interest. The standard text of Black and Conant, on which the New York Province syllabus is happily based, is an example of this latter type. Professor Black in the latest revision of his text, as in the earlier editions, follows the general principles of Alexander Smith. In the clear and interesting presentation of matter he is sympathetic to the immaturity of the student, and at the same time presupposes intellectual cooperation on the part of the student. The photographic illustrations are abundant and well chosen. The diagrams are simple, apt, and devoid of grotesqueness. In general, the clear, interesting, yet dignified presentation of matter seems to warrant a far better impression and lasting effect on the student than the poor arrangement and ephemeral style of some of our modern texts.

In recent years effort has been made by some authors in the matter of study questions, exercises, and mathematical problems arranged at the end of chapters. Much remains to be done in this respect. While the mathematics required in secondary school chemistry is no more involved than setting up and solving a simple proportion, yet this operation taxes the ability of many students. In the light of present day emphasis on mathematics, it is to be hoped that fundamental mathematics may bear fruit in the chemistry course. Would it be out of place here to ask mathematics teachers to introduce logarithms or the operation of an inexpensive slide rule as early as possible in mathematics training that logarithmic knowledge may be applied in the chemistry course? The physics course would also profit by this knowledge of logarithms. These courses are usually placed in the latter two years of secondary school training.

In conclusion, if future chemistry texts present chemistry clearly and interestingly but always as a sound "disciplina mentalis" according to the mind of the Ratio Studiorum, if these texts are arranged pedagogically according to the principles of the Ratio and the conservative methods of the earlier masters of chemistry, much profit will accrue to our young chemistry students.

MATHEMATICS

AN INTERESTING CURVE

Rev. Henry J. Wessling, S.J.

The curve described in the following article has a purely theoretical value. For some it may possess an interest insofar as the right hand branch has the property of trisecting all circular arcs subtended by the line joining the right hand branch of the curve with the vertex of the left hand branch and whose centers are on a line parellel to the axis of Y, bisecting the distance between the origin and the vertex of the right hand branch of the curve. For this reason the author has called the curve the Cyclotomic Hyperbola.

The derivation of the curve is as follows:

On a set of rectangular axes lay off OF and OB, so that OF=OB=K (Fig. I).

If now we draw a series of circles which have their centers on the Y axis and which pass through B and F, the arcs subtended by the cord BF, will in their turn, subtend all angles ranging from 0° to 360° as the center passes from minus infinity to plus infinity on the Y axis. The coordinates of the center of the arc which subtend a given angle will be $\left(O, \pm \frac{\overline{OF}}{\tan \frac{\theta}{2}}\right)$

If we now trisect the arc BRF and draw the radius RS calling it unit radius, this radius will divide the angle CSF or $\frac{0}{2}$ into two angles, CSR and RSF equal to $\frac{0}{3}$. Draw RM parellel to the X-axis and draw the cord RF, which subtends the angle $\frac{0}{3}$ and by the cosine law is equal to $\sqrt{2\left(1 - \cos \frac{\theta}{3}\right)}$, or by further development equal to $2 \sin \frac{\theta}{6}$. Since RS is being taken as unity, MR will be equal to $\sin \frac{\theta}{6}$. Hence the point of trisection of the arc BRF lies twice as far from F as it does from the axis of Y. That is 2RM=RF. The same reasoning applies to all the arcs subtended by the cord BF, whether they be above or below the axis of X. Hence the locus of the point whose distance from F is equal to twice its distance from the axis of Y, is

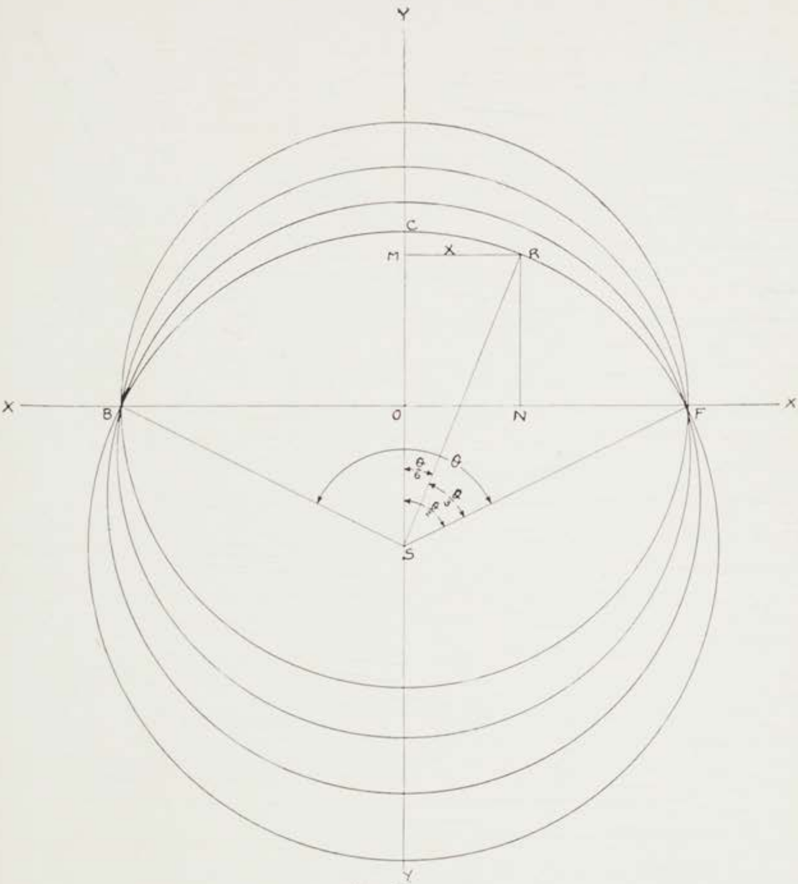

Fig I

the curve passing through and trisecting the arcs subtended by the cord BF.

To determine the nature of the curve we note from the construction that OF is a constant K and RF = 2MR. Now draw the line RN, the ordinate of the point R of the locus. In the triangle RNF we have

$$\overline{RF}^2 = \overline{RN}^2 + \overline{NF}^2$$

$$\text{But } RF = 2RM = 2X$$

$$\text{And } NF = OF - ON = (K-X)$$

therefore by substitution

$$4X^2 = Y^2 + (K-X)^2$$

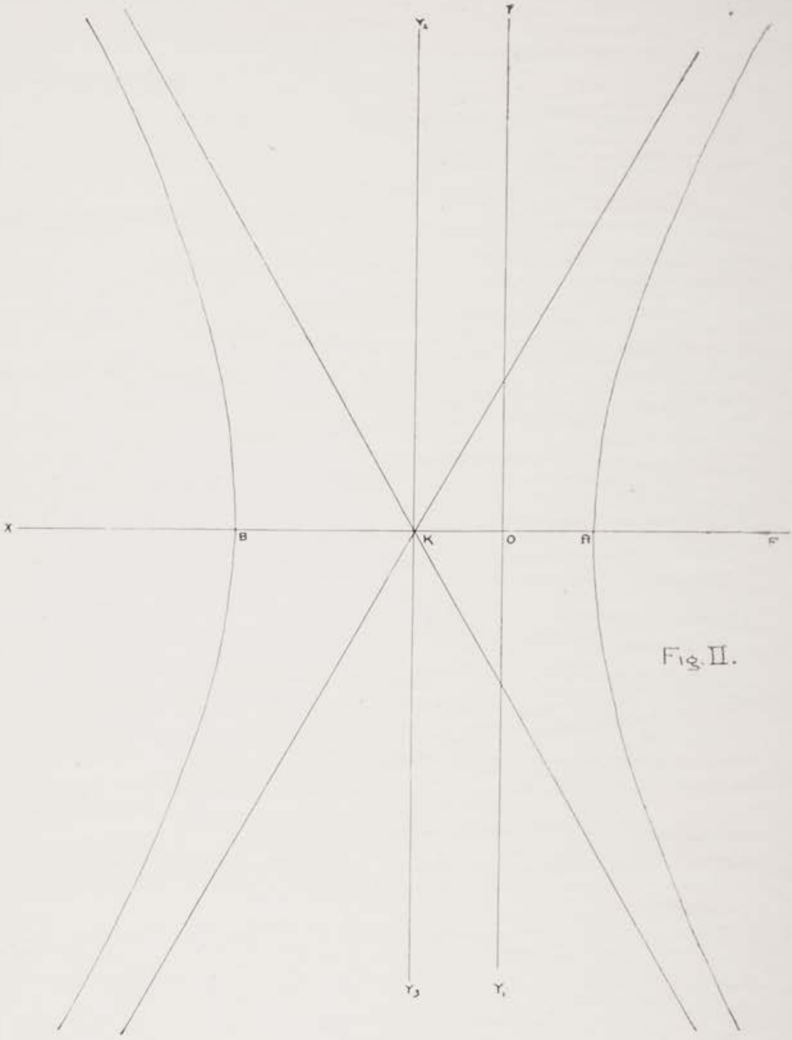

Fig. II.

or by expanding

$$Y^2 - 3X^2 - 2KX + K^2 = 0 \qquad (1)$$

This is obviously an hyperbola symmetrical with respect to the X axis (Fig. II). If now we apply the methods of substitution to obtain the asymptotes for this curve we get the equation

$$Y^2 - 3X^2 - 2KX - \frac{K^2}{3} = 0$$

The X intercept for this equation is $-\frac{K}{3}$ so that the asymptotes intersect at the point $(-\frac{K}{3}, 0)$.

If now we translate equation (1) to the point of intersection of the asymptotes as a new origin we obtain

$$Y^2 - 3X^2 + \frac{4K^2}{3} = 0 \qquad (2)$$

Referring also the equation of the asymptotes to this new center we obtain

$$Y^2 - 3X^2 = 0$$

from which we can conclude that the asymptotes make angles of 60° with the X-axis.

The constants of the cyclotomic hyperbola are readily determined from equation (2) and are found to be

$$a = \frac{2K}{3} \quad b = \frac{2K}{\sqrt{3}} \quad c = \frac{4K}{3} \quad e = 2$$

ON THE APPLICATION OF THE COMPARISON TEST FOR CONVERGENCE

By REV. THOMAS F. MULCRONE, S.J.

It is the purpose of this study to formulate and illustrate a more straightforward method of applying the comparison test for the convergence of a series; a method having the twofold advantage of giving a precise analytic expression to the comparison test, and, in many instances, minimizing the labor involved in the process.

The comparison test states that *if no term of a given series of positive numbers is greater than the corresponding term of a known convergent series, the given series converges; and if no term of the given series is less than the corresponding term of a known divergent series, the given series diverges;* where the known *convergent* series is generally the P-SERIES:

$$1 + \tfrac{1}{2}P + \tfrac{1}{3}P + \dots + 1/nP + \dots, P > 1,$$

or the GEOMETRIC SERIES:

$$A + AR + AR^2 + \dots + AR^n + \dots, R < 1,$$

and the known *divergent* series is the P- SERIES:

$$1 + \tfrac{1}{2}P + \tfrac{1}{3}P + \dots + 1/nP + \dots, P \leqq 1.$$

In actual practice the choice of a value of the quantity P, satisfying the condition of the comparison test, may involve considerable time and effort if we are to rely solely on the trial of various p-series, whereas the following expeditious approach, based upon the statement of the comparison test as given above, removes much of the guesswork from the process.

RULE: If $\underline{u}_n$ denotes the $\underline{n}$th term of the given series which is to be tested for convergency of divergency, then this given series will be:

$$\text{CONVERGENT} \quad \text{if } u_n \leq 1/nP \text{ for some P1} > 1,$$

$$\text{DIVERGENT} \quad \text{if } u_n \geq 1/nP \text{ for some P1} \leq 1.$$

For example, consider the series

$$\frac{2}{2(3)(4)} + \frac{4}{3(4)(5)} + \ldots + \frac{2n}{(n+1)(n+2)(n+3)} + \ldots \quad (1)$$

for which the rate test fails.

Applying the comparison test, this series will be convergent if

$$\frac{2n}{(n+1)(n+2)(n+3)} \leq \frac{1}{nP}, \text{ for some } \underline{\text{P1}} > 1,$$

$$\text{or} \qquad \leq \frac{2n}{2n\ P\text{-}1};$$

that is, if $\quad 2nP\text{-}1 \leq (n+1)(n+2)(n+3)$

$\qquad$ or $\qquad \leq n^3 + 6n^2 + 11n + 6.$

Hence, letting $\underline{p}=3$ (>1) we have $2n^2 \leq n^3 + 6n^2 + 11n + 6,$

$\qquad$ or $\qquad 0 \leq n^3 + 4n^2 + 11n + 6,$

which is true for all $\underline{n} \geq$ O, and hence the series (1) is convergent.

Again, consider the series

$$\frac{1}{3} + \frac{1}{\sqrt{3}} + \frac{1}{\sqrt[3]{3}} + \ldots + \frac{1}{\sqrt[n]{3}} + \ldots \quad (2)$$

for which the ratio test fails.

Applying the comparison test, this series will be convergent if

$$\frac{1}{\sqrt[n]{3}} \leq \frac{1}{nP}, \text{ for some } \underline{\text{P1}} > 1,$$

that is, if $\qquad nP \leq 3\ 1/n$

But it is evident that there is no value of $\underline{P}$ (> 1) that satisfies this inequality for all $\underline{n}$ greater than a given $\underline{n}$.

Now the given series (2) will be divergent if

$$\frac{1}{\sqrt[n]{3}} \geq \frac{1}{nP} \qquad \text{for some P1} \leq 1,$$

that is, if $nP \geq 3\ 1/n$.

Hence, letting $p = 1$ we have $n \geq 3 \ 1/n$ which is true for all $n \geq 2$, and hence the series (2) is divergent.

It will be found that this method of applying the comparison test fails in the case of such series as

$$\frac{1}{3} + \frac{1}{6} + \frac{1}{9} + \ldots + \frac{1}{3n} + \ldots \qquad (3)$$

and

$$\frac{1}{3} + \frac{1}{5} + \frac{1}{7} + \ldots + \frac{1}{2n+1} + \ldots \qquad (4)$$

for which the ratio test also fails. In such examples, however, we may make use of the theorem that the series $u_1 + u_2 + u_3 + \ldots + u_n + \ldots$ is convergent or divergent according as the series

$$k\,u_1 + k\,u_2 + k\,u_3 + \ldots + k\,u_n + \ldots$$

is convergent or divergent, k being a positive constant. A suitable value of k may readily be determined from the inequality relation used in formulating the comparison test. Thus we may show that series (3) is divergent by showing that the series

$$\frac{4}{3} + \frac{4}{6} + \frac{4}{9} + \ldots + \frac{4}{3n} + \ldots \qquad (3^1)$$

is divergent; and that series (4) is divergent by showing that the series

$$\frac{4}{3} + \frac{4}{5} + \frac{4}{7} + \ldots + \frac{4}{2n+1} + \ldots \qquad (4^1)$$

is divergent.

Scholion I. It is to be noted that in attempting to ascertain the nature of a series we generally apply the expeditious ratio test as the first step in the process, having recourse to other tests only if the ratio test fails.

II. This method may also be used when the comparison series is a geometric series. In the case of such examples, however, it will be found more convenient to construct a suitable geometric series term by term from a study of the given series, rather than by trying to find the general term ar^n by the method herein proposed.

PHYSICS

PHYSICS PROGRAM IN WAR TIME

By Rev. Joseph L. Murray, S.J.

If some few wears back there was a failing interest in Physics among High School students, the picture seems now quite reversed. The wide-spread, even wholesale, present interest among young students for everything scientific is, of course, attributable in large part to the present war. Army and Navy requirements in preparation for V-12 and V-5 training programs have stressed Mathematics and Science: in particular, Physics. The V-12 examinations have devoted a large percentage of science questions to Physics.

And yet, in spite of the increased demand for this subject, and renewed interest in Physics among the students, old vexing problems, like a spectre, still haunt the Physics teacher. In fact with increased enrollment in his courses, his problem is automatically magnified. The present writer has noted among his students a marked enthusiasm for Physics as the scholastic year gets under way. In spite of the relatively dry, factual beginning of the science, in spite of the new units, new teaching methods, and so on, the classes taken as a whole start the year with a will. They wish to master the subject; they know its importance for them in the immediate future; and they are more than ordinarilv diligent in the preparation of the classes. This is particularly commendable when we reflect that Physics is after all, only one out of several subjects on the student's schedule.

But as the year wears on, this fine enthusiasm begins to wear out — and this in spite of the teacher's best efforts. Students in the upper intellectual brackets remain as keen as ever, but after a few months, the average pupil, perhaps not consciously or willingly, becomes discouraged. Instead of his mastering High School Physics as he had hoped, he finds in the end that Physics masters him. In its broad scope it is too much for his average mind. It is not that he does not find his Physics classes as enjoyable as ever. If anything he finds the subject more interesting as he sees more of it. The lectures can be illustrated with exciting and practical demonstrations taken from everyday life, and this appeals to him. But after some months it is noticed that the average student, unwillingly perhaps, begins to leave his interest behind when he departs from the classroom. He has become confused; he is overwhelmed. The subject matter he finds too diversified; there are so many physical principles rolling around inside of his head, like nuts in a bag, that he cannot coordinate them.

His memory is a limited faculty. He has tried to remember so many of the facts of Physics, so many definitions, perhaps, or formulas, that each new fact added to the former ones hurts his head. Since the average boy is not very fond of headaches, he may now give up trying.

These symptoms of waning interest, rather we should say, of discouragement manifest themselves very gradually. They are not found in all the boys, as we have said, but nevertheless enough are affected to constitute a real problem for the instructor. Discouragement, I have found, rears its ugly head when the teacher leaves off teaching and begins to lecture. Sooner or later the instructor must 'turn on the pressure' in order to cover the matter assigned for the year. He instinctively adopts 'lecturing' as a refuge. I think it can be admitted that a teacher can cover much more of the text-book by lecturing than by teaching. But while the instructor is forging ahead, the students are apt to straggle out behind. Here is where discouragement sets in.

No single part of High School Physics is too difficult for a pupil to master if he is taught properly. The subject must be analyzed for him; diagrammed; illustrated. It must be repeated again and again; oral and written repetition must be insisted upon. This would be ideal if the teacher had to cover only half the assigned matter and had twice the time in which to do it. The present writer has found four teaching hours a week, not counting Laboratory, quite inadequate to thoroughly TEACH the prescribed matter. He can cover most of it by lecturing, but when he 'lectures', teaching suffers, and the pupils suffer too.

Lecturing is an accepted method of presenting Physics to more mature students, let us say, in college. It strikes me, in general, as a bad method for instructing the average High School boy. And yet lecturing is the only means left the teacher if he is to complete his text-book by June.

If less insistence were made on finishing so much matter, and more effort given to teaching a relatively few physical principles well, it seems to me the average student would profit immensely. It is not even good scientific method to treat a difficult subject cursorily. Now the least, (some would say the most) we can give our science pupils is a good introduction to the scientific method. If at the end of the year the majority of Physics students know a good measurement when they see one; if they have learned to respect, even reverence, the instruments and apparatus of science; if they can present a neat, careful and accurate list of simple facts as observed in the laboratory, then the year has been worthwhile for them. It is poor pedagogy for the teacher to jeopardize these obvious benefits of science by setting the pupil the bad example of haste. By hurrying over important sections of Physics in order to cover the whole subject, the instructor may give his pupils a smattering of the entire science, but he will not be scientific in doing so.

The prospects of the majority of our present High School graduates have a pronounced military tinge. If present government plans remain unaltered our High School youth will be absorbed into the all-important task of preserving the well-being, the very life of our country. What college education some of our young men shall receive will be with the blessing, encouragement and assistance of their country. Should these facts influence Science teaching in secondary schools? The obvious answer seems the correct answer.

*Captain Benjamin C. Bowker of the United States Army, speaking at the meeting of the Association of Physics Teachers in May, 1942 outlined what the army requires of our educated youth today. These requirements are not many. They call for no elaborate program, but they do demand a knowledge of rock bottom fundamentals. The first three of these needs are, in order:

1. Capacity for clear accurate expression.
2. Ability to do mathematical computations accurately, and with comparative rapidity.
3. A clear general picture of some exact science.

Captain Bowker implied that many of the young men entering the Armed Forces were lacking these essential characteristics. He suggested giving Physics pupils many problems. involving basic arithmetic with insistence that they *get the right answer*.

For our schools to meet these army prerequisites requires, as it seems to this writer, not more Physics, or Mathematics or Science, but less. For in giving the boys less we can insist more on fundamentals. In this way we can make haste slowly.

*School Science and Mathematics, October, 1942.

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Ohio	The Xavier University, Cincinnati
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Washington	Seattle College, Seattle
Wisconsin	Marquette University, Milwaukee

High Schools are not included in this list.

Jesuit educators are maintaining and directing nearly 300 Universities, Colleges and High Schools in the world.

Laus Deo Semper.