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The Editor's Page

The Editor would like to call the attention of all the members of the Association to the article published in the September Issue of this year entitled, "Suggested Topics for Articles to be Published in the BULLETIN." It is his fond hope that this article will be read and pondered by every member interested in the welfare of the BULLETIN. The contents of this article may be considered the official editorial policy of our publication. Certainly it proposes a scope wide enough to provide subjects for every one of our members from those who are starting their work in scientific fields to those whose work and opportunities have carried them much farther into the depths of their subjects. High school teachers, college professors and graduate directors will find subjects fitted to their daily work. It is the Editor's conviction from discussions with the members that they want especially to know what other Jesuits in the Provinces are finding helpful in arranging courses, adapting laboratory space to today's needs, modifying and developing apparatus, clubs, seminars, publications and the thousand details that make up the running of a science department in our schools.

Sufficient time has now elapsed since the end of World War II for us to evaluate the work done in each of our colleges. Little or nothing of this valuable history has appeared in the pages of the BULLETIN. Wouldn't it be unfortunate to allow the details of this period to be lost in obscurity? A rather lengthy "News Item" on this subject from each and every department in the Provinces would be of inestimable value for present information and for future record.

The Editor has been gratified with the reports of our Secretary, Mr. Robert Brennan, S.J., on the response of the Association concerning the new membership list. This list is now nearly completed, and as soon as possible will be Addressographed and used for the mailing list of the BULLETIN. This will facilitate the mailing of the BULLETIN, and at long last modernize the mailing to insure each member receives his copy.

Science and Philosophy

MEASURE AND MEASUREMENT KNOWLEDGE

JOSEPH P. KELLY, S.J.

> *"The aim of the physicist is to understand the world of reality. The means which he uses to attain this end are what are known in physical science as measurements".* PLANCK.

The professed purpose of the natural scientists is to present a logical interpretation of the material universe, of the bodies which compose the universe and of the properties and activities of these bodies. All scientific investigation is directed to that goal. All the natural sciences presuppose the objective existence of physical bodies, together with their activity. "Theoretical physics is based on the assumption that there are real events not depending on our senses. This assumption must be maintained in all circumstances and even the physicists of positivist leanings make use of it". (1). It would be even more true of experimental physics. Almost every textbook in science states this proposition in some form: e.g., "science is objective"; "science does not create facts but merely discovers what already exists". Stated in other terms, it means that there are physical events apart from and independent of the observers. Gravitational phenomena were real events in the world before man existed to note and observe them. Chemical compounds were formed and dissolved throughout the long ages anterior to man's coming on earth. This is the evident meaning of the extension of a scientific theory into past eras.

The task of interpreting Nature is so vast that no one branch of human knowledge is capable of embracing it in its totality. Hence we employ the "divide et impera" principle and divide our knowledge into various parts. Moreover, even in the sciences, no individual science can make pretence to be all-inclusive in its own field, that is, to exhaust the entire content of the objects which it studies. Physics and Chemistry both investigate the atom and neither tells the whole story of this physical body. Whence arises the unavoidable limitation of scientific knowledge and the equally unavoidable necessity of selecting certain aspects of the material world and of material bodies as the proper and formal object of the separate sciences. Nature in its *quantitative aspects* has become the formal object of the natural sciences. A quantitative object is one that is subject to sense perception and capable of measurement, so that the scientist, ex professo, limits his

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(1) Planck, "The Philosophy of Physics", p. 20. Norton, 1936.

inquiry to the sense-observables and the measurables. The other aspects, such as the qualitative, must be left to other fields of investigation. The non-observables are outside the scope of physical science. "Physics is an exact science and depends upon measurement, while all measurement requires sense perception". (2). Although there is no unanimous agreement among the scientists on the precise meaning of the "observables", they are all in accord with the principle that only the observables and the measurabes fall within the scope of scientific investigation. This would fit in with the citation just given from Planck and with his definition of a physical law: "a proposition enunciating a fixed and absolutely valid connection between measurable, physical quantities." (3). Since most physical laws and theories are expressed mathematically in equations, Heisenberg proposed that only those quantities shall enter the equations which are intrinsically measurable. Bridgman claims that this follows the Operational Viewpoint and that "only those physical concepts have meaning which can be defined in terms of physical operations, which means in particular that no quantitative physical concept has meaning unless it corresponds to something measurable". (4). All these opinions follow the same pattern. On the other hand, some scientists push these opinions to an extreme and assert that the non-observables are non-existent. Dingle writes that "the criterion of objective existence is the general observability by physical means". (5). When Einstein asked the question: "if an object cannot be observed, why is it necessary to assume its existence"? it was obvious that he expected the answer to be that there was no reason for assuming its existence. We cannot take this principle in its literal sense, for there are other means of knowing the existence of an object besides scientific observability. The interpretation must be something like this: that the non-observables have no existence in science, in the sense that they do not enter into the proper object of scientific investigation. But even here certain difficulties arise. Meyerson notes that some non-observable factors enter into many scientific explanations simply because they are necessary for the formulation of a theory. (5a). Without going further into this controversy, we may accept it that the scientists are agreed on the principle that those things are observable which are intrinsically measurable. In this sense, the observables and measurables are the property of the physical sciences.

THE PHILOSOPHY OF MEASURE

That measurement and measurement processes are of fundamental importance in science is but to state a truism. The history of the physical sciences shows that progress and success in science have grown in proportion to the degree in which exact measurement of phenomena

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(2) Planck, "The Universe in Light of Modern Physics". P. 7. Norton, 1931.

(3) idem. p. 62.

(4) Bridgman. "The Nature of Physical Theory." p. 62. Princeton, 1936.

(5) Dingle. "Science". May 1938.

(5a) DeBroglie. "Matter and Light". p. 23. Dover Pub. 1946.

has been found feasible. Through quantitative measurement the scientists have been able to calculate to what extent and intensity physical agents operate. As the study of Nature became more profound and new facts were brought to light the scientists with admirable ingenuity devised new standards and new instruments of measure. One of the striking features of this development has been to make the measurement more objective. Yet, despite the fact that measurement has become the specialized province of the sciences, one would be hard pressed to find in scientific writings a formulated philosophy of measure, that is, definitions, principles and methods. When Galileo first directed his attention to the "quantitative" as opposed to the "qualitative" interpretation of Nature, he did not think out a new philosophy of measure but made use of common knowledge and the principles then current in the Schools. (6). He did not deny that the "qualitative" had its own value. He believed that the "quantitative" investigation was more fruitful for scientific knowledge. History has confirmed his judgment. It would be a false inference to conclude that the Medieval Philosophers had no knowledge of the quantitative aspects of the material world. True, they had no well equipped laboratories to carry out experiments, nor precisional instruments to measure accurately physical phenomena. On the other hand, they were well aware that the quantitative and the qualitative existed side by side and they did formulate a definite philosophy of measure. They defined measure as "that by which quantity is known" (7). They stated definite principles of measure and measurement processes; they recognized that standards were necessary and that these norms should be relatively fixed and unchangeable; that there were a multitude of possible standards in the universe. And finally that measure was essentially a comparison between one quantity and another, as a standard, from which could result only a knowledge of quantity. It is much to be regretted that the Scholastics did not make use of this philosophy of measure which they so clearly stated. For, it was according to these principles of measure that modern science has so well succeeded in the past three or four centuries. Granting all the new standards and the innumerable applications to more recent phenomena of light, heat, electricity, etc., wherefrom we have built up a veritable fund of knowledge of the physical universe, modern science has added little to the *philosophy of measure* formulated in Scholastic Philosophy. We believe that this conclusion is evident from the study of the history of science.

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(6) Galileo. "Two New Sciences". Northwestern. 1939. Galileo acknowledges that Aristotle had already used some of the principles that he was using.

(7) Suarez. "Disputationes Metaphysicae" Disp. XL. Sect. III. No. 11. Vives, 1861.
Jesuit Science Bulletin. Vol. XIV. May 1937. p. 159. sq.
Jesuit Science Bulletin. Vol. XXII. May-June 1945. p. 98. sq.

The problem is not concerned with measurement in itself nor with the knowledge that results from measurement processes but rather with the place that measurement knowledge should hold in the hierarchy of human cognition. That it has a valid place, no one would deny. The history of the human race as well as the history of physical science demonstrates only too clearly that men have always found measurement necessary and useful in daily life. In this field man has met each crisis successfully just as to-day the scientists are devising new measures to deal with their latest, scientific discoveries. Whether we take the simplest methods of linear measure, by palms and cubits, or the much more complicated mathematical calculations of Wave Mechanics or Relativity, the process is essentially the same: the comparison of one unit quantity with another quantity to gain some knowledge of the latter. *But it is always in the order of quantity.* As Mach asserts: "measure is the definition of one phenomenon by another phenomenon" (8). In all cases, the measurer touches upon the real but upon *only one aspect* of the real object. The act of apprehending the objective reality, whose existence is supposed, seldom if ever touches the whole of reality. All our cognitional acts are partial. The "divide et impera" principle, which we employ in studying the material universe and all that compose it, is always a sort of isolationist process; it helps us to focus our attention of one part of the being but leaves others untouched. Hence any individual branch of human knowledge demands a "complement" in some other branch (9). This is but another way of saying that no individual science can present a complete picture of the external world, as we noted above. For this reason we have separate sciences: Physics, Chemistry, Geology, etc. And on the same principle we find various divisions, e.g., of Physics into heat, light, electricity, etc., and even these have their own subdivisions. This limitation of the human mind face to face with reality demands an approach through some methodology, determined partly by the goal intended and partly by the nature of the object under consideration. Different studies have different methods and rules of procedure. The rules of one method cannot be transferred and applied to another branch of knowledge without necessary modification. The methodology of physical science as such, cannot be applied to humanities or legal justice without due regard to the subject matter and its relation to the human intellect.

Measure is the methodology of the physical sciences. There are

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(8) Mach. "Scientific Lectures". p. 206. Open Court.

(9) This idea of "complimentarity" is well illustrated in modern science. Certain light phenomena cannot be adquately explained by the corpuscular theory alone nor by the wave theory alone. An adequate explanation demands that one "complement" the other.

c. f., DeBroglie. "Matter and Light". p. 93. Dover, 1946.

definite rules and procedure for measurement processes. It has its defined goal, viz: the knowledge of the quantitative. The scientist constantly asserts that he is dealing with facts. As far as his science is concerned, a fact can become *scientific* only on the condition that it have a quantitative aspect and that it can be assimilated within the framework of physical observability and quantitative measurement. Otherwise, it has, generally speaking, no interest for him; it is not scientific. The patriotism of the soldiers in World War II would not be a *scientific* fact, since it is not judged by quantitative measurability. Scientifically, it has no existence according to the criterion proposed above by Dingle and Einstein. One would be rash indeed to deny its reality. The knowledge derived through measurement processes is real and valid knowledge, but it is one and only one aspect of reality. Even the most accurate measurement does not touch the intrinsic nature of the object, but only its phenomenal aspects. A scientist may set up his apparatus in the laboratory to measure the force of gravity. He may so control the experiment as to eliminate as far as possible all errors, (except the personal equation), or reduce them to a minimum. His calculation may be very accurate to the seventh decimal place. Yet all these measurements do not tell us what the force of gravity really is. Measurement knowledge, useful though it be, does not and cannot tell us the whole story of the material world. The human intellect carries man far beyond the limits of measuring instruments. The very logic of scientific knowledge, the logical and intellectual consistency of Physics is itself a non-measurable. To try to confine the mind of man to the observables and measurables would belie the history of the human race and nullify the intellectual endeavors of the great minds of the past who have been the forerunners of our civilization. The hierarchy of human cognition contains very many branches of which the physical sciences are but one. The knowledge derived through measurement processess does help us to the better understanding of the universe and the beings that make up this universe. The universe of "science" is a new universe, one might say, and yet if it were merely a universe of the measurables I doubt that even the scientist would care to live in it. Now all this might be summed up by saying that measurement knowledge is only one small part of human knowledge and that it occupies but one relatively small place in the hierarchy man's cognition. To this I suppose that most would subscribe and little more need be said except for the fact that certain ones in both science and philosophy claim that there is no valid knowledge except what comes to us by way of the sciences, and that we should accept no knowledge unless it squares with scientific knowledge. Perhaps these ideas are not as prominent as they were some years ago. Jeans and Eddington have told us that the scientist has learned humility in recognizing the limitations of scientific investigation. Planck and De-Broglie would go beyond this in holding that "it is wholly absurd to maintain that an intellectual experiment is important only in proportion as it can be checked by measurement; for if this were so, there could be no exact geometrical proof" (10). Reality is a very complex entity, and knowledge is the mental counterpart of reality. Therefore it is also very complex and made up of many phases. The "complementarity" aspect of human knowledge, to borrow a phrase from science, is a necessity for the adequate interpretation of the objective. Measurement of the quantitative contributes one share. Other branches also contribute their share whether they are based on the measurable or independent of it. The sum and total of all present a rather satisfactory picture of the real world.

A DISPLAY RAIL FOR MAPS AND CHARTS

Some school suppliers sell map rails. These are designed to overcome a difficulty that the teacher encounters in having to check the spacing of blackboard hooks for each map or display he intends to use in a given class. In such devices the hooks can be slid along the rail at a moment's notice to accommodate the spacing requirements for any chart or map. By adapting some standard electrical molding to that purpose, display rails can be made at about one-quarter of the price ordinarily demanded by the school supply houses.

No. 500, "Wiremold" Raceway can be obtained from almost any electrical supply house in ten foot lengths at about seven cents per foot. It is one form of the familiar electrical molding that is sometimes used in short lengths over ceilings and walls for providing another outlet or two from some electrical line that was put up with the building. Its channel is about 3/4 inch wide and 17/32 inch deep. A long strip of metal that comes with it is slid out of the channel. Holes are drilled in the back of the channel for attaching it to the wall. This provides the map rail.

The hooks for this rail are made by cutting off 1½ inch lengths of the metal strip that was withdrawn. These are then ground down so that they run easily in the channel track. Each of these sliders is drilled at the centre and suitable hooks are bolted to the sliders. After a sufficient number of sliding hooks have been placed in the track, the ends of the track may be crimped with a pair of pliers to keep the slides there permanently.

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(10) Planck. "The Philosophy of Physics". p. 27.

Biology

MODERN MENDELIANISM

WILLIAM D. SULLIVAN, S.J.

There is no knowledge, termed "scientific", which does not include the unchangeable and definite laws of science. No science is truly known unless the laws of that science control and actually predict the inevitable happenings of nature. There is a definite cause for every effect, a definite effect from every cause. To know these causes and their effects is the acme of the scientist's desire; it is the 'finishing-touch' to his patient labor. Such are supposed to be the laws of Mendel; but are they? Do the laws of Mendel's discoveries control and predict the inevitable happenings of the genes and the chromosomes? With the modern discoveries of linkage of genes and crossing over of homologous chromosomes, it would appear that the laws of Mendel are not scientific; they do not control or predict the happenings of genetical evolution. It seems that these rather recent discoveries of new principals violate the laws, making them untrustworthy, changeable and indefinite. Is all the care, therefore, the patience and the labor of Mendel contradictory to his conclusions? Are there, in other words, any unpredictable exceptions to his laws — if they are laws? No. Linkage and Crossing-over are not exceptions; rather they are his laws expanded through modern research.

The formation of the laws of science is by no means an easy undertaking. For eight long years Mendel pursued his monotonous task of breeding the Leguminosae. His voluntary task was by no means an easy one. "It requires indeed some courage to undertake a labor for such far-reaching extent; this appears, however, to be the only right way by which we can finally reach a solution of a question the importance of which cannot be overestimated in connection with the history of the evolution of organic forms.

"This paper, now presented, regards the results of such detailed experiment. This experiment was practically confined to a small plant group, and is now after eight years pursuit, concluded in all essentials. Whether the plan on which the separate experiments were conducted and carried out was the best suited to attain the desired end is left to the friendly decision of the reader."[1]

1—Experiments in Plant-Hybridisation by Gregor Mendel. pg. 1.
(Read at the meetings of the 8th February and the 8th March, 1865)
Translated by the Royal Horticultural Society of London.

The two principles resulting from the many experiments of Mendel, are the principles of segregation and independent assortment. The law of segregation means that there is a separation and redistribution of allelomorphic genes (Mendel did not know them as genes, but as determiners) during the reduction of chromosomes in spermatogenesis and oogenesis. No gamete, in other words, carries both genes (or determiners) for the allelomorphic characteristics. Mendel discovered these two laws in the following way: he crossed a red-flowered legume with a white-flowered legume. The entire F_1 was a hybrid with the red color dominating the white. From 929 plants which he raised in the F_2 generation, 705 of them were found to be red, and 224 were white; the ratio being 3:1. In all his experiments with any pair of characters, his results showed the same ratio of 3:1, the dominant character appearing on the top side of the ratio and the recessive on the bottom side.

The pairs of characters and the results of his experiments are as follows:

F_2 a) Difference in the form of seeds:—of the round seeds (dominant) there were 5,474; of the wrinkled seeds (recessive) there were 1,850. Ratio of 2.96 : 1.

b) Difference in the color of the seed albumen (cotyledons, containing food for the embryo):—of the yellow (dominant) there were 6,022; of the green (recessive) there were 2,001. Ratio of 3.01 : 1.

c) Difference in the color of the seed-coat:—of the gray (dominant) there were 705; of the white (recessive) there 224. Ratio of 3.15 : 1.

d) Difference in the form of the pods:—of the inflated pods (dominant) there were 882; of the constricted or wrinkled pods (recessive) there were 299. Ratio of 2.95 : 1.

e) Difference in the color of the pods:—of the green (dominant) there were 428; of the yellow there were 152. Ratio of 2.82 : 1.

f) Difference in the position of the flowers:—of the axial flowers (dominant) there were 651; of the terminal (recessive) there were 207. Ratio of 3.14 : 1.

g) Difference in the length of the stem:—of the long stem (dominant) there were 787; of the short there were 277. Ratio of 2.84 : 1.

Mendel's experiments may be summarized by the following diagram:

S represents the dominant character.
s represents the recessive character
Parents: .... S x s
F_1 .... Ss
F_2 .... SS Ss sS ss

	S	s
S	SS	Ss
s	sS	ss

Illustrating the ratio of the phenotypes 3:1 and the genotypes 1:2:1.

SS is dominant and a pure line (first genotype) } 1 phenotype
Ss is dominant and recessive (second genotype) }
sS is dominant and an impure line

ss is recessive and an impure line (third genotype) 2 phenotype.

In the offspring there are only two phenotypes and three genotypes. Mendel also found that if the F_2 is unknown, the unknown individual may be mated with the pure recessive parent which is already known to be such, i.e. recessive and pure. If the offspring appear recessive, then the offspring, which was doubtful, is a pure individual. If one appears dominant and another recessive, the doubtful individual is a hybrid.

The second law of inheritance discovered by Mendel is the principle of independent assortment, which means that the relation of each pair of different determiners or genes in hybrids is independent of the other pair in the two parental stocks. The seven pairs of characters in the Leguminosae, used by Mendel, took in the color of the seed, surface of seed, color of the flower, height of the vine, color of the pods, shape of pods, and position of flowers.

Mendel crossed a legume having a round and yellow seed with one having a wrinkled and green seed. The F_1 generation of the dihybrid were round and yellow, the two dominant characteristics. On crossing two of these F_1, the F_2 appeared containing not only the two characters of round-yellow and wrinkled-green, but also round-green and wrinkled-yellow. Just as before, Mendel noticed a definite ratio in the number of these four characters appearing in different plants; the ratio being 9:3:3:1. From the 556 seeds yielded in this F_2 generation there were 315 round-yellow seeds, 101 wrinkled-yellow, 108 round-green and 32 wrinkled-green. Considering the law of segregation where only pairs of characters are noted, there were 423 round seeds and 133 wrinkled seeds, making the ratio 3.1:1; there were 416 yellow seeds and 140 green seeds, making the ration 2.9:1. When both pairs of characters were considered together, however, 9/16 of the plants were round-yellow, 3/16 were round-green, 3/16 were wrinkled-yellow, and only 1/16 were wrinkled green. All of which means that the segregation of each pair of characters when taken alone is altogether independent of the segregation taking place in the other pair.

The following diagram illustrates and summarizes Mendel's law of independent assortment:

	SY	Sy	sY	sy
SY	SY SY	Sy SY	sY SY	sy SY
Sy	SY Sy	Sy Sy	sY Sy	sy Sy
sY	SY sY	Sy sY	sY sY	sy sY
sy	SY sy	Sy sy	sY sy	sy sy

Illustrating the ratio of phenotypes 9:3:3:1.
The genotype ratio is 1:2:2:4:1:2:1:2:1.

Laboring over these experiments for eight long years, Mendel's book-keeping, tremendous as it must have been, reveals a perfect and very accurate account of his two findings: i.e. the principal of segregation with a ratio of 3:1, and the principal of independent assortment with a ratio of 9:3:3:1. According to these two principles Mendel could predict any result which could possibly take place.

Modern research, however, thought that it had found exceptions to these principles, or, at least, that these principles were not fulfilled in every case. The results of modern researches were not in accord with their predictions, predictions first formulated by Mendel. On further research, however, their findings were proved to be not exceptions, but expansions to the laws of Mendel.

Bateson and Punnett, in 1906, discovered the first of these findings in their experiments with the sweet pea. This has since been called 'linkage'. Briefly, linkage may be defined as the tendency of many genes to remain together in the original combination because they are in the same chromosome. Lindsay says that the term linkage "satisfactorily describes the persistent association of unit characters which may well be expected to behave according to Mendelian laws, and which are, indeed, reassorted in a sufficient percentage of individuals to indicate that they are like all unit characters except in their tendency to remain together."[2]

In their experiment with the sweet pea a purple flower with long pollen grains was crossed with a red flower with round pollen grains. Considering the pairs individually, i.e. the color of the flower

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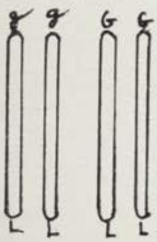
[2] 2—Text Book of Genetics by Lindsay. pg. 126.

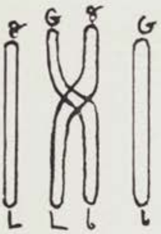
or the shape of the pollen grain, the law of segregation showed the same ratio as predicted, 3:1, with purple dominant over red and the long grain dominant over the round. The inheritance of the two characters together, however, did not eventuate as was expected. Instead of assorting independently of each other so as to produce the ratio of 9(purple-long): 3(red-long): 3(purple-round): 1(red-round), out of 6,952 F_2 plants, 4,831 were purple-long, 390 were purple-round, 393 were red-long, and 1,338 were red-round. These results differed tremendously from the predicted results, which were 3,910.5 purple-long, 1303.5 purple-round, 1,303.5 red-long, and 434.5 red-round. There were, by far, too many of the parental types and too few new combinations in their actual results.

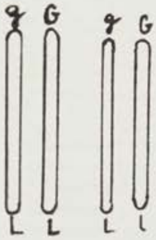
In a second experiment they crossed a purple-round with a red-long. According to the law of independent assortment the results should have been 235.8 purple-long, 78.5 purple-round, 78.5 red-long, and 26.2 red-round. Their actual results in the F_2 generation were 226 purple-long, 95 purple-round, 97 red-long, and 1 red-round. Again there were far too many of the parental stock and far too few of the new combination.

The first experiment of Bateson and Punnett made them believe that some genes (in this case purple and long) clung together and were not inherited independently. While the second experiment caused them to believe that certain genes would not enter the same gamete (F_2), and also were not inherited independently. Experiments such as these were continued for the next few years; the final result being that Morgan, in 1910, claimed that these genes, which either clung together or refused to enter another gamete, were on the same chromosome and would not be inherited independently, but, in what he termed, a 'block'. Such is the principle of linkage, the first expansion or advancement made by modern scientists on the law of independent assortment.

The next advancement made on the second law of Mendel is that of the principle of 'crossing-over'. This too, is an apparent exception to the principles of Mendel, as well as to the principle of linkage. According to the principle of linkage genes on the same chromosome should remain together, but this is not always so; for the genes linked together are sometimes separated. It is known that this link sometimes breaks, and that the breakage is due to an interchange of parts of two homologous chromosomes which cross each other when they pair-up in synopsis.







The above diagram is what is believed to happen in the action of crossing-over. This action, also, is limited by the phenomenon known as 'interference', which has been described as follows: the number of times genes cross over is proportional to the distance between genes. To quote Lindsay, "experiments dealing with crossing-over between associated genes are complicated by the phenomenon known as interference. Since crossing over is an exception to the normal course of meiosis, its occurrence at one point on the chromosome lessens the possibility of its occurrence at a neighboring point, merely because of the infrequency of the phenomenon. An increase of distance between genes lessens the amount of interference to be expected, and also complicates experimental results through the increased possibility of multiple crossing over."[3] Genes are said to be unit distances apart from each other on the chromosomes. If then, genes are within a certain number of units from each other, you will have interference. Colin says that two cross overs never occur within a minimum distance of one another. In Drosophila, for example, this minimum distance is from 10 to 20 units. And as the distance between these units increases, interference decreases. Should the distance exceed 45 units there is almost no possibility of interference.

Since the time, therefore, when Mendel's paper was once again taken from the shelf, dusted and reread, many new genetical facts and theories have been microscoped. Today, genetics is, perhaps, the widest and most scrutinized field in Biology. Old scientists as well as young adjust their objectives, raise their stages and examine the minute worm-like structure, the chromosome, for new discoveries. They all begin with the findings of Mendel and proceed to their prospective ends.

Truly, the humble Augustinian Monk, who was not a professional biologist in name, but surely a scientist in fact, should rightly be hailed the Father of Modern Biology.

3—Text Book of Genetics by Lindsay, pg. 135.

Chemistry

DIMERIC FORM OF ALUMINUM TRIMETHYL AT ROOM TEMPERATURE

Clarence C. Schubert, S.J.

In recent years a great deal of interest has been manifested in such compounds as mercury dimethyl[1], azomethane, acetone, dimethylether, etc., as sources for free radicals. Aluminum trimethyl was deemed a likely subject for investigation, and in the course of interpreting kinetically the decomposition process of the aluminum alkyl it was found advisable to certify the extent of polymerization of the vapor at room temperature.[2]

At twenty degrees Centigrade, aluminum trimethyl is a watery clear liquid with a vapor pressure of approximately 10 mm. On contact with the oxygen of the atmosphere, the alkyl decomposes spontaneously to aluminum oxide and carbon dioxide. The compound may safely be handled in a vacuum, or in a hydrogen or a nitrogen atmosphere. W. Odling and G. B. Buckton[3] announced the preparation of aluminum trimethyl in 1865. The same year, C. Quincke[4] observed that the vapor density corresponded to that of the monomer at 126°, but it was subsequently discovered that at lower temperatures the dimeric form was more in accord with vapor density measurements. Laubengayer and Gilliam[5] made a thorough investigation of the vapor density from 65 to 160 degrees, and concluded that the vapor density corresponded to that of the dimer at 70 degrees. From a consideration of the curve reproduced by Laubengayer and Gilliam there were indications of the possibility of the existence of a higher polymeric form of aluminum trimethyl at temperatures below 70 degrees. Since in our work the absolute amount of aluminum trimethyl present in the reaction vessel had to be known, it was deemed advisable to run a simple experiment to certify the state of polymerization of the alkyl at the temperature employed in measuring the amount of aluminum trimethyl introduced into the reaction vessels.

To accomplish this end, aluminum trimethyl was allowed to react with an excess of water vapor and the decomposition products were analyzed. Distilled water was sealed, in a vacuum, into a small glass tube equipped with a "break-off" end. By distillation of the water at very low pressure it was possible to seal the water in the glass tube with a minimum of dissolved air. The water was frozen down in liquid aid and the tube sealed off in a vacuum of approximately 10^{-3} mm. of mercury. This tube of water, containing water in excess of that needed to react with the amount of alkyl later to be introduced into the reaction vessel, was inserted into the reaction vessel. Thereupon the reaction vessel was sealed to the apparatus used in the kinetic studies described in reference no. 2. After the introduction of the alkyl, the reaction vessel was removed from the apparatus, the water capsule broken by shaking the tube, and, since the reaction occurred spontaneously, the vessel was resealed to the apparatus in position for the analysis of the reaction products both qualitatively and quantitatively.

The gas which distilled over from the reaction vessel while it was immersed in liquid air contained methane and would have contained hydrogen if any had been present, since both of these gases have appreciable vapor pressures at liquid air temperatures. Analysis by means of the microchemical gas analysis apparatus of Blacet and Leighton[6] showed that there was no hydrogen present. Distillation of the gases noncondensable in a mixture of Dry Ice and ether would have yielded ethane and other two-carbon hydrocarbons, had any been present. In the reaction of the alkyl with water no trace of these gases was found. Since the aluminum oxide was plainly visible it was concluded that the only products formed in the reaction were methane and aluminum oxide.

The analysis for the methane was rendered quantitative through the use of a calibrated McLeod gauge. The aluminum oxide remaining in the reaction vessel was, in one experiment, dissolved in nitric acid and subsequently precipitated as the aluminum complex of 8-hydroxyquinoline and weighed as such after drying to constant weight.

Experimental Results

Exp.	°C.	mm. alkyl	mm. CH_4	%H_2	mm. C_2H_6 etc.	ratio: CH_4/alkyl
72	22	13.1	78	0	0	5.9
74	22	12.4	80	0	0	6.4
75	21.7	12.9	80	0	0	6.2

Though the data presented is meager, nevertheless it points in one direction and was satisfactory for the purpose in view. Of the three runs made with the water vapor, run no. 72 is, perhaps, the most reliable since it was made with most care. The other runs were made at the time only as a check on the method. For run no. 72, analysis for the aluminum resulted in finding that three moles of methane were formed per mole of aluminum. For the ratio of methane to alkyl it is only necessary to compare the pressure of methane to that of the alkyl originally present. All pressures were calculated to the original volume of the reaction vessel and at room temperature, hence they were comparable. It is thus seen that one mole of aluminum trimethyl vapor at room temperature decomposed to form six moles of methane. This results in the equation:

$$[Al(CH_3)_3]_2 + 6\,H_2O \rightarrow 6\,CH_4 + 2\,Al(OH)_3$$

Hence it is concluded that at room temperature the vapor of the alkyl is predominantly dimeric. This was the information required.

It is interesting to note that the trimethyl derivatives of Gallium and Indium[5] are monomeric in the vapor state. Gallium and Indium are in the fourth and fifth periods of the Periodic Table and have correspondingly larger atomic diameters. If the bond joining the two molecules of aluminum trimethyl to form the dimer between the aluminum atoms as would be the case if the ethane-like structure was present in aluminum trimethyl, then it would be expected that the alkyls of Indium and Gallium would be dimeric also. That they are not gives added weight to the hydrogen bridge structure for aluminum trimethyl recently proposed by Buraway[7]. In the cases of Indium and Gallium trimethyls the increased diameters of the metals would militate against the formation of the hydrogen bridge.

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This work was done by Clarence C. Schubert, S.J., at Canisius College as a sequel to his thesis work, "Thermal and Photochemical Decomposition of Gaseous Aluminum Trimethyl." The thesis appeared in The Journal of Chemical Physics, Vol. 14, No. 1, p.p. 1-7, January, 1946.

A SATISFACTORY SYSTEM FOR DISPENSING HYDROGEN SULFATE

REV. BERNARD A. FIEKERS, S.J.

Much has been written on devises for dispensing hydrogen sulfide gas in the analytic laboratory. Indeed, the topic has been aired so much in the literature as to put an end to any further consideration of it and to abate this perennial nuisance of collegiate environs. It was only when the writer recently saw a record for five years' service tagged on a No. 2 tank of the gas in the Holy Cross College Analytical Laboratory, that he decided to look into the matter and pass these findings on.

This record showed that one of the two tanks had been in operation from 1939 to October 2, 1944. It was then replaced. At the date of writing (May 1946) the pressure indicated on its successor would lead one to believe that it had just been installed. The other no. 2 tank for supplying the other half of the hood was started on April 20, 1942, and, barring leakage, we expect two or three more years of service. Since 1942, we have averaged 35 students in the qualitative course "around the calendar". This record speaks for itself.

Further investigation showed that the system for dispensing the gas has been described substantially in the Holy Cross HORMONE (5, 114, 1931) and then modified in 1934 (7, 47, 1934). Since inquiries on this matter are received from time to time, it might be well to bring improvements up to date and record them here. No originality is claimed for any of the features.

Each tank is housed in a closet near the hood. Each is fitted with a no. 613 Hoke—Phoenix pressure reducing valve and the gas is then conveyed to the hood through ½ inch galvanized lead lined pipe. Inside the hood, fourteen evenly spaced ¼ inch hard rubber pet cock outlets were provided on each line. Of the 28 hard rubber cocks, bought from Matheson in 1931, 21 are still in service today. Presumably only seven of these have been snapped off by accident over all these years. The pipe has been plugged at these outlets.

The gas is lead from the pet cock at each outlet into a wash bottle. The student supplies his own capillary drawn tube (1 mm. tip diameter) for connection to the wash bottle.

The "pressure technique" of sufide precipitation is employed. The capillary is not immersed into the solution of cations. A one hole rubber stopper is provided with the capillary, so that it cannot possibly be dipped into the solution. This tube is stoppered very loosely into the top of the reagent flask and the gas is turned on slowly at a rate just rapid enough to allow the bubbles to be counted in the wash bottle. This serves to displace air from the reagent flask with hydrogen sulfide. The reagent flask is then stoppered tightly. The H_2S enters the solution at the surface. When the solution is saturated, the bubbling in the wash bottle ceases. In operation, the solution is presumed to be saturated after three minutes, since there may be leaks at the stopper-glass connections. A gauge pressure of one pound is kept on the lines during laboratory sessions.

Some years ago the writer found that needle valves had to be cleaned and replaced periodically to prevent leakage; the hard rubber fixtures obviate the difficulty. Some instructors advocate having a short length of capillary concealed in one of the rubber connections commonly employed at the outlet in order to prevent excessive flow and uneven pressures at the other outlets. These tend to get clogged with rustlike particles from the line. The lead lined pipe and the student capillary take care of this difficulty. There has always been the practical difficulty of having to wash the bubbling tubes, so as to prevent contamination of the next sample to be used. The pressure system gets around this difficulty to some extent.

The dissolving of precipitated sufides at the desk instead of the hood, still gives the laboratory its "qualitative" character. On certain days, the students can with the minimum of difficulty advertise the fact that they are working. Still, it is generally agreed that this course is no longer the social menace of college legends that it once was. This is also due to the fact that the qualitative course has been on the semi-micro scale since 1939 or 1940.

If it were necessary to rebuild the line, it seems reasonable to connect both parts and use but a single tank of the gas. Under the circumstances it would be necessary to buy the tanks in order to avoid an accumulation of demurrage charges for rented tanks.

Physics

MOMENTUM SPECTRA OF MESONS IN COSMIC RADIATION

William D. Guindon, S.J.

Shortly before America entered World War II, Marcel Schein and his co-workers performed a series of experiments on the momentum spectra of mesons in cosmic radiation.[1] They measured, as a function of altitude above sea-level, the number of penetrating cosmic-ray particles having sufficient momentum to traverse certain fixed thicknesses of lead absorber. Employing the method of coincidences with a counter telescope, they measured the number of particles (which are known to be mesons because of their great penetrating power) able to traverse 10 centimeters of lead, and the number able to traverse 27 centimeters. They were able to plot, in units of coincidences per minute, the number of mesons of range in lead of more than 10 and of more than 27 centimeters as a function of altitude over the range from sea level to 9 kilometers. It is convenient to convert the values of altitude (actually pressure in centimeters of mercury) to equivalent depth, h, in the atmosphere in the usual units of grams per square centimeter. Thus the range in h is from 300 gm/cm^2 down to about 1000 gm/cm^2.

We shall show how, with very simple postulates, it is possible to infer from these simple measurements the characteristics of the momentum spectra, differential and integral, of mesons. Following custom we define the differential momentum spectrum, m (h, p), as the (average) number of mesons with momentum p, present at a depth h, (per unit time) per unit momentum range; or to say it in another way, m (h, p) dp gives the number of mesons with momentum between p and p+dp, present at h. The total number of mesons (per unit time) with momentum greater than p present at h is defined as the integral momentum spectrum, M (h, p), and obviously may be obtained by integrating m (h, p) dp from p to oo. Thus the two momentum spectra are mutually related:

$$M(h,p) = \int_{p}^{\infty} m(h,p')\,dp' \qquad (1)$$

$$m(h,p) = -\,\partial M(h,p)/\partial p \qquad (2)$$

For a given depth, h, below the (hypothetical) top of the atmosphere, the differential spectrum gives the distribution of momentum, p,

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[1] Phys. Rev., 58, 1027 (1940).

among its possible values, while the integral spectrum gives the total number whose momentum exceeds any given value.

The system of units emploped in this paper is that suggested by Rossi,[2] sometimes called the "electron-relativistic" units. The four fundamental units are (1) electric charge: e (charge of positive electron); (2) potential: v (volt); (3) velocity: c (velocity of light); and (4) length: cm (centimeter). Derived units pertinent to this paper are (1) time: cm/c; (2) energy: ev; (3) momentum: ev/c; and (4) mass: ev/c^2.

We now make the following simple assumptions: (1) that we are dealing with mesons of unit charge, e, and of mass, μ, equal to 180 electron rest-masses (i. e.: 0.918×10^8 ev/c^2), with a mean life-time, r, of 2.15 microseconds, or 6.45 cm/c; (2) that mesons experience in air a constant rate of momentum loss equal to 2×10^6 ev/c per gm/cm^2; and (3) that all the mesons are produced above 9 kilometers so that the only processes capable of changing the number of mesons present in an incident beam within a given momentum range, are (a) their natural decay, and (b) their absorption by the matter they traverse.

We are now ready to turn to Schein's results; as plotted in Figure I they represent values of the total number of mesons of momentum large enough to traverse 10 or 27 centimeters of lead. Denoting these limiting momenta by p_{10} and p_{27}, we see that these curves are plots of the integral momentum spectra $M(h,p_{10})$ and $M(h,p_{27})$ as functions of h. Next we note that the difference in corresponding ordinates of these two curves is the number of mesons able to penetrate 10 but not 27 centimeters of lead, and hence

$$M(h,p_{27}) - M(h,p_{10}) = m(h,p')_{\mathrm{ave}}\Delta p \qquad (3)$$

where

$$\Delta p \equiv p_{27} - p_{10} \qquad (4)$$

It follows then that from this difference we can derive an average value of the differential momentum spectrum at h, for some intermediate momentum, p′, for which we choose $p_{18.5}$, the momentum corresponding to the mean range, 18.5 centimeters of lead.

With the assumptions made as to the mass and charge of the mesons, it is possible to determine the values of momentum corresponding to ranges in lead of 10, 18.5, and 27 centimeters; using the calculations of Rossi and Greisen,[3] these momenta are, respectively, 2.25, 3.27, and 4.46×10^8 ev/c. Then, subtracting corresponding ordinates in Figure I, and dividing by Δp, where

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[2] Phys. Rev., 57, 660(L) (1940).

[3] Rev. Mod. Phys., 13, 240 (1941).

$$\Delta p = 2.21 \times 10^{7}\ \mathrm{ev}/c \qquad (4')$$

we obtain average values of $m(h,p_{15.5})$ as a function of h; this function is plotted in Figure II.

This function, however, since it gives the number of mesons of a single momentum as a function of h, is not, as it stands, a useful description of the momentum distribution of cosmic mesons. But, under our assumptions, it can be made to yield the desired function, which is $m(h,p)$ as a function of p for some selected h, the probability distribution of momentum at a given depth in the atmosphere.

First of all, given the rate of loss of momentum as the mesons traverse the atmosphere, we can determine the momentum that each group of mesons (corresponding to each point in Figure II) had when they were at the level $h = 300$ gm/cm^2, for instance, by adding to their momentum at the level where they were observed the loss of momentum due to the intervening material. (This loss, of course, varies with h.) Thus, in general, if h_1 and h_2 ($h_2 > h_1$) are levels where the same meson has momentum p_1 and p_2 respectively, and if a is the loss of momentum per unit of h, then obviously

$$p_1 = p_2 + a(h_2 - h_1) \qquad (5)$$

Secondly, if we know the probability of the meson's survival to the depth h_2, despite its natural decay process, then from the observed number at depth h_2 of momentum p_2 we can deduce what number must have been present at depth h_1 of momentum p_1. This procedure obviously rests on the assumption that no mesons have been produced between h_1 and h_2. By a simple calculation the probability, w_{12}, that a meson whose momentum at h_1 is p_1 will survive to h_2 where it is p_2, is found to be

$$w_{12} = (h_1 p_2 / h_2 p_1)^{\mu z_0 / \tau (p_2 + a h_2)} \qquad (6)$$

where z_0, the apparent depth of the whole atmosphere, when assumed to be isothermal, has the value 8.15×10^{5} cm, and the other symbols have their previously defined meanings.[4]

Combining these results we take each point of the curve in Figure II and (1) find the corresponding momentum at $h = 300$ gm/cm^2, (2) determine the probability of survival from $h = 300$ down to the level of the point chosen, (3) divide the ordinate of that point of Figure II by the probability of survival, and (4) plot the quotient as ordinate against the corresponding momentum for $h = 300$. Thus we have in Figure III the differential momentum spectrum, $m(h,p)$ at the level $h = 300$ gm/cm^2 as a function of momentum. Then from this valuable curve we can, by graphical integration, obtain the integral mo-

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[4] Cf. Appendix for derivation of Equation (6).

mentum spectrum, $M(h,p)$ at $h=300$ as a function of p, as in Figure IV. Furthermore, it is possible, by repetition of the same procedure, to obtain similar information for any other level (below which no mesons are produced); curves for $h=600 gm/cm^2$ are given in Figures V and VI.

We have now results sufficiently detailed to be of service in discussing the validity of our assumptions and method; some of the points of Figures IV and VI represent quantities found in the empirical plot of Figure I and thus the consistency of these points serves as a measure of the correctness of the theory. Let us compare experimental and derived values of the total number of mesons present at $h=600$ with range larger than 27 centimeters of lead: Figures I and VI give 1.9 and 2.1 per minute. This agreement is again found if we compare values of the number of mesons able to penetrate 10 centimeters of lead at the same level: Figures I and VI give 2.6 and 2.8 per minute. The agreement of theory and experiment is not entirely satisfactory, however. For instance, at 9 kilometers ($h=300$ gm/cm^2) Figures I and IV give 4.0 and 14.0 mesons per minute capable of passing through 27 centimeters of lead, and 5.9 and 14.5 per minute able to penetrate 10 centimeters of lead.

There seem to be two likely explanations of this discrepancy: either or both may be correct. First, it may be that mesons are produced below 9 kilometers; thus our theory, proceeding from low altitudes to higher ones, gives too high a number of mesons present at the upper altitudes. The experimental determination of the place of production of mesons is among the current investigations of Rossi and his group at M. I. T. Second, implicit in our extraction of $m(h,p)$ for mesons of 18.5 centimeter range from Schein's data of Figure I was the tacit assumption that the ranges of all mesons penetrating 10 but not 27 centimeters of lead were distributed more or less uniformly in this interval. Suppose that this is not so, that they are clustered about the 18.5 centimeter range at $h=300$ gm/cm^2. This could well be the case, as Figure III shows such a maximum density in the region of 4×10^8 ev/c, which corresponds to about 23 centimeters range. If the distribution of momentum possesses such a peak, our simple method of procedure breaks down.

The most probable conclusions that may be drawn seem to be: (1) that the assumptions as to the properties and absorption loss of mesons are correct, (2) that probably some mesons are produced below 9 kilometers altitude, and (3) that the simple procedure here employed gives reliable results only for values of the momentum spectra at levels well below $h=300$ gm/cm^2.

Appendix. Derivation of the Probability of Survival w_{12}.

We wish the probability that a meson which is present where z_1, h_1, and p_1 are its altitude, depth in the atmosphere, and momentum, will survive to the place where these quantities are z_2, h_2, and p_2. Now, if the probability of survival from some zero point to the altitude z is w, and to the altitude $z + dz$ is $w + dw$, then the probability of decaying in dz at z is —dw, and is equal to the probability of survival to z, multiplied by the ratio of the time spent in dz to the (relativistic) mean life of the meson:

$$—dw = w\ (dz/v)/(\tau/\sqrt{1—B^2}) \qquad (6a)$$

Here we use the facts that the relativistic momentum is $p=\mu v/\sqrt{1—B^2}$ and that the altitude and pressure are connected by the relation

$$h = h_0\, e^{—z/z_0}$$

$$\text{or} \qquad dh/h = —dz/z_0 \qquad (6b)$$

This assumes that the atmosphere is isothermal and that h_0 is 1.03×10^3 gm/cm^2 while z_0 is 8.15×10^5 cm. Substitution in (6a) gives

$$—dw/w = \mu dz/p\tau$$

$$= - \frac{\mu}{\tau} \frac{z_0}{p_2+a(h_2—h)} \frac{dh}{h} \qquad (6c)$$

Integration by partial fractions between the limits h_1 and h_2 and defining w_{12} as the probability of survival from h_1 to h_2 we have

$$w_{12} = (h_1p_2/h_2p_1)^{\mu z_0/\tau(p_2+a\ h_2)} \qquad (6)$$

FIGURE I

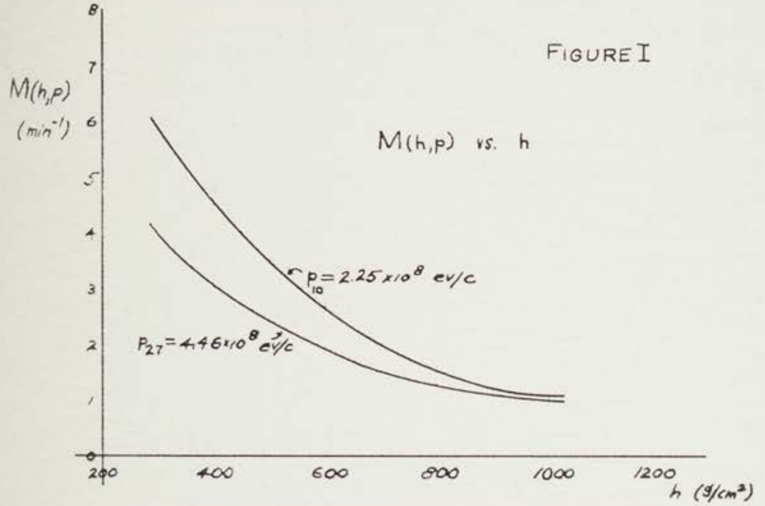
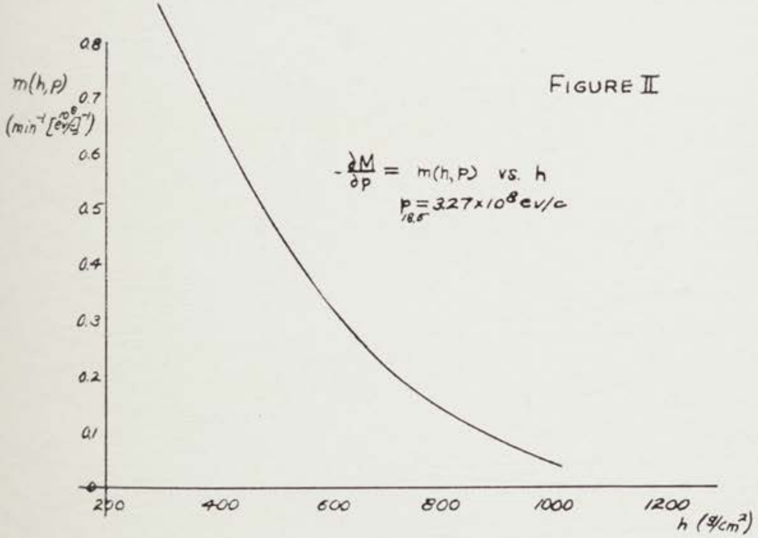


FIGURE II



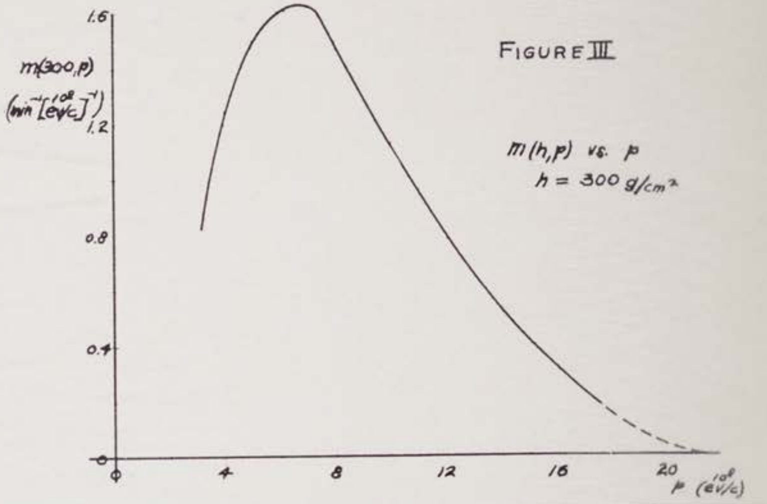


FIGURE III


FIGURE IV

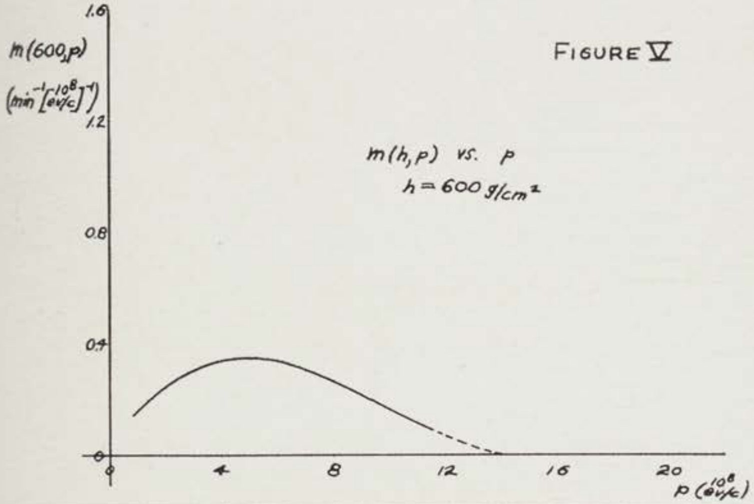


FIGURE V

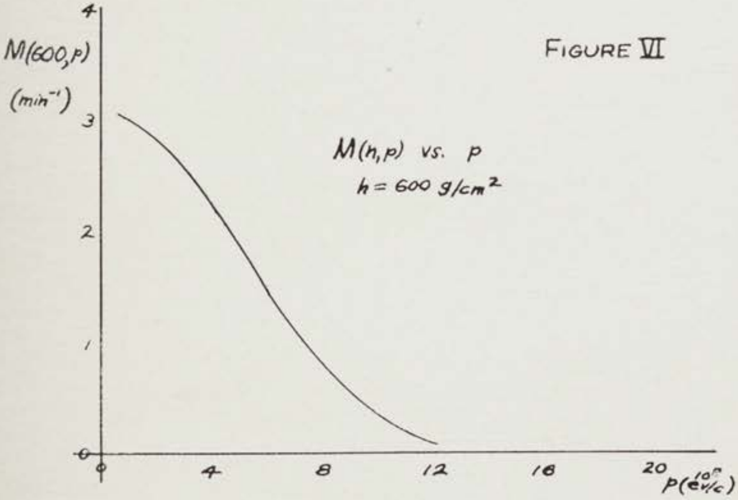


FIGURE VI

News Items

BOSTON COLLEGE

PHYSICS DEPARTMENT

The returning veterans have manifested a great interest in the natural sciences. Out of 1321 September Freshmen we have 402 in the B.S. in Biology, B.S. Chemistry, B.S. Mathematics and B.S. Physics courses. All these students take General Physics in their Freshman year. A group of over 100 February Freshmen are in the second semester. Another 130 in the advanced courses and 16 in Graduate School give us a total of 645 students in the department.

The Physics Research Academy is holding its first meeting at the Sheraton Hotel on Nov. 20th. Dr. Rand McNally of M.I.T. is the speaker. Dr. Fred E. White will welcome the new members.

The veterans who were in radio work in the Signal Corps or in the Navy have reorganized our Station W-1 P R and are operating the 10 meter phone on 29,092 KC with a triple element beam antenna. We hope to have the 20 meter transmitter rebuilt this year.

CANISIUS COLLEGE

CHEMISTRY DEPARTMENT

After a lapse of three years, due to wartime conditions, the Alumni Chemical Society resumed its monthly meetings this year. The Student Affiliates will also attend these meetings besides their own monthly meetings.

A program of speakers is being arranged. At present it is not complete but we expect to have it for the next issue of the Bulletin.

FORDHAM UNIVERSITY

BIOLOGY DEPARTMENT

The facilities in the department, as in all our colleges, are being used day and night to their full capacity. 948 students are taking undergraduate and graduate courses in biology. Seventy of these are graduate students—forty-five of whom are full time graduate students. The students working for the Master's and Doctor's degrees are divided into almost equal numbers.

Many former college classrooms in the biology building have been converted into private research and study laboratories for the large influx of graduate students. Each graduate student is given a desk and work bench with a microscope and other equipment for his own personal study and research.

Last January Dr. Charles G. Wilber, a graduate of Marquette and Johns Hopkins Universities was added to the faculty. He is at present conducting courses in general physiology for the graduate students and mammalian physiology for the undergraduates.

Dr. James Forbes, instructor in Parasitology and Histology is expected to return from the Army in January. He has been attached to the Malarial Research Division of the Army since 1942.

Because of the very large classes in biology seventeen graduate students have been made assistants in the department this year.

There are seven Jesuits studying for degrees this year: Rev. Alfred Kilp of the California Province, ex-Army chaplain; Rev. Leo Schmid and Rev. Edward Healy of the Oregon Province; Rev. James J. Deeley, Rev. Stanislaus Gerry, Rev. Michael P. Walsh and Mr. John J. Alexander of the New England Province.

Some articles by members of the faculty and graduate students are appearing in current issues of various biological journals. Members of the faculty and some graduate students are planning to deliver papers at the AAAS convention in Boston during the Christmas vacation.

Research for the most part has been conducted during the past semester in protozoology, general physiology, entomology, and animal and botanical cytology.

ST. JOSEPH'S COLLEGE

BIOLOGY DEPARTMENT

The total school enrollment is about 1550 — 1200 day and 350 night. The Gen. Biology course has 150, about three times the largest previous class. The Junior and Senior biology classes are still normal but next year, of course, they will also jump to record enrollments. In view of the fact that the present Frosh class is 750, some provision will have to be made for the undoubtedly large Gen. Biology class of next year, i.e., lockers, microscopes, etc. The story is the same in all science departments.

Last June, the Rev. Clarence E. Shaffrey, S.J., M.D., head of the Biology Department received an honorary degree of Doctor of Laws from the college in tribute to his twenty-one years of labor as department head. A host of doctors (all former pupils of his) were present.

JESUIT EDUCATIONAL ASSOCIATION *of the* UNITED STATES OF AMERICA

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California	Loyola University, Los Angeles
California	Santa Clara University, Santa Clara
California	Univ. of San Francisco, San Francisco
Colorado	Regis College, Denver
District of Columbia	Georgetown University, Washington
Illinois	Loyola University, Chicago
Louisiana	Loyola University, New Orleans
Maryland	Loyola College, Baltimore
Massachusetts	Boston College, Boston
Massachusetts	Holy Cross College, Worcester
Michigan	University of Detroit, Detroit
Missouri	Rockhurst College, Kansas City
Missouri	Saint Louis University, St. Louis
Nebraska	The Creighton University, Omaha
New Jersey	St. Peter's College, Jersey City
New York	Canisius College, Buffalo
New York	Fordham University, Fordham
Ohio	John Carroll University, Cleveland
Ohio	The Xavier University, Cincinnati
Pennsylvania	St. Joseph's College, Philadelphia
Pennsylvania	The University of Scranton, Scranton
Washington	Gonzaga University, Spokane
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.