S. J. B

A. M. D. G.

BULLETIN

of the

American Association of Jesuit Scientists

(Eastern Section)

For Private Circulation

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LOYOLA COLLEGE

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EASTERN STATES DIVISION

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REVEREND PIERRE TEILHARD DE CHARDIN, S. J.
PALEONTOLOGIST

PERE DE CHARDIN RECEIVES MENDEL MEDAL FROM VILLANOVA

The Mendel Medal for 1937 was conferred upon the Reverend Pierre Teilhard de Chardin, S.J., by the Very Reverend Edward V. Stanford, O.S.A., LL.D., president of Villanova College, on March 22, 1937. The presentation was made at a dinner given to the faculty of Villanova and the following distinguished guests: Very Reverend Mortimer A. Sullivan, O.S.A., LL.D., Provincial of the American Province of the Augustinian Order, Very Reverend Thomas J. Higgins, S.J., Ph.D., president of St. Joseph's College, Very Reverend Arthur A. O'Leary, S.J., Ph.D., president of Georgetown University, John A. Kolmer, M.D., D.Sc., professor of medicine, Temple University, three members of the Academy of Natural Sciences, and the members of the board of trustees of Villanova.

In presenting the Mendel Medal, Father Stanford said in part:

"Pere de Chardin has been unanimously chosen to receive the Mendel Medal for 1937 because he exemplifies in an especially significant manner the truth that the medal symbolizes. The Mendel Medal was not established to be just one more scientific award. The world already recognizes a number of scientific awards that are granted under the most exacting conditions. The unique character of the Mendel Medal rests on its twofold requirement that it be awarded to one who has rendered distinguished service in advancing the cause of science and who also has given proof to the world, by fidelity to his religious convictions, that between religion and science there is no real conflict. Nowhere in the realms of science does this supposed conflict seem more evident than in paleontology, involving as it does, a need to reconcile the words of Genesis with modern findings on the origin and age of man.

"For over two decades, most of the time in China, far from his native land, Pere de Chardin has labored as a patient research worker in this most interesting and important field. Although engaged full-time as a scientist in advancing the researches on early man, he is worthy heir to scientist missionaries of the past who have played an important part in the apostolate of the Church in China. Since the middle of the eighteenth century, there has been a distinguished line of Catholic priest-scientists in China who have won from the rulers and intellectual leaders of that country a respect that would not ordinarily be accorded to them in the role of missionaries. This scientific activity has been an indirect apostolate inferior only to the primary work of the missions proper.

"The scientific work of Pere de Chardin has been rated of the highest order and he has been accorded international recognition. The prominent part which he has taken in the recent International Symposium on Early Man to mark the celebration of the 125th Anniversary of the Academy of Natural Sciences testified to his standing amongst his contemporaries.

"Distinction as a scientist has occasioned no conflict with his religious beliefs. There is nothing incongruous about his priestly character in the role of an eminent paleontologist. Thus it is that Pere de Chardin is particularly worthy of the Mendel Medal because he exemplifies the truth that it was established to convey, that between religion and science there is no conflict".

Pere de Chardin in his acceptance address made mention of the far-reaching meaning of Mendel's discoveries. He discussed very briefly the change that has taken place in the attitude of science towards evolution, pointing out that from the materialistic evolution of a half century ago, we have come to think of evolution as a passing from the materialistic to the spiritual. He recalled to his audience that the Mendel Medal has been conferred upon Abbe Lemaitre, who proposed the theory of the expanding universe, and added that we are on the eve of recognizing that the cosmos is on the verge of a slow birth of spiritualistic consciousness. Man, in his power of thought, carries in himself the most precious part of the universe; since there is no thinkable limit to consciousness, we must continue to move ahead, drawn on by an attracting force, the Divinity.

The 1937 Mendel Medalist, who has attracted world-wide attention through his paleontological investigations in China, was born near Royat, France in 1881. He began his studies on early man at the University of Paris in 1911 under the celebrated vertebrate paleontologist, Marcellin Boule. After receiving the degree, Doctor of Philosophy, he served for some time as professor of paleontology at the Institut Catholique de Paris.

In the summer of 1923 the French Ministry of Education and the Musee National d'Histoire Naturelle sent him with Pere Licent on a geological expedition to the region of the Ordos, along the Great Wall of China. Here he began the work on source material concerning early man. He has carried on this work ever since with conspicuous success. He was also intimately associated with Pere Licent in the development and enrichment of the Hoangho-Paiho Museum. Together they led a combined paleontological mission of the Musee National d'Histoire Naturelle and the Hoangho-Paiho Museum in 1924, in 1926, and again in 1927. Pere Teilhard was associated with other important expeditions into the interior of Asia.

He has also cooperated with the American Museum of Natural History, New York City, and with the Academy of Natural Sciences in Philadelphia.

From 1915 on, Pere Teilhard has contributed extensively to scientific journals in Belgium, China, England, and France. A representative collection of his works is to be found in the Osborn Library of the American Museum of Natural History in New York.

He is a member and onetime president of the Societe Geologique de France, honorary adviser of the National Geological Survey of China, and recipient of the Medal Grand Prix de Institut International in 1931. The Mendel Medal was founded by Villanova College in 1928. It is conferred upon a Catholic, usually each spring, "for distinguished achievement in science." The medal bears the name and commemorates the work of Gregor Johann Mendel, Abbot of the Augustinian Monastery at Brunn, Austria, who by his patient labors among the flowers of the monastery garden, discovered the now celebrated Mendelian Laws of Heredity. Although he published the results of his researches in 1865, the importance of his work was not realized until the year 1900. Since that time it has become the foundation stone of the science of genetics.

Former recipients of the Mendel Medal include:

John A. Kolmer, M.D., D.Sc., professor of medicine at Temple University.

Albert F. Zahm, Ph.D., director of aeronautical research in the Library of Congress.

Karl F. Herzfeld, D.Sc., professor of physics at the Catholic University of America.

Francis P. Garvan, Ph.D., president of the Chemical Foundation of America.

Hugh Stott Taylor, D.Sc., F.R.S.L., chairman of the Chemistry Department, Princeton University.

Abbe Georges Lemaitre, Ph.D., D.Sc., professor of astro-physics at the Catholic University of Louvain.

Francis Owen Rice, Ph.D., associate professor of chemistry at the Johns Hopkins University.

Rev. Julius A. Nieuwland, C.S.C., late professor of chemistry at the University of Notre Dame.

J. H. CRAWFORD, O.S.A.

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SCIENCE AND PHILOSOPHY

THE PHILOSOPHY OF MEASURE

ANTHONY J. EIARDI, S.J.

A book-reviewer once wrote that life, no less than yardsticks, tons, or railroad tracks, needs its standards. He told where the standards of life were to be found in their fulness,—only in the traditional scholastic philosophy. Just now we are interested only in the standards of measurement: those standards which the natural sciences such as Physics and Chemistry employ. And for our present purpose we do not need the whole system of scholastic philosophy but only that tiny part of it which tells what measure is. Suarez gives us a satisfactory treatment of measure in the third section of his fortieth metaphysical disputation. He will be our guide in the philosophic study of measure.

We know what it is to measure something. It is an act common to all men. They perform it in their work and thoughts. The saleslady, for example, applies the yardstick once or oftener to cloth, ribbon, etc.; this, she says, is measure. The chef in following the directions of a recipe measures the ingredients of a cake. The carpenter, the machinist, tradesmen of all kinds, are continually measuring wood and steel and all the other materials which go to make up the objects on which they are working. To them, the process of measurement is the same as it is to the saleslady; they would describe it in the same terms even though neither they nor she would perhaps be able to define the process in the terms of philosophy. To apply a standard to some object to be measured is the content of the common notion of measure.

Consideration discloses three factors in the process: a standard, a measurable object and an act of comparison. The standard may be either material and tangible or immaterial and residing in the mind. For measurements of things that have no matter in their constitution are frequently made. A familiar example of the material standard is the gram weight which the chemist places on one pan of the sensitive balance. We often hear such expressions as a true friend, a good person, a beautiful scene. Men have ideals of friendship, goodness and beauty and these ideals are the immaterial standards to which a particular person or a concrete scene conforms. The tiny mass of matter that rests upon the other pan of the chemical balance, the person, the scene are examples of measurable objects and have the same nature, in the aspect of measure, as the standards. That there is an act of comparison on all measurements is evident. The comparison is made either by a direct, physical application of the standard when both standard and object are material as in the case of physical measurements, or by a mental application from which we derive our moral estimates.

Every comparison, then, is measure of some kind. The act of comparison constitutes the process of measurement. If the comparing of one thing with another were impossible, a fount of practical knowledge would be lost to us; standards would be useless; the physical laws would be unknown to us, and Physics and Chemistry would have retained that pre-Galileo qualitative character. Both these sciences depend on measurements; measurements are the result of comparison.

It is this comparison which we desire to consider in this article. We are seeking answers to such fundamental questions as: what sort of knowledge do we gain by measuring physical entities? what is the purpose of measure? what basic reason can be given for the measurability of physical entities? and lastly, why are certain things chosen as standards? This scrutiny will disclose the philosophy of measure. In other words, this investigation will establish the metaphysical principles upon which the process of measurement is based.

What is measure, i. e., that process whereby measurements are made? The answer is given by Aristotle (10 Metaph., c.2): "Mensura est id quo quantum cognoscimus."*—Measure is that medium by which we know the dimensions of some object. This definition states that measure is a medium of acquiring knowledge. By means of our senses we perceive the qualities or properties of things. But our senses fail to give us definite measurement-information about them. Observation reveals an object as large or small, soft or hard, red or yellow, sweet or bitter. By means of measure, a large object becomes an object of a very definite size because measurement is a complement of sense-data, adding to it quantitative information which brings to our intellect very precise, scientific knowledge of material things.

This quantitative knowledge, or knowledge of the how-muchness of things, is the purpose of measure. In order that Galileo might formulate the physical law concerning falling bodies, he had to *measure* the time it took bodies of different weights and forms to fall, and the weights of the various bodies themselves. The table of values or measurements, experimentally obtained, enabled him to reason to the general statement that the velocity of falling bodies is measured by the product of the attraction of gravity and the time it took the body to fall. This is and has been the way that physical

*Quoted by Suarez: cf. Metaph. Disp. XL.

laws have been established and in this rests the usefulness of measure. But if a law is formulated from theory, its validity depends on the agreement of its consequences with the physical facts; in other words, it must coincide with the measured entities stated in a mathematical formula or equation. Hence from this other point of view the usefulness of measure is likewise observed.

The search for knowledge or measurement need not necessarily be restricted to quantitative bodies alone. The above definition justifies the extension of the process of measurement to immaterial things such, v.g., as virtue, beauty, perfection and goodness. The justification is to be found in the word "quantum" for it is used in a wide sense. "In this wide or improper sense, quantity designates the amount of virtue or perfection that one possesses, and by reason of which there are grades of perfection in a certain nature. So this sort of quantity belongs also to things incorporeal. Hence, on account of the analogy with quantity in the strict sense, we have become accustomed to speak of great heat, great wisdom, in order to indicate either the superiority of one's intellect or the intensity of some quality. Quantity, in the strict sense, means dimensional quantity which only corporeal bodies have. By reason of this dimensional quantity a body is said to be extended, to be greater or smaller than another body."* Therefore it is legitimate to measure the physical qualities: heat, electricity, force, etc., because these have a quantitative aspect and it is this that is measured.

Such a philosophic treatment of measure as the above does not come within the scope of the scientist. To him, the process of measurement is a tool and the measurements are everything. He is satisfied if the measuring instrument is properly adjusted and calibrated. He centers his attention upon the careful use of this tool. If we put to him a few questions, we can expect to learn something about the process of measurement from the scientist's view-point. What is measurement? It is a comparison.** What is the purpose of the comparison? To assign a numerical value to the object which is being measured. We assign numbers to the houses in a street but we do not call this measurement, because the properties of their

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*Cahill, S.J., "Cosmologia", p.1.

**"The process (of measurement) consists in the comparison of two things in respect to some property. One of them is taken as the standard in terms of which the magnitude of the other is expressed. If the standard used and the object to be measured happen to be equal then the comparison is a simple affair, but as they usually are not it is apt to be somewhat complicated. The most convenient procedure usually is to take a standard that is small relative to the magnitude to be measured or to sub-divide the standard, and to find by repeated application in the correct manner to the unknown how many times greater the unknown is. . . . There are two characteristics of the process that should be mentioned. (1) The actual numerical value assigned is not fixed except by fixing the unit of the standard: (2) even the fixing of the unit does not fix the value absolutely but it is determined as lying between certain limits. That is to say the error of measurement is something inherent in the process: though it can always be made smaller than any given amount it can never be eliminated. It is only in theory too that it can be indefinitely reduced: in practice the difficulties increase so rapidly with each diminution in error as to set a fairly definite limit at any given stage in the progress of knowledge."—Ritchie, "Scientific Method", pp. 127-8.

numbers give us no information about the properties of the houses. In fact, any other arbitrary determination would just as well symbolize the order of the houses; the letters of the alphabet could be so utilized. This numbering of the houses involves only the ordinal properties of numbers. This process, then, must be distinguished from measurement proper. Is measuring counting? "Counting is a necessary part of measurement but it is not itself measurement. Briefly, in counting we assign cardinal numbers to groups of things; in measurement we assign a ratio to represent some property of a thing. The number we write down to stand for the results of measurement are always ratios, not cardinal numbers. When we say a man has two legs, we are making a different type of assertion, namely one about a cardinal number. This is seen from the fact that we do not mention a unit, and that we are confined to one definite number."* In the terms of science, this whole process of measurement may be summarized as a process which involves a comparison of a standard and a measurable object in respect to some property with the purpose of assigning a ratio between them. The process is experimental and hence must be distinguished from counting.

An exact measurement is impossible. It is a comparison and, at best, a comparison is a very close approximation of the true value. The very nature of our senses which limits them in their power of perception and the defects in the measuring instruments are the principal reasons for this lack of exact conformity between the measurement and the measured magnitude. This, however, presents no serious difficulty. Before the scientist begins an experiment, he knows the purpose of it and especially the desired precision in the result. He makes the measurements accordingly. For example in the Hooke's Law experiment, if the elongation can only be measured to 1%, i. e., if the measurement is precise or correct to 1%, it is useless and a waste of time and effort to measure the length to more than 1%. A series of measurements of the same object, each of which differs, is another indication that a measurement does not *exactly* represent the measured magnitude. Repeated measurements are made so that the best representative value of the measured magnitude may be obtained. This is either the arithmetical mean of all the measurements or the result determined by the Method of Least Squares. The number of the measurements to be taken is determined by the Calculus of Errors or Theory of Probabilities. The general methodological principle followed is this: errors should be made negligible to the purpose in view. With this done, the measurement is said to be precise.** By the accuracy of a measure-

*Ritchie, "Scientific Method", p. 121.

**To one interested in the precision of measurements, the following books should prove helpful.—*Goodwin*. "Precision of measurements and Graphical Methods." *Holman*, "Discussion of the Precision of Measurements."

ment is understood the closeness of the agreement, i. e., between the measurement and the true value.

Granted the fact that a measurement is only an approximation, there remain to be said a few words about the kinds of measurements. Measurements may be classed as direct or indirect according as the process of measure gives the desired result directly or indirectly. An indirect measurement is obtained by substituting values in a formula which can be solved for the desired measurement. The great majority of problems arising in practice comes under the second class. Examples of the first class are the measurement of a length by means of a scale, the mass of a body by means of an equal arm balance, and the electrical resistance of a wire by the direct method of substitution. Examples of indirect measurements are the determination of the index of refraction of a substance from the measurements of the angle and the minimum deviation of a prism by means of a spectrometer, and the determination of "g".

We now come to the question of the measurability of physical entities. The metaphysical reasons explain why some things are measurable, v. g., lengths, masses, densities, velocities, etc., and why other realities like essences are not measurable. These reasons look directly at the possibility of a certain object's being measured and prescind from the actual measuring of the same. The factors upon which the actual measuring of an object depends were so well treated by Father Brock, S.J., in a recent issue of the Bulletin that they need no further amplification.

In Philosophy is found the basic truth in this matter. A material substance is from its very nature actually extended. Consequent upon this actual extension, or what we might term dimensional quantity, there is inherent in the material substances an aptitude for being measured. Hence Suarez defines passive measurability as that certain aptitude which a body possesses and on account of which its magnitude can be known through some extrinsic medium.* Briefly, measurability is an attribute of quantity. Note that we do not make it the essence of quantity. Nor does the essence of anything at all consist in the aptitude that it be known in any way whatsoever. Therefore, since measurability is only an attribute of quantity, it accompanies quantity either absolutely or under conditions required by us. Those quantities which are within our grasp and power are absolutely measurable. In all other cases of measurements, we set up certain conditions which render the object measurable. We do this when we are dealing with very low temperatures—temperatures that approach zero on the absolute scale. After a certain limit has been reached on the scale and other means of cooling have been applied we estimate the temperature of the object.

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*"Illa mensurabilitas solum est aptitudo quaedam, ut rei magnitudo cognosci possit per extrinsecum medium."—Metaph. Disp., XL, Sec. III, 11.

Since the essence of quantity is to render a body extended and because it does this, the body becomes measurable, physical properties, inhering in this dimensional quantity which gives them the aspect of quantity or how-muchness, also share the attribute of measurability. Hence it is logical to conclude that such qualities as density, heat and all the other forms of energy, motion,—in short, all the properties of matter are faced by no metaphysical repugnance as to their measurability, i. e., it is legitimate to measure their quantitative aspect.

Philosophically, time differs from the contents of space, viz., matter, in the kind of a quantified substance that it is. Bodies have all their constitutive parts at one time and so are called "permanent continua." Of course, it is not maintained that bodies are perfect continua. However, for the purpose of measure they may be considered as such. "Successive continuum", however, has not its constitutive parts simultaneously, but successively, i. e., one part follows the previous. Inasmuch as time differs in kind but not in class—for time is a "successive continuum"—what has been said above applies to time. Therefore time is measurable.

Just as a paper dollar without some mineral standard in the government treasury to back it up has no value, so measurements would be meaningless if there were no physical standards of length, mass and time. Measurements, as has been often said, represent the ratio or relation in the order of how-muchness between the measured object and the unit. Standards, then, are an essential part of the process of measurement and do call for a brief consideration here.

Suarez looks upon a standard as something that is actively a measure: it is held in contradistinction to passive measurability which was discussed in the previous section. Active measurability is predicated of that which can be used as a standard of measurement. But why such a predicate? The aptness or the aptitude of a thing to become a measure rests ultimately in the fact that it is a quantitative something. Although a quantified substance has such an aptitude, there is nothing in its essence that requires its use as a standard in preference to another quantified substance. For example, we depend upon the daily rotation of the earth to measure time. But there is no necessity, springing from the nature of this phenomenon, that it should be so utilized. Any other phenomenon of regular occurrence could serve this purpose and hence receive from us the formality of a natural clock. Suarez insists upon this point* which brings us to the further point of the arbitrary choice of standards.

Ultimately, then, something is a standard or measure because it is a quantified substance. The proximate reason for its aptitude is none other than human choice. This does not mean that in the mak-

*Metaph. Disp. XL, Sec. III, 5.

ing of a measurement the numeric part of it is arbitrarily set down. Once the standard has been determined, all arbitrariness vanishes. It does mean, however, that the scientists have agreed among themselves to use a certain thing as the standard. And their choice at least implies the participation of the standard in the conditions of unity, which are three: 1) unity is better known than multitude; 2) it is the principle of multitude; and 3) it is just a little more than nothing. What one or unity is to number, that the standard is to measure. Continuous quantity, clothed with the formalities of unity at the mere beck of man's will, exercises the function of a standard.

What are the philosophic requirements of a standard? They are three. First, it must be known, definite and rigid; next it must be accommodated to the investigator's powers; and lastly it must be homogeneus with; i. e., of the same nature as, the object to be measured.** The knowing of the standard is first demanded for the same reason that makes it incumbent upon the logician to know, in the first place or beforehand, the major of a syllogism; for otherwise the conclusion never could be reached. The rigidity of the standard will be considered in the next paragraph. The second requirement which arises from the first can be best brought out by an example. Advertising agents have impressed the public with the size of the Normandie by comparing its length with the heights of the Woolworth Building. They used the Woolworth Building as a standard in measuring the titanic vessel, but such a standard could hardly serve the scientist as a practical, workable unit. Incidentally, this example refers also to the previous point, viz., that any quantitative substance is a potential standard. The third condition is clear from all that we have been saying and inasmuch as a measurement is in terms of feet or pounds or hours, the standard must be of the same nature as the object which is compared with it.

In general, the scientific requirements are two. The standard must be a rigid body and must remain constant. The former requirement takes care that the standard is, for example, the actual length it is supposed to be. With regard to measuring instruments, this condition means that the materials of the instrument can be shielded from external action. In order to rely upon the standard, it is not necessary to assume some absolutely rigid substance. It is known that some bodies are less rigid than others and the standard is made of the most rigid material obtainable. The second requirement assures the user that his standard has not been observably altered by change of place or lapse of time.

Although the actual choice of units is quite a technical matter and, for this reason, nothing shall be said on the subject, still the universal agreement in scientific work—especially in the field of electricity— that has resulted from the acceptance everywhere of the

**cf. Metaph. Disp. XL, Sec. III, 14.

C. G. S. system of measure is worth mentioning. All the units of the system are related; measures of capacity and weights can be expressed in terms of measures of length; for example, the liter is equal to one cubic decimeter and the gram is a mass of one cubic centimeter. When measurements are given in these measures, no confusion arises as is apt to be the case in this country. We speak of long and short ton, of wet and dry measures. Such a multiplication of units is unnecessary; it is, in fact, confusing and misleading. Selling potatoes by volume does not assure two different buyers that they will receive the same quantity of potatoes. "Troy pound or avoirdupois pound?" some one may be asked. If he is in a jewelry shop, he chooses the troy pound, but the avoirdupois pound if he is in a butcher shop. This mental anxiety would be avoided by the universal acceptance of the C. G. S. system.

Having viewed the matter of measure from the scientific position and with the viewpoint of the philosopher, we are finally prepared to formulate our philosophy of measure. It must begin with a definition. The process of measure is that medium by which we may know the how-muchness of a body or properties of the same. This definition supposes that things can be measured; hence it must be determined what things are measurable. Anything that has quantity or can be assumed as having a quantitative aspect is measurable, at least, metaphysically; physically measurable if a standard or measuring instrument is given. The standard is an essential factor of the process; it is the basis of comparison. But it must be remembered that the essence of any physical entity is not such as to necessitate its adoption as a standard. For anything measurable is a potential measuring rod but its adoption as a standard depends upon human choice. This is so for the simple reason that there is no greater reason that the standard should measure something else of the same nature than the latter should measure the standard. The arbitrariness of standards is a well-known fact.

In conclusion, we shall feel that this article is not mere words, if it will convince others that it is the result of an attempt to gather the elements and philosophic principles of the process of measure into one place for ready reference, in order to promote the development of the process with the laudatory aim of making our knowledge of the physical world more satisfying, complete and accurate. With Planck we say that the guide to further progress in the sciences—especially Physics—is measurement. More precise measurements require refinement in the already refined measuring instruments. Making more refined our present-day instruments is a work not without its reward of achievement and renown.

ASTRONOMY

WESTON ASTRONOMICAL OBSERVATORY

REV. THOMAS D. BARRY, S.J.

The Weston College Astronomical Observatory had its beginnings in the telescope purchased by Father Ahern for use in connection with his classes in Astronomy. It was a three-inch portable refractor, with coarse finding circles, with no driving mechanism; bought from the Eastern Science Supply Co. in Boston. In the fall of 1928, Father John Blatchford and the writer attempted to use it for observation of variable stars, but gave up that program, since the work of carrying the telescope and tripod out of the house to a convenient location, setting it up and orientating it, and then finding the stars was too much for the limited time at our disposal. We then turned

our attention to the observation of occultations of stars by the moon, with more success, since the only requirement was the ability to find the moon. The time of disappearance of a star was registered on a stopwatch, which was then compared with the electric clock system of the house, which in turn was checked by the radio signals from Arlington. During the first two years, observations were limited to those stars for which the approximate times were predicted in the American Ephemeris, that is, down to magnitude 6.5. As the Weather Bureau apparently used the same volume as a basis for furnishing cloudy nights, the results were fairly meager. In 1930, a set of Bayer-Graff star charts was obtained, through the generosity of Fr. Ahern, and we began to make our own predictions, with the result that the number of observations was about doubled, since we could get stars down to magnitude about 8.5. A prismatic eyepiece was also obtained about this time for observing stars at high altitudes.

Old-timers at Weston will remember the "Blue Tower", which supported the tank for the water supply of the old estate. By 1931, this had become such an eyesore that it was demolished, but the stone foundation was left standing, and in the fall of that year work was begun on its transformation into an observatory. A concrete pier was built from bedrock through the center of the structure, and a floor laid around it about two feet below the top of the walls. Access was had to the floor by means of a staircase and trapdoor. The dome was made of wood covered with copper at the shop of a local contractor, and then transported here by truck and mounted. It revolves on eight roller-bearing trucks running in a circular track. The telescope mounting was that of the old three-inch at Woodstock, consisting of an equatorial head on two sections of iron pipe. The head was changed slightly to take care of the difference in longitude and to accommodate the bolts of our own telescope. The observatory is set on the edge of a hill, with a view to the west and south obstructed only by a couple of trees to the southwest. The trees shown in the photo are northeast, a sector rarely used by us. Work was finished in the spring of 1928. When the writer left theology that summer, Father Sydney Judah took over the work and made a number of observations during the next three years.

In the summer of 1935, the three-inch telescope with its accessories was sent to Boston College in exchange for a five-inch portable Clark refractor, with a heavy wooden tripod, two celestial and one terrestrial eyepieces, right-angle prism and sun-glass, but with no circles. The three-inch is now located at Cohasset for the amusement of those wishing to watch the movements of ships. The five-inch was placed on the mounting in the observatory, but it was found that the mounting was not rigid enough to prevent very troublesome vibrations. So the equatorial head was removed and the tripod set over the remaining section of the mount. This gives greater rigidity in mounting, but any movement in the observatory transmits vibrations through the legs of the tripod which are resting on the floor.

In all, 122 occultations have been predicted, observed, reduced (in duplicate), and published in "The Astronomical Journal". These results have been used by Profs. Ernest W. Brown and Dirk Brouwer of the Yale University Observatory, and Dr. James Robertson, head of the Nautical Almanac Office of the United States Naval Observatory, in their researches on the motion of the moon. Two unexpected results of our publications have been the following. Last summer two students of astronomy at Brown University journeyed up from Providence to inspect our equipment, and expressed surprise that we had achieved such fine results with our meager equipment. The head of the British Nautical Almanac Office wrote from Greenwich, requesting the position of our observatory, so that it might be included in the list of Observatories in that publication.

SIXTEENTH ANNUAL MEETING

of the

AMERICAN ASSOCIATION

of

JESUIT SCIENTISTS

August, 1937

BIOLOGY

A JUNIOR AND THE SEVENTEEN-YEAR LOCUSTS

REV. JOHN A. FRISCH, S.J.

In 1911 the seventeen-year locust (Tibicinia septendecim) emerged in great numbers at St. Andrew-on-Hudson. I was continuing my hereditary interest in Natural History under the genial tutelage of our beloved Fr. Francis P. Donnelly and seized this opportunity to study the life-history of our visitors at first hand. To watch the process of egg-laying I potted a two or three-year-old horse-chestnut tree, put it in a screened box, added several male and female cicadas and placed the outfit on my desk in the ascetory. The arrangement was very satisfactory. After the laying of the eggs I watched for the emergence of the young to see how they descended from the twigs to the ground. Six long weeks I watched, and at last I was rewarded. The tiny larva, only about one-twelfth of an inch long, emerged from its cell in the twig, preened itself and stepped off the twig. But instead of falling to the ground it descended very slowly, rear end first. Suspecting that it was descending by means of a thread of its own spinning, I examined the space between the twig and the larva from all angles, and finally confirmed my suspicions. But the thread was so very delicate that it was all but invisible. I could find no mention of this method of descending in the literature then at my disposal, but I felt that it must have been observed by others, and forgot about it for the time being. I hoped to do more detailed work on this problem later, when the classics would no longer be so insistent. But I never got around to it since I was never again in a locality where a brood emerged.

While in Baltimore the past summer, I found Dr. E. A. Andrews of Johns Hopkins University studying the seventeen-year locust which had appeared in huge number in Baltimore that spring. I casually mentioned my long-ago observation to him and was surprised to hear that there was no mention in the literature of such a method of descent. He moreover thought it very unlikely that the larva used a thread, because it has no silk glands with which to spin a thread. I however felt certain that I had seen the larva use a thread, and asked him to look for it when the larvae hatched.

At Christmas time I met Dr. Andrews again and to my satisfaction he informed me that my Junior observation had been correct, and that the larvae manufactures the thread from the lining of the intestine, a method employed by other forms. The thread is so fragile that even a slight breeze disintegrates it and this is probably the reason why it has never been observed before. So it took 26 years to have my original observation confirmed, and even then it probably would not have been confirmed if I had not asked Dr. Andrews to search diligently for the threads. Even a Junior can make a discovery which for 26 years eludes seasoned scientists constantly studying the same insect. What an argument for science studies in the Juniorate!!

THE RATE OF PULSATION AND THE FUNCTION OF THE CONTRACTILE VACUOLE IN PARAMECIUM

(Abstract)

REV. JOHN A. FRISCH, S.J.

I. Relative rate of pulsation of anterior and posterior contractile vacuoles.

1. Flourishing cultures.
   - a. *Paramecium multimicronucleatum.*
   - b. *Paramecium caudatum.*
2. Depleted and depressed cultures.
3. During Fission.
4. Non-feeding animals.

Summary and Discussion.

II. Relation between rate of feeding and rate of pulsation.

a. Variation in size of food vacuoles

b. Variation in rate of food vacuole formation.

c. Variation in size of contractile vacuoles.

d. Relation between rate of feeding and rate of pulsation.

Conclusion and Discussion.

III. Relation between locomotion and rate of pulsation.

a. Types of locomotion.

b. Effect of continuous swimming on rate of pulsation.

c. Effect of "crawling".

d. Effect of "spasmodic movements".

Conclusion.

IV. Variation in rate of pulsation.

V. Relation between absorption of water from oesophagus and rate of pulsation.

a. Absorption of water from oesophagus in feeding animals.

b. Absorption of water from oesophagus in non-feeding animals.

c. The cytostome and its relation to rate of absorption of water from oesophagus.

d. Impermeability of the pellicle of *Paramecium* to water.

VI. Function of the contractile vacuoles.

VII. Summary.

VIII. Literature cited.

This is an outline of the Research Problem completed by Father Frisch at The Johns Hopkins University. Those who wish complete copies of this work may obtain them from the Author.

CHEMISTRY

APPLICATION OF STATISTICAL METHODS TO ANALYTICAL AND PHYSIOLOGICAL CHEMISTRY

Rev. Francis W. Power, S.J.

PART III

The last of this series of articles will be devoted to a brief description of the statistical technique employed by modern writers, especially R. A. Fisher, when there is question of only a few samples or measurements being available, as is often the case in physical and chemical practice. Fisher's book already cited gives a summary of this technique; it will be found rather hard to understand and a good deal of preliminary acquaintance with the subject is necessary to apply his methods, but it is well worth the effort.

One case very often encountered by the chemist is the one involving the difference between two mean values, each one having been established by only a few observations. Such a case is had for example in the two series of barium sulphate recoveries from sodium sulphate solutions cited in an earlier part of this paper; there it was treated by the method usually employed when large numbers of observations are available; it will serve again at this point to exemplify Fisher's treatment. I will use the nomenclature previously used in this present discussion as far as possible.

Let

x_1 = mean percent recovery by method A

x_2 = mean percent recovery by method A

Δx = Difference between these means

Σd_1^2 = sum of the squared differences from x_1 of the individual observations in method A

Σd_2^2 = sum of the squared differences from x_2 of the individual observations in method B

N_1 = number of observations, method A

N_2 = number of observations, method B

The standard error of the difference is now calculated by the expression

$$S_D = \sqrt{\frac{\Sigma d_1^2 + \Sigma d_2^2}{N_1 - 1 + (N_2 - 1)}}$$

The "coefficient of certainty" t is now calculated:

not $t = \frac{\Delta x}{S_D}$ as we have done before, but rather, this quantity times a coefficient depending for its value on the size of the sample; Fisher gives this coefficient the value

$$\sqrt{\frac{N_1 \quad N_2}{N_1 + N_2}}$$

The corrected t is then looked up in Fisher's table (e. g. 5th Edition p. 158) which is entered at $n = N_1 + N_2 - 2$ and the t value for this n is run up to the corresponding probability value at the top of the table, interpolating if necessary.

Fisher's t therefore is given by the expression

$$\frac{\sqrt{\frac{N_1 \quad N_2}{N_1 + N_2}}}{\sqrt{\frac{\Sigma d_1^2 + \Sigma d_2^2}{N_1 + N_2 - 2}}} . \Delta x$$

In the problem of the barium sulphate the values are:

$x_1 = 99.63 \qquad x_2 = 99.98$

$\Delta x = 0.35$

$\Sigma d_1^2 = 1.1897 \qquad \Sigma d_2^2 = 4.0685$

$N_1 = 13 \qquad N_2 = 14$

$$S_D = \sqrt{\frac{1.1897 + 4.0685}{12 \quad + 13}}$$

$$= 0.459$$

The correction coefficient will be

$$\sqrt{\frac{13 \times 14}{13 + 14}} = 2.60$$

whence $t = \frac{2.60}{.459} \times 0.35 = 1.983$. Entering Fisher's table at

$n = N_1 + N_2 - 2 = 25$ we find

$P = 0.10$ for $t = 1.708$

$P = 0.05$ for $t = 2.060$

whence we estimate that for $t = 1.983$, $P = 0.061$; that is to say, there are about 6 chances in 100 that the difference between the two methods is accidental and 94 chances in 100 that it is caused by the experimental conditions; in other words, the latter conclusion is about 15 times as probable as the former.

Let me cite another example. An investigator is studying the metabolic path of adenylic acid fed to a dog on nitrogen balance. A study of the urea nitrogen figures seems to show that the adenylic acid is being converted into urea in the body, since the latter quantity is increased after feeding the test substance. The question is, however, is this increase really due to the adenylic acid, or may it not have arisen as one of the accidental variations in urea nitrogen during the time the dog was fed a normal diet? A statistical analysis will show which of these alternatives is the more probable. In the experiment in question the following figures were obtained (nomenclature as has just been given):

$x_1 = 4.226$ gr. per day urea N in control feedings
$x_2 = 4.285$ gr. per day urea N in test feedings
$\Delta x = .059$ gr. increase in urea N per day
Σd_1^2 for the control periods $= 0.524$
Σd_2^2 for the test feeding $= 0.130$
$N_1 = 25$ observations in control series
$N_2 = 4$ observations after feeding adenylic acid

Then

$$S_D = \sqrt{\frac{0.524 + 0.130}{24 + 3}} = 0.156$$

The correcting coefficient will be

$$\sqrt{\frac{25 \times 4}{25 + 4}} = 1.85$$

$$\text{whence } t = \frac{1.85}{0.156} \times 0.059 = 0.700$$

On entering the t table at $n = 25 + 4 - 2 = 27$
we find $P = 0.5$ for $t = .684$
$P = 0.4$ for $t = .855$

whence we estimate that for $t = 0.700$, $P = 0.491$; that is to say that it is just about a 50-50 proposition—the probability that the extra urea nitrogen came from the test substance is just about the same as the propability that the larger values arose from the ordinary accidental variations possible in the course of such an experiment. There is not therefore enough evidence from this experiment to conclude with any assurance that adenylic acid on feeding is converted into urea by the body.

It is important to note one thing in using Fisher's t table. If the reader will refer back to P. 86 of this bulletin (Dec. 1936), he will find a table of both direct and inverse probability for different values of t. The point is, Fisher's t table is given in terms of inverse probability. That is, for large values of t, P is small and for small values of t, P is large; the probability at which one comes out of this table will be the probability that an accidental error is involved, or that the difference between two means is not significant.

Another point would be that Fisher's t table, intended primarily for working with small samples or with small numbers of observations, will give a higher value of P (i. e. a greater degree of inverse probability) for a given value of t than will the normal table. For a sample size over 30 the two tables coincide to all intents and purposes, accounting for the statement often found in the books that for most ordinary purposes 30 is regarded as a 'large sample' to which the ordinary probability function may usually be applied without correction. Since the inverse probability means the probability of occurrence of a non-significant or accidental discrepancy, Fisher's table tends to enhance this probability; by its use a discrepancy between two mean values is more likely to be ascribed to accidental variations and there is less chance that their difference will be regarded as significant. This can be seen by considering the probability that a given discrepancy be regarded as non-significant as judged from the normal probability table and as judged by Fisher's table entered at a value of $n = 10$ — i. e. where 12 observations are available between the two series to be compared.

Value of t	Chances in 1000 that the difference Δx between the means of the two series is accidental and non-significant. By normal table	By Fishers' table
3.00	2.6	14.2
2.00	45	77
1.00	317	344
0.6745	500	516
0.25	803	832

One very interesting use of this method of analysis has been worked out here at Fordham in studying the growth of mice kept on a vitamine B_1 — deficient diet supplemented by the administration of vitamine B_1 extracts or the pure crystalline vitamine itself. The experiment is conducted as follows. A group of mice shortly after weaning are given a diet adequate for normal growth in all respects except that it is lacking in vitamine B_1; they lose their appetite, lose weight, and gradually acquire the typical symptoms of experimental polyneuritis; at the end of about 3 weeks they are in the last stages of the disease. When the investigator feels that they have gone far enough he adds to the diet weighted amounts of a vitamine-containing material or injects known volumes of standardized vitamine B_1 solution made from the pure crystalline substance. The mice are weighed each day to the nearest decigram and soon begin to eat at a phenomenal rate and gain correspondingly in weight—in the first couple of days they may gain as much as 10% of their initial weight in 24 hours. After about 3 weeks they weigh nearly as much as the control mice fed on a regular stock diet and have entirely recovered from the deficiency disease. Since there is as yet no simple quantitative test specific for this vitamine, all the investigators use some sort of biological test to judge the potency of their preparations—

the recovery of pigeons from experimental polyneuritis was the first test of this sort used and is still being employed. Other investigators have used rats and Dr. Cerecedo at Fordham is the only one who uses white mice. Since the gain in body weight parallels the disappearance of the deficiency syndrome, the potency of the vitamine preparation is taken to be some direct function of the weight of the experimental animals after they are treated with the preparation being tested. Since the mice vary considerably among themselves in weight as the test proceeds, fairly large groups have to be taken in order to insure significance even by statistical methods. The main questions to be solved are: 1) is preparation A richer in Vitamine B_1 than preparation B, and approximately how much so? 2) Given the pure crystalline vitamine itself, what is the minimum daily requirement of the animals for a significant gain in weight? Both of these questions can usually be answered by an application of the same statistical analysis.

This is done by setting down in a column the *gain* in weight of each individual mouse for each day of the experiment (after the first week the gain on every 5th day is sufficient) and getting the mean gain of the group (e.g. 10 mice) for each day or period of the experiment. The variation of each mouse from the mean of the column is then taken, squared, and the sum of the squares set down. The same procedure is gone through for the other group of animals whose gains are being compared with those of the first group. The test for significance will then be to compute t between the two groups taken at the same interval, since essentially the whole experiment consists in studying two plots of gain in weight against time. The value of P corresponding to the computed t will then give a rough quantitative estimate of the superiority, if any, of one of the two preparations being tested. In this way Dr. Cerecedo and his associates have been able to show that a daily dose of as little as 1 gamma (0.001 mg.) will just barely protect a mouse from the deficiency disease, and they have been able also to detect definitely the influence of even a third of this minute quantity.

Countless applications of these statistical methods can be made, and indeed should be made. If a man submits a set of data where many observations or measurements are involved, his conclusions have objectively only the statistical value warranted by the precision of his measurements, and his readers have the right to know just what this precision is without having to plough through his tables of figures to ascertain this for themselves, supposing that they knew how to do so. Anyone however can understand the statement that such and such a conclusion has a statistical probability of 80% or 95% or 99.9% in its favor; if the author can really *prove* this, he has got something; if he cannot, he would have done better to have said nothing.

I might add that owing to the fact that few chemists have even the faintest notion of modern statistical technique a young man who comes along with a good working knowledge of the subject will find himself in a very commanding position among his colleagues—he will have 'gotten in on the ground floor' so to speak on a (to them) new and mysterious subject whereby he can 'debunk' a lot of conclusions which would otherwise be accepted as gospel truth. The one equation

$$\sqrt{N} = \frac{t\,s}{\Delta x}$$

alone is enough to keep one's feet on the ground for quite some time.

In these articles I have not referred to the specific matter of correlation with which a large part of modern statistical literature is concerned; nor with the analysis of covariance, a very powerful and useful tool in both analytical and physiological chemistry. The main reason is that so far I have not found the time to acquire even as superficial an acquaintaince with them as I have with the methods having a more obvious bearing on our problems.

"When, as, and if" I ever get an inkling as to how they may be usefully applied, I shall do my best to pass on my summary of them (such as it is) to the readers of the Bulletin.

In this I hope to receive as I have during the past year the generous and most welcome cooperation of Dr. Jack W. Dunlap, Professor of Educational Psychology in the Fordham Graduate School. He has spent many hours with me both on fundamentals and applications, and I am much indebted to him for placing his wide knowledge of statistical theory and practice so generously at my disposal.

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PHYSICS

NUCLEAR DISINTEGRATION

Rev. John S. O'Conor, S.J.

It seems quite fitting that Lord Rutherford of Cambridge who was the first to synthesize the "nuclear atom" in the conceptual order should also have been the first to explode it in the physical order, although as Born remarks the discovery of nuclear disintegration should have been called rather nuclear transformation, since new atoms are built from the disintegration products of the old.

This discovery, like so many others recounted before, resulted from the extension of Rutherford's classical scattering experiments (1). In these tests alpha particles from a radioactive source were allowed to collide with other atoms which were set up as a target either in the form of thin foils, or in the case of gases the target merely constituted the medium through which the high speed alpha ray was made to pass. The scattered projectiles were then detected by the scintillations which they produced on a fluorescent screen which could be placed at various distances from the source, as well as at diverse angles; thus making possible the study of the distribution in range and angle of the scattering. Such studies on heavy nuclei led to the verification of Rutherford's classical scattering law based on the Coulomb field of force between elementary particles, and built on the assumption of the validity of the laws of conservation of energy and momentum.

For light nuclei certain anomalies in the scattering were found, which were attributed to a variation in the Coulomb field at close encounters.

In these however we are not directly interested at present, except in as much as they led Rutherford to make a more extended study of scattering by light nuclei.

One of the primary differences between the study of scattering by heavy and light nuclei consists in the fact that in the former case the target may be considered to remain at rest during the impact, and a study of the scattered alpha particles gives practically the whole story. Whereas in the case of hydrogen, the lightest of all nuclei, it is really the struck target-atom which is "scattered", since it is four times lighter than the alpha particle (helium nucleus) which strikes it. To take a specific case: Alpha particles from radium C′ have an equivalent air range of about seven cms. From ordinary classical mechanics it can be shown that for a head on collision between two particles with mass ratios 4 : 1, the smaller one initially at rest is projected forward (in an elastic collision) with a velocity 1.6 times that of the impinger.

Since it has also been shown (2) that protons and alpha particles of like speeds have like ranges, and since the range of a particle varies as a power slightly higher than the cube of the velocity, it also follows that the maximum range of a proton projected forward by a 7 cm. range alpha particle will be $(1.6)^{3+}R$ or approximately 29 to 30 cms.

All this detail has been given to establish the simple fact that in a scattering chamber, no matter what element be present as scatterer, no particles of range greater than 4.1 times that of the projectile used, may be expected from elastic collision based on classical mechanics.

Now in the study of nitrogen Rutherford found not only particles with ranges of 29 and 30 cms. (which might have been attributed to hydrogen impurities in the gas), but also those with ranges as high as 40 cm. air equivalent. He therefore correctly concluded that these long range particles could not possibly be the result of any elastic collision between alpha ray and other nucleus, and going a step further he drew on a modification of Prout's hypothesis, and stated that the scintillations on the screen at distances greater than 30 cms. (air equivalent) must be due to a particle knocked out of the struck nucleus which had received additional energy from the process of disintegration initiated by the alpha particle striking the nitrogen nucleus. Rough measurements of the magnetic deflections of such particles indicated that they were actually protons, that is hydrogen nuclei. And Rutherford estimated the probability of disintegration as about twenty per million alpha particles passed through the nitrogen.

Rutherford continued the study of distintegration by alpha particles and was able to show that all the elements from boron to potassium inclusive could be disintegrated,—with the exception of carbon and oxygen. He found in all these cases the emission of a proton took place and by studying the ranges at right angles to the direction of the impinging alpha ray (in which direction no elastically rebounding nuclei can appear) he was able also to determine that the kinetic energy of some of the particles resulting from disintegration was less than the kinetic energy of the incident alpha particle, aluminum being an example of this class, and nitrogen of course exemplifying the type where the kinetic energy is greater after disruption.

This difference between the kinetic energy input and output is the key to the study of the nucleus and it is the determination of "Q" values,—the numerical value of this energy difference for nuclear reactions, which is of greatest interest to-day. Rutherford sensed this and applied the findings of Aston on atomic masses to the problem of accounting for these energy differences.

These data indicated that the mass of a nucleus is not given by the sum of the protons and electrons (then presumed to be contained in it), as these masses would be measured in free space. But inside the nucleus the protons are packed so closely together that their electromagnetic fields interfere and a fraction of their combined mass is destroyed. The mass destroyed appears as a release of energy in the formation of the nucleus,—the greater the loss of mass the more firmly bound are the charged particles, and the more stable the nucleus thus formed. The atomic number and the mass number of the elements thus take on a new significance, for by an accurate determination of the mass of a nucleus a prediction of the energy of release at its formation may be made from the difference between its "free" and "bound" component masses.

Aston expresses his measurements of the masses of the elements in terms of the "packing fraction",—the divergence of the mass of the atom from the whole number rule divided by its mass number. It is therefore the mean gain or loss of mass per proton when the nuclear packing is changed from that of oxygen to that of the atom in question.

In nuclear disintegration we are concerned not so much with the actual value of the packing fraction as in its change from one atom to the other.

Thus in the cases we have so far discussed we may state what is now definitely known; the most common disintegration type produced by alpha rays consists in the capture of the alpha particle by the bombarded nucleus and the ejection of a proton. This will always therefore result in the change of the nucleus from one of even to odd, —or odd to even atomic number. And as Aston's results showed that the light elements of odd atomic number have a much higher packing fraction than those of even number we will conclude logically that when a disintegration takes place that changes an element of odd number to one of even number there will be a disappearance of mass,—and this lost mass will appear as the kinetic energy associated with the emitted proton. (Part of it however, may go into the generation of gamma rays,—a point which we are not here considering, in order to avoid confusion.)

Somewhat coincidently the kinetic energy of the incident alpha ray used by Rutherford was about equal to the gain in mass of the proton in its release from the nuclear binding so that these practically cancel out and thus the range of the emitted proton (or better its energy) gave a very good approximate measure of the energy change that took place in the disintegrated nucleus,—where the range was shorter than that of the incident alpha ray energy had been absorbed, where it was longer, energy had been released.

Setting up equations for conservation of energy and of momentum (very similar to the manner in which the Compton encounter relations are established) we may derive an equation for the evaluation of Q in any nuclear reaction involving only the capture of one projectile and the emission of another. Calling the three free masses (of projectile, target and ejected particle) respectively M_1, M_2 and M_3, and their velocities V_1, V_2 and V_3, and defining Q in terms of Einstein's mass energy relation as $Q = c^2 \Delta m$, and calling the mass of the target *after distintegration* M_4 we may write

$$Q = [(M_1 + M_2) - (M_3 + M_4)]c^2 - \gamma \text{ rays, and also } Q = \tfrac{1}{2} M_3 V_3^2 \left(\frac{M_3}{M_4} + 1 \right) - \frac{1}{2} M_1 V_1^2 \left(1 - \frac{M_1}{M_4} \right) - \frac{1}{M_4} \left(M_1 V_1 \right) \left(M_3 V_3 \right) \cos \theta;$$

where θ is the angle between direction of incident alpha ray and ejected particle.

Further work by Pettersson and Kirsch at Vienna (3) and by Pose at Halle and a continuation of the work at Cambridge by Chadwick and Feather led to a division into the five following classes of possible encounters between alpha particles and other nuclei: 1st: The alpha particle may encounter a nucleus and escape without loss of energy; it will then appear as an elastically scattered alpha particle following the ordinary scattering law based on a Coulomb field of force,—unless the encounter has been such as to allow the alpha particle to approach closer than a certain critical distance (about 10^{-12} cm.). In this case the alpha will escape from the field of the nucleus in a manner formerly known by the term "anomalous scattering", which means that for such close encounters the Coulomb force field is superseded by some higher power inverse law, or on the wave picture as developed by Taylor, there is a change of phase between alpha and nucleus waves due to this type of encounter.

2d. The alpha particle in its encounter may give up part of its energy to the nucleus, exciting the latter to a higher energy state. We may call this type of encounter "Non capture excitation". Example: $\alpha + {}_3Li^7 \rightarrow {}_3Li^7 + \alpha + \gamma$

3d. The alpha particle may give up some of its energy in ejecting another particle from the nucleus, and then escape itself. We call this "Non capture disintegration", and so far there is no experimental data indicating the actual occurrence of such a process.

4th. The alpha particle may be captured and no further emission take place. This is theoretically unlikely and no case is known.

5th. The alpha particle may be captured by the nucleus and another particle ejected. This is called "Capture disintegration by alpha rays" and is the most common of all encounters involving any type of disintegration (by alpha particles).

This is the type of reaction first observed by Rutherford, and studied in detail for nitrogen and aluminum. ${}_{7}N^{14} + \alpha \rightarrow {}_{1}p^{1} + {}_{8}O^{17}$ and ${}_{13}Al^{27} + \alpha \rightarrow {}_{1}p^{1} + {}_{14}Si^{30}$. An alternate reaction in class five must also be mentioned and that is the emission of a neutron instead of a proton. This for example in the case of Al gives ${}_{13}Al^{27} + \alpha \rightarrow {}_{15}{}^{*}p^{30} + {}_{0}n^{1}$. ${}_{15}{}^{*}p^{30}$ is unstable and constitutes the so-called artificially produced radioactivity discovered by the Curie-Joliots. For this unstable isotope of phosphorus disintegrates spontaneously, with a half value period of three minutes, into silicon,—with the emission of a positron. ${}_{15}{}^{*}p^{30} \rightarrow {}_{14}Si^{30} + e^{+}$

The first mentioned reaction of alpha capture (which has been verified by cloud chamber photographs,—showing incident alpha, ejected proton and recoiling target nucleus—but no scattered alpha) may be indicated by the general type reaction ${}_{Z}M^{A} + {}_{2}\alpha^{4} \rightarrow {}_{Z+1}M^{A+3} + {}_{1}p^{1}$ and there are seven well confirmed examples of this class: ${}_{5}B^{10}$ ${}_{7}N^{14}$ ${}_{9}F^{19}$ ${}_{11}Na^{23}$ ${}_{13}Al^{27}$ ${}_{15}P^{31}$ and ${}_{12}Mg^{25}$, the latter being radioactive by the emission of a negative electron. The neutron emitters are more numerous; their reaction being given by: ${}_{Z}M^{A} + {}_{2}\alpha^{4} \rightarrow {}_{Z+2}M^{A+3} + {}_{0}n^{1}$ and ${}_{3}Li^{7}$ ${}_{4}Be^{9}$ and ${}_{5}B^{11}$ going directly to stable isotopes with the emission of a neutron whereas ${}_{5}B^{10}$ ${}_{7}N^{14}$ ${}_{9}F^{19}$ ${}_{11}Na^{23}$ ${}_{12}Mg^{24}$ ${}_{13}Al^{27}$ ${}_{15}P^{31}$ and ${}_{19}K^{42}$ go to unstable isotopes and only settle down to stability after radioactively emitting a positron.

To explain nuclear disintegration in as far as it can be explained to-day we must here introduce the nuclear model conceived simultaneously by Gamow (4) and Gurney and Conden (5).

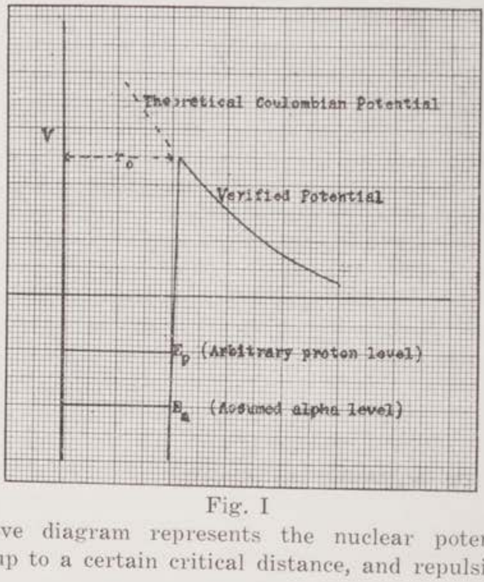

Fig. I

The above diagram represents the nuclear potential field,—Coulombian up to a certain critical distance, and repulsive of course in the case of alpha particle and nucleus. Beyond that distance it becomes attractive, and this we know from the experiment of capture,—or in fact from the stability of any nuclei. But the question we want answered is: "What is the mechanism of escape of an alpha particle from a radioactive nucleus;—or that of penetration of an alpha particle from without into a "normal" nucleus? On classical mechanics there would be no possibility of crossing this barrier in either direction unless the particle possessed energy greater than that of the opposing barrier. On wave mechanical principles there is a finite probability that such particles as have energies even less than that of the opposing wall may pass through it despite their small energy. This probability may be infinitesimally small where the barrier height is vastly greater than the particle energy, or it may approach unity as the particle energy approaches the energy value of the barrier. The optical analogy given by Born (6) is enlightening: "The escape of an alpha particle from a radioactive nucleus is likened to the phenomena associated with total internal reflection of light. From a corpuscular point of view no light penetrates into the air when a ray which passes through glass meets at a sharp angle, the plane separating glass and air. According to the wave theory however there exists in the air also, a sort of wave disturbance which although it carries off no energy and only penetrates a few wave lengths into the air may be said to really exist. For if we now set a second piece of glass with its face parallel to that of the first piece at such a short distance that the disturbance in the air gap reaches it with intensity not too much impaired, then a small amount of energy at once passes into the second piece of glass and the incident wave is propagated through it though of course very much weakened." The picture of the alpha particle in or outside of a nuclear barrier has much in common with the above case when considered from the wave mechanical point of view. An alpha particle, existing in a nucleus may be represented by a set of standing waves, and although the walls of the nuclear crater may be of finite height and thickness these standing waves are by no means obliterated at the wall but are propagated in weakened form and emerge on the outside as progressive waves. Since the square of the wave amplitude gives the probability of appearance of the waves (outside the barrier) and since we know that the thickness of the nuclear barrier decreases with height it follows that high energy particles will have much higher probability of penetrating the barrier (inwards or outwards) than those of low energy. Yet these latter are not completely excluded from the possibility of penetration as they are on the classical conception.

Thus the mode of disintegration of radioactive elements given by the Geiger Nutall law is supported by the wave picture, for it is the long range alpha particles (of high energy) which come off from bodies with short half value periods,—and they come off thus frequently just because of the high probability associated with their high energy. Conversely this penetrability of the potential wall gives us an insight into the mechanism of artificial disintegration of nuclei by bombardment from without by alpha particles from naturally radioactive bodies, and leads us to the conclusion, that if we have enough of them we can hope to get low velocity projectiles (of energy *less than* the value of the potential wall of the nucleus they are bombarding) into the said nucleus and thus produce disintegration without going so to speak "over the top" of the nuclear potential wall.

Experiments (7) performed with alpha particles of successively decreasing range and energy showed not only that those of energy less than that of the potential wall were able to penetrate that wall but also that there were certain preferred energies at which the alpha ray went through more readily.

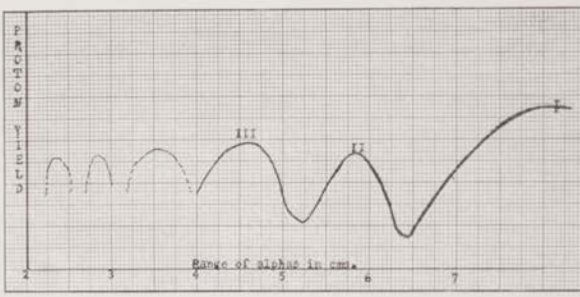

Fig. II

The diagram shown in Fig. II indicates that as the energy of the alpha particle is decreased from a value of that greater than the potential barrier (first maximum,—out at 7 cm. range) the chance of penetrating the nucleus falls rapidly to a minimum at about 5.6 cm., but then rises again to a maximum,—to two successive maxima in fact as the range is further decreased. These maxima are also explained by Gurney as a resonance effect between incident particle and nucleus. If the alpha particle has exactly the same energy corresponding to a resonance level in the nucleus then the chance of penetrating this barrier is much greater than if its energy were *more* or less than this.

These levels are indicated in the upper part of figure IV where the information obtained by alpha bombardments of an aluminum nucleus are summarized.

Probably one of the most valuable results of disintegrations studies has been the determination of nuclear energy levels from the range of the protons emitted during the disintegration process.

Assuming the potential barrier picture (Fig. I) referred to before, the captured alpha particle of kinetic energy W will fall into some nuclear level E_a and a proton will be emitted from a level E_p.

The kinetic energy of this proton will then be $W = E_a - E_p$, neglecting the energy of the residual nucleus.

Thus if we allow a *homogeneous* beam of alpha particles to fall on an aluminum foil the emitted protons should all come out with the same energy.

The following diagrams (Figures III a and b) show that instead

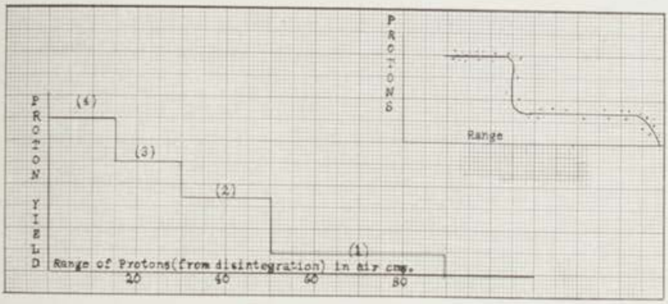

Fig. III a and b

of one, two and in some experiments as many as four different groups of protons have been found, indicating as many intermediate levels into which the alpha particle may fall. (Cf. reference 8.)

We have as a result of nuclear bombardment what might be

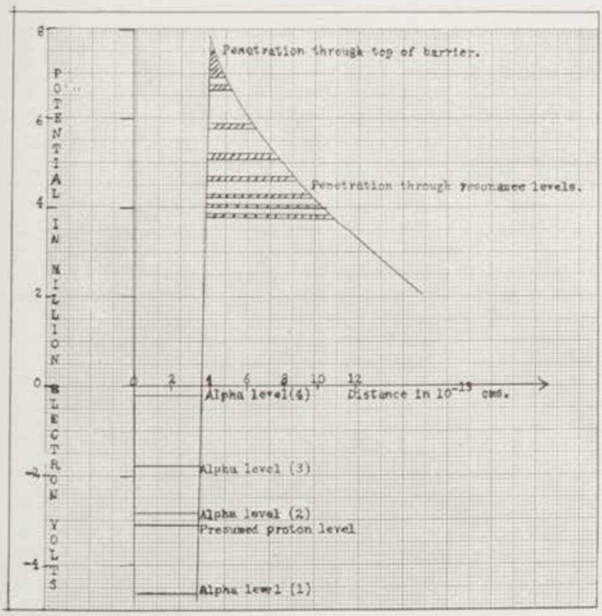

Fig. IV

called a "fine structure" of protons, giving on the spectroscopic analogy the equivalent of energy levels in the nucleus.

Thus the occurrence of several groups of protons rather than a single group (from bombardment *in this case* with alpha rays of a *single* energy) can be explained by supposing that in some cases the alpha particle is captured in an intermediate level and a proton is emitted with the formation of an excited nucleus. The nucleus then settles down into the ground state by the emission of a gamma ray. We therefore have multiple "Q" values from a single disintegration, these being determined as previously by the several proton ranges resulting from the reaction. In terms of energy levels, Q (determined from the Kinetic Energy of the proton) is then the measure of the difference in energy between the level in which the alpha particle is captured and the level from which the proton is emitted (Cf. Fig. IV)

So far we have confined ourselves to a discussion of disintegration processes which were produced by bombarding alpha particles from naturally radioactive bodies emitting these particles. Without going into the details of the discovery of the neutron we must now note that this particle which is without charge and has a mass approximately that of the proton acts as one of the most effective projectiles in disintegration processes.

We have already seen that certain nuclear reactions result in the emission of these neutrons. Using this disintegration product as a projectile it was found that as a promoter of nuclear transformations the neutron was far more effective than the alpha particle. This can easily be explained on the basis of the neutron's lack of charge. Atoms heavier than potassium could not be penetrated by alpha particles because of the increasing electrical repulsion between alpha and nucleus as the nuclear charge increased. No such condition exists between neutron and heavy nuclei. The force between a neutron and a group of protons (constituting the electrically charged bodies of a nucleus) is presumed to be negligible up to a very small distance,—where it becomes attractive. Thus there is no question of repulsion of the neutron, and the question of nuclear reaction becomes one which involves rather the energy necessary to promote the reaction rather than a question of penetration.

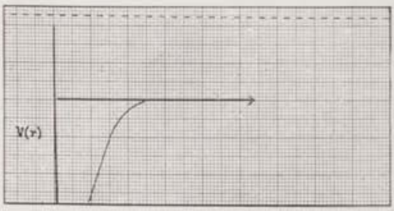

Fig. V

Figure V is a representation of the supposed potential between neutron and proton. It is a hole rather than a barrier.

Using the neutrons from the reaction of polonium alpha rays on beryllium, to attack nitrogen Fcather (9) first produced the reaction: ${}_7N^{14} + {}_0n^1 \rightarrow {}_5B^{11} + \alpha$.

This is the most probable type of neutron nuclear reaction,—the capture of the neutron and emission of an alpha particle. Carbon and oxygen yielded to this method of attack, as well as ${}_9F^{19}$, ${}_{10}Ne^{20}$.

Concerning the heavier elements, the evidence for their disintegration by neutrons is somewhat indirect, since it is concluded to from the fact that over fifty of the heavier atoms which have been thus bombarded have shown the development of an artificial radioactivity with the emission of beta rays.

While the half value periods and energies of this beta ray activity can be measured no certain knowledge is had concerning the primary reactions between these heavy nuclei and the neutron,—except that the atomic number of the nucleus doing the capturing changes by 2, 1 or 0, corresponding to the three possibilities of emitting an alpha ray, a proton or merely gamma radiation.

We now turn to what may be most properly called "artificial disintegration".

The advent of the nuclear model of Gamow and of Conden and Gurney should have at once indicated to all students of the disintegration processes discussed above, that it was not necessary to have projectiles of energies greater than the energy value of the potential barrier in order to produce penetration and disintegration in a given nucleus.

However, many research workers devoted their attention to the development of high voltage sources, by means of which they hoped to be able to accelerate various ions to velocities where the kinetic energies of these particles would be of the same order of magnitude as that of the alpha particles from naturally radioactive substances. The attempts which have since been highly successful may be classified into three groups: First the high voltage method, in which by means of step up transformers and vacuum tubes an ion is made to fall through the requisite potential difference. A modification of this method is that used by Van de Graaff (10) wherein the high voltage is produced directly by the direct current electrostatic generator developing potentials between 5 and 10 million volts. Secondly a pulse or so-called surf-board method, in which the ions are caused to travel along in the field of a progressing wave. And thirdly the method of multiple acceleration, using resonance methods, which is exemplified in the cyclotron of Lawrence (11). This latter has devoloped the highest artifinally accelerated particles to date, and essentially consists of a powerful magnetic field and an oscillating electric field. The ions introduced into two hollow semicircular electrodes are accelerated by the application of the high frequency potential difference, but in addition by reason of the magnetic field are made to travel in circles. In completing their paths they circulate in the two hollow electrodes in such a way that they spiral around in synchronism with the oscillating electric field, with the result that they can be made to gain successive increments in linear velocity, since their angular velocity is determined by the magnetic field alone. Thus going faster and faster on ever widening spirals they finally emerge at the periphery of the apparatus where they may be directed onto any target by another fixed deflecting electrostatic field.

While the above methods were still undergoing development, Cockroft and Walton (12) during the period between 1930 and 1932 attempted artificial disintegration with hydrogen ions which had less than one quarter of the energy necessary to surmount the potential barrier of the nucleus they were attacking.

Lithium has a potential barrier of about 2 million electron volts, and with ions of only between two and four hundred thousand electron volts they were able to produce the first disintegration with particles accelerated by laboratory rather than natural means. The reaction they produced was ${}_3Li^7 + {}_1p^1 \rightarrow 2\,\alpha$ and later experiments verified the fact that these alpha particles were shot out simultaneously in opposite directions, as might be seen from their tracks in a cloud chamber.

Later on Rausch and Traubenberg showed that lithium could be disintegrated with ion voltages as low as 30,000.

When boron was bombarded with hydrogen ions it yields alpha particles much more abundantly than lithium, with voltages of the same magnitude.

In this case the particles not only have no fixed energy of emission, or group of energies, as in the proton type of emission, but they are distributed continuously between zero and 5.65 million electron volts. We may explain this by the interpretation of the reaction as the breaking up of the nucleus (${}_5B^{11}$) and its captive proton into three alpha particles, which then may share the energy of transmutation in any of the practically infinite number of ways which are compatible with the principle of the conservation of momentum.

${}_4Be^9$, ${}_6C^2$, and ${}_9F^{19}$ have been disintegrated by hydrogen ions.

With the discovery of deuterium which when ionized makes an extremely effective projectile a new type of disintegrator was at hand. For as it has been shown that ${}_1D^2$ really consists of a proton and a neutron the action of such a particle when shot at a nucleus may be likened to that of a dissectible "dumbell"; for frequently when the deuteron reaches the nuclear barrier it splits up and the proton part is repelled while the neutron part enters the nucleus, increasing its mass by one. At other times the entire particle is captured and an alpha particle is emitted. Both resultant nuclei are radioactive and the reactions may be written:

$$ {}_{12}Mg^{26} + {}_{1}D^{2} \begin{cases} \to {}_{1}p^{1} + {}_{12}Mg^{27} \xrightarrow{e^-} {}_{13}Al^{27} + \gamma \\ \to {}_{2}\alpha^{4} + {}_{11}Na^{24} \xrightarrow{e^-} {}_{12}Mg^{24} + \gamma \end{cases} $$

Another interesting reaction is the deuteron on another deuteron which may also result in two different end products:

$$ {}_{1}D^{2} + {}_{1}D^{2} \begin{cases} \to {}_{1}p^{1} + {}_{1}H^{3} \\ \to {}_{0}n^{1} + {}_{2}He^{3} \end{cases} $$

It is practically impossible to make a list of all the disintegrable elements at this time since new ones are constantly being added. (13)

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THE BETA RAY SPECTRUM OF RADIUM E.

REV. JOHN S. O'CONOR, S.J.

(Abstract)

The distribution in energy of electrons from Radium E was examined by means of a magnetic spectrometer using Geiger-Mueller double coincidence counters for detection purposes. Special precaution, in the form of a baffle system, was employed to minimize scattering effects.

The radioactive material was examined under different conditions of source strength, mounting and aperture of defining slits with a view to determining the effect of these variables on the experimental distribution curve.

It is concluded that the position of the high energy experimental end point depends upon the source strength used as well as the width of the defining slits.

However, below a definite source strength and with a narrow central defining slit, the results from Radium E mounted on Nickel and Platinum were self consistent.

Using the data from these latter distribution curves an analysis was made to test the validity of the Fermi and Konopinski-Uhlenbeck theories of beta disintegration, after the manner introduced by Kurie, Richardson and Paxton.

It was found that the linear relation used as a criterion for the agreement of theory with experiment did not exist for the Fermi function but appeared in the "K.U." plot within the limits of error set by the statistical fluctuations and finite slit widths.

The high energy end point of the Radium E spectrum was found to be 1.25 $\pm$ .03 MEV from the extrapolation of the "K.U." plot.

This paper was presented at the meeting of the American Physical Society, Washington, D. C. April 29—May 1, 1937.

X-RAY EQUIPMENT AT ST. JOSEPH'S COLLEGE

A. H. W.

During the present scholastic year we completed the installation of high voltage equipment useful, among other applications, in the generation of Roentgen rays. The apparatus is located in the research laboratory. Because of the danger of contact with high tension lines, a cut-off switch was placed out of reach at a height of ten feet.

The installation of this equipment was made possible by the generosity of Alfred S. Doyle, M.D., who presented the mechanical rectifier and control units. The Westinghouse Electric and Manufacturing Co., supplied the Coolidge X-ray tube and a filament transformer.

The equipment is used to make X-ray photographs of the human body and so is a demonstration apparatus for the pre-medical physics course.

A second use of the equipment has been made by incorporating experiments on X-rays and crystal structure in our advanced course in physics. The instrument is equipped with a camera for making Laue photographs of crystals by X-ray diffraction. Successful crystal photographs were made by the advanced students. A complete description of the Laue camera was submitted for publication in: The American Physics Teacher.

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Hevesy und Alexander—Praktikum der chemischen Analyse mit Röntgenstrahlen (1933) (RM 4.80)
Ostwalds Klassiker der exakten Wissenschaften (240 brochures):
(1) Helmholtz—Ueber die Erhaltung der Kraft (1847) (RM 1.20)
(3) Dalton und Wollaston—Abhandlung zur Atomtheorie (1803-1808) (RM 1.20)
(4) Gay-Lussac—Ueber das Jod (1814) (RM 1.20)
(7) Bessel—Länge des einfachen Sekundenpendels (1826) (RM 4.80)
(8) Avogadro und Ampere—Abhandlungen zur Molekulartheorie (1811-1814) (RM 1.80)
(11) Galilei—Mathematische Demonstration über zwei neue Wissensweige. 1. und 2. Tag. (1638) (RM 4.20)
(13) Coulomb—Vier Abhandlungen über die Elektrizität (1785-6) (RM 2.60)
(20) Huygens—Abhandlung über das Licht (1678) (RM 3.20)
(24) Galilei—Math. Demonstration usw. 3. and 4. Tag (1638) (RM 3.60)
(25) —Anhang zum 3. und 4. Tag. 5. und *. Tag. (RM 1.80)
(37) Carnot—Bewegende Kraft des Feuers usw. (1824) (RM 2.40)
(40) Lavoisier und Laplace—Abhandlungen über die Wärme (1780-4) (vergriffen)
(42) Humboldt und Gay-Lussac—Das Volumgesetz gasförmiger Verbindungen (RM 1.20)
(52) Galvani—Die Kräfte der Elektrizität bei der Muskelbewegung (1791) (RM 2.30)
(57) Fahrenheit. Reaumur, Celsius—Thermometrie (1724-1742))RM 3.80)

(59) Guericke—Neue 'Magdeburgische' Versuche usw. (1672) (vergriffen)

(63) Oersted und Seebeck—Zur Entdeckung des
Elektromagnetismus (1820) (RM 2.20)

(68) Meyer und Mendelejeff—Das system der chem. Elemente (1864-71)
(RM 4.20)

(69) Maxwell—Ueber Faraday-Kraftlinien (1855-6) (RM 4.80)

(70) Seebeck—Magnetische Polarisation der Metalle usw. (1822-3) (RM 2.50)

(72) Kirchhoff und Bunsen—Chemische Analyse durch
Spektralbeobachtungen (1860) (RM 2.10)

(79) Helmholtz—Zwei hydrodynamische Abhandlungen (1858-68) (RM 2.00)

(81) Faraday—Experimentaluntersuchungen über Elektrizität (1832) (RM 2.80)

(86) —Experimentaluntersuchungen über Elektrizität (1933) (RM 2.60)

(87) —Elektrochemische Zersetzung (1834) (RM 5.00)

(99) Clausius—Ueber die bewegende Krafte der Wärme (1850) (RM 1.20)

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(101) —Abhandlungen über mechanische Wärmetheorie (1858) (RM 1.30)

(102) Maxwell—Ueber phyiskalische Kraftlinien (RM 3.00)

(106) D'Alembert—Dynamik (1743) (RM 4.60)

(107) Bernoulli—Wahrscheinlichkeitsrechnung. I. und II. Teil (1713)
(RM 3.80)

(108) —Wahrscheinlichkeitsrechnung. III und IV. Teil (RM 4.20)

(114) Volta—Briefe über tierische Elektrizität (1792) (RM 3.50)

(118) —Untersuchungen über den Galvanismus (1796-1800) (RM 2.80)

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(126) Faraday—Selbstinduktion und Dielektrizität (1835) (RM 2.80)

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(131) —Arten der Entladung (1838) (RM 2.00)

(132) Andrews—Ueber die Kontinuität der gasförmigen usw. (RM 2.30)

(134) Faraday—Gegen Kontakttheorie (1840) (RM 4.20)

(136) —Dampfelektrisiermaschine. Drehung der
Polarisationsebene (1843-1846) (RM 2.40)

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(140) Faraday—Diamagnetismus. Kristallmagnetismus (1846-50) (RM 5.30)

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Farbenzerstreuungsvermögens usw. (RM 1.80)

(157) Toepler—Beobachtungen nach einer neuen optischen Methode. (RM 2.20)

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(167) Lagrange, Rodrigues, Jacobi and Gauss—Die Prinzipien der Mechanik
(RM 2.40)

(168) Wheatstone, Brewster, Riddell, Helmholtz, usw.—Das Stereoskops
(RM 4.00)

(180) Mayer—Mechanik der Wärme (RM 2.00)

(188) Lebedew—Die Druckkräfte des Lichtes. Abhandlungen. (RM 2.20)

(191) Newton, Bernoulli und D'Arcy—Die Grundsätze der Mechanik (RM 3.20)

(192) Huygens—Die Pendeluhr—Horologium oscillatorium (RM 6.40)

(193) Thomson—Die dynamische Theorie der Wärme (1851-2) (RM 5.80)

(196) Rydberg—Die Beschaffenheit der Emissionsspektren (1889) (RM 5.00)

(204) Laue, Friedrich, Knipping—Die Interferenz der Röntgenstrahlen
(1912-14) (RM 3.50)

(205) Bartholinus—Versuche mit dem doppelt brechenden usw. (1669) (RM 1.80)

(206) Planck—Die Ableitung der Strahlungsgesetze (RM 2.80)

(207) Smoluchowski—Die Brownsche Bewegung (RM 4.80)

(213) Archimedes—Ueber schwimmende Körper usw. (RM 3.40)

(214) Faraday—Das Verhalten von Gold zum Licht (RM 3.20)

(215) Fresnel—Die Bewegung des Lichts (1815-18) (RM 3.80)

(216) Clapeyron—Die bewegende Kraft der Wärme (RM 2.80)

(222) Wiedemann und Franz—Die Wärmeleitungsfähigkeit der Metalle
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(228) Wien und Lummer—Das Wiensche Verschiebungsgesetz usw. (RM 2.80)

(229) Boyle—Der skeptische Chemiker (RM 4.80)

(230) Lavisier—Das Wasser (1930) (RM 2.85)

(231) Goldstein—Kanalstrahlen (1930) (RM 4.30)

(237) Hagen-Poiseuille-Hagenbach—Drei Classiker der Strömungslehre (1933)
(RM 5.60)

Planck—Ueber neuere thermodynamische Theorien (1912) (RM 0.90)

van der Waals—Die Zustandsgleichung (1911) (RM 0.90)

—Weiteres zur Zustandsgleichung (1913) (RM 1.10)

The following works are published by J. A. BARTH, Leipzig, Germany:

Boltzmann—Populäre Schriften (1925) (RM 11.40)

—Vorlesungen über Gastheorie (1923):

Teil 1. Theorie der Gase mit einatomigen Molekülen usw.
(RM 6.00)

2. Theorie van der Waals—usw. (RM 7.00)

—Vorlesungen uber Maxwells Theorie (1908):

Teil 1. Die Grundgleichlungen (RM 5.00)

2. Verhältnis zur Fernwirkungstheorie, usw. (RM 5.00)
—Vorlesungen über die Prinzipe der Mechanik (1920-22):
Teil 1. Prinzipe, usw. (RM 7.00)
2. Die Wirkungsprinzipe, usw. (RM 10.00)
3. (Buchholz) Elektrizitätstheorie usw. (RM 6.00)
Mach—Die Prinzipien der Wärmelehre (1923) (RM 12.00)
—Optisch-akustische Versuche (1873) (RM 4.00)
Seeliger—Einführung in die Physik der Gasentladungen (1927) (RM 22.00)
Wiener—Ueber Farbenphotographie usw. (1908-9) (RM 2.40)

The following works are published by JULIUS SPRINGER, Berlin, Germany:

Berliner und Scheel—Physikalisches Handwörterbuch (1932) (RM 96.00)
Bjerknes V. und J., Solberg und Bergeron—Physikalische Hydrodynamik (1933) (RM 66.00)
Born—Optik (1933) (RM 36.00)
Courant und Hilbert—Methoden der mathematischen Physik (1931) (RM 29.20)
Hort—Technische Schwingungslehre (1922) (RM 21.60)
Kayser—Tabelle der Hauptlinien der Linienspektra aller Elemente (1926) (RM 24.00)
Karman und Levi-Civita—Vörtrage aus dem Gebiete der Hydro—und Aerodynamik (1924) (RM 16.20)
Madelung—Die mathematischen Hilfsmittel des Physikers (1936) (RM 27.00)
von Mises—Fluglehre (1933) (RM 14.50)
Rohr—Die optischen Instrumente (1930) (RM 5.13)
Sattelberg—Wörterbuch der Elektrischen Nachrichtentechnik:
I: Teil: Englisch-Deutsch (1925) (RM 9.90)
II. Teil: Deutsch-Englisch (1926) (RM 10.80)
Schottky—Thermodynamik (1929) (RM 50.40)
Struktur der Materie (Born, Franck und Mark):
I. Band: Zeemaneffekt (Back und Lande) (1925) (RM 12.96)
II. Band: Vorlesungen über Atommechanik (Born) (1925) (RM 14.85)
III. Band: Anregung von Quantensprüngen durch Stösze (Franck und Jordan) (1926) (RM 17.55)
IV. Band: Linienspektren und periodisches Systems (Hund) (1927) (RM 13.50)
V. Band: Die seltenen Erde (Hevesy) (1927) (RM 8.10)
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VII. Band: Graphische Darstellung der Spektren (Grotien) (1928) (RM. 30.60)
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IX. Band: Elementare Quantenmechanik (Born und Jordan) (1930) (RM 25.20)
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XIII. Band: Die Quantenstatistik (Brillouin und Rabinowitsch) (1931) (RM 42.00)
XIV. Band: Molekülstruktur (Stuart) (1934) (RM 32.00)
XV. Band: Molekülspektren Teil 1. Tabellen (Sponer) (1935) (RM 16.00)
XVI. Band: Molekülspektren Teil 2. Text (Sponer) (1936) (RM 36.00)
XVII. Band: Kristallplastizität (Schmid und Boas) (1935) (RM 32.00)
Verständiche Wissenschaft:
XIV. Band: Die Relativitätstheorie (Hopf) (1931) (RM 4.80)
XX. Band: Physik für Jedermann (Haas) (1933) (RM 6.80)
XXV. Band: Die Bausteine der Körperwelt (Wulf) (1935) (RM 4.80)
Zühlke—Praktischer Leitfaden zum Färben von Textilfasern (1930) (RM 8.55)

The following works are published by B. G. TEUBNER, Poststrasze 3/5, Leipzig, Germany:

Aus Natur und Geisteswelt:
Band 170: Ahrens—Mathematische Spiele (1927) (RM 1.80)
Band 372: von Rohr—Das Auge und die Brille (1918) (RM 1.80)
Band 684: Hamel—Mechanik (1921) (RM 1.80)
Born—Atomtheorie des festen Zustandes (1923) (RM 13.40)
Föppl—Vorlesungen über technische Mechanik:
I. Band: Einführung in die Mechanik (1925) (RM 13.50)
II. Band: Graphische Statik (1926) (RM 13.50)
III. Band: Festigkeitslehre (1927) (RM 14.90)
IV. Band: Dynamik (Von Busemann, L. Föppl und O. Föppl) (1933) (RM 14.00)
V. Band: Die wichtigsten Lehren der höheren Elastizitätstheorie (vergriffen)
VI. Band: Die wichtigsten Lehren der höheren Dynamik (1921) (RM 11.30)
Klein und Sommerfeld—Ueber die Theorie des Kreisels:
1. Heft: (1923) (RM 7.00)
2. Heft: (vergriffen) (RM 9.00)
3. Heft: (1923) (RM 8.00)
4. Heft: (vergriffen)

Kohlrausch—Praktische Physik zum Gebrauch für Unterricht, usw. (1935) (RM 32.00)

Kohlrausch und Krüger—Kleiner Leitfaden der praktischen Physik (1932) (RM 14.80)

Kultur der Gegenwart (Hrsg. v. Hinneberg):
III. Teil: Die mathematischen, naturwissenschaftlichen und medizin. Kulturgebiete:
3. Abt: Anorganische Naturwissenchaftlichen:
I. Band: Physik (1925) (RM 34.00)

Lecher's lehrbuch dere Physik für Mediziner, Biologen u. Psychologen 1933) (RM 16.20)

Mathematisch-Physikalische Bibliothek (Reihe II.):
4. Band: Gewöhnliche Differentialgleichungen usw. (1933) (RM 3.00)
10. Band: Physik des Tonfilms (Haas) (1934) (RM 2.20)

Mathematisch-physikalische Lehrbücher (Hrsg. v. Trefftz.):
3. Band: Schaefer—Einführung in die Maxwellsche Theorie (1929) (RM 6.60)
15. Band: Mathematische Instrumente (1912) (RM 5.60)
17. Band: von Mises—Elemente der techn. Hydromechanik (1914) (RM 6.00)
18. Band: Runge—Graphische Methoden (1928) (RM 5.40)

Teubner's Lehrbücher der mathematischen Wissenschaften:
XI: Webster—Dynamik (1925) (RM 16.00)
XXXIV: Voigt—Lehrbuch der Kristallphysik (1928) (RM 37.00)

Wissenschaft und Hypothese:
I. Band: Poincaré und Lindemann—Wissenschaft u. Hypothese (1928) (RM 8.00)
VI. Band: Planck—Prinzip der Erhaltung der Energie (1925) (RM 7.40)
XVII. Band: Poincaré und Lindemann—Wissenschaft und Methode (1914) (RM 6.40)

The following works are published by NICOLA ZANICHELLI, Bologna, Italy:

Fermi—Introduzione alla fisica atomica (1928) (L. 75,—)
Leonardo da Vinci—Del moto e misura dell'acqua (1923) (L. 35,—)
Levi-Civita—Questioni di meccanica classica e relativistica (1924 (L. 16,—)
—Fondamenti di meccanica relativistica (1928) (L. 30,—)
—Carratteristiche dei sistemi diff. e propagazione ondosa (1931) (L. 15,—)

Levi-Civita e Amaldi—Lezioni di meccanica razionale:
Vol. I: Cinematica. Statica. (1930) (L. 90,—)
Vol. II: (parte prima) Dinamica. (1926) (L. 65,—)
Vol. II: (parte seconda) Dinamica (1927) (L. 80,—)

Levi-Civita e Amaldi—Compendio di meccanica razionale:
Parte prima: Cinematica. Statica. (1928) (L. 60,—)
Parte seconda: Dinamica (1928) (L. 50,—)

Marconi—Le radiocomunicazioni a fascio (1927) (L. 8,—)

Note: (1) Part III. (French, German and Italian publications) will be published in the Bulletin A.A.J.S. for December, 1938.)

(2) A discount of 25 per cent. is allowed on many German publications outside of Germany, Palestine and Switzerland.

(3) Too much reliance should not be placed on the prices quoted in the above list. Recall the fluctuation of prices during the past few years.

NEWS ITEMS

JESUITS IN SPAIN.—Forty-eight Jesuits are known to have been murdered in Spain. All the members of the Society have been banished from the country. Jesuit Universities, Colleges, Schools and Churches have been burned and pillaged.

CHARACTERISTIC of the early stages of religious persecution is the suppression of the Jesuit Order. Spain has not made an exception to the rule. The extent of the loss to the country may be gauged by a consideration of the Jesuit achievement there within recent years. The Order was suppressed on January 24th, 1932. At that time the Jesuits maintained, in Madrid, 134 primary schools with over thirty thousand pupils, at an annual cost of more than five million pesetas. This may be compared with the State's achievement; it maintained 202 schools with over fifteen thousand children, at an annual cost of three million pesetas. There were besides twenty-seven schools with about seven thousand pupils supported by the municipality which cost it about one million pesetas a year. The Jesuits also owned the following secondary schools in the country: three in Barcelona; one in Bilbao; one in Gijón; one in Las Palmas; two in Madrid; one in Málaga; one in Orduña; one in Orihuela; one in Oviedo; one in San Sebastian; one in Seville; one in Tudela; two in Valencia; one in Valladolid; one in Vigo; one in Villafranca de los Barros; one in Zaragoza: a total of twenty-one institutions where about seven thousand pupils were educated by 530 teachers, of whom over a hundred were not Jesuits. Moreover, these centres were considered to be the best-equipped with scientific material in all Spain. For instance, the secondary school of Gijón possessed the best entomological collection in the country, Valladolid had one of the best laboratories for biological research, in Zaragoza there was a museum and library considered unique.

Besides these schools the Jesuits maintained the following institutions for scientific research: the "Observatorio del Ebro" (a meteorological and astronomical observatory) which was once officially recognized as the first in Spain; the "Instituto Quimico" and the "Instituto Biológico" (biological and chemical institutes, both in Madrid); the "Laboratorio Paidométrico" (pedagogical laboratory in Barcelona); and the "Observatorio Astronómico" in Granada.

Other cultural centres founded and supported by the Jesuits were: the "Instituto Católico de Artes e Industrias" (Catholic Institute of Arts and Industries), Madrid, where about six hundred young men received technical training; the "Centro de Estudios Villa San José," Madrid, especially maintained for writers of the Order but also open to other people. (This centre possessed a magnificent library.) The "Universidad Pontificia de Comillas," a Divinity School especially dedicated to poor students. The Literary and Commercial Universities of Deusto, close to Bilbao. The first of these universities possessed several libraries, the most important consisting of fifty thousand volumes. All the professors had university degrees in Spain and abroad. More than four thousand young men, Spanish and Spanish-American, studied law and literature in this University.

LOYOLA COLLEGE, Baltimore, Maryland. Department of Chemistry. On Friday, March 5th, Rev. Walter G. Summers, S.J., Professor of Psychology, Fordham University Graduate School, gave a lecture demonstration of a Recording Psychogalvanometer. This instrument is the result of several years of research by Father Summers. In the audience were judges, lawyers, professors and many distinguished guests including Mayor Jackson.

Mr. Walter A. Weldon, Superintendent of the Locke Insulator Corporation, lectured to the members of the Chemists Club, on March 18th. His subject: Ceramics and the Art of the Potter. The lecture was illustrated with excellent specimens and the actual molding of a statuette.

On April 29th, Mr. Charles J. Copley of the Socony Vacuum Oil Company of New York City, gave an illustrated lecture on the subject: The Theory of Lubrication. A new sound motion-picture well illustrated the various theories of lubrication.

ATENEO DE MANILA, P. I. Department of Chemistry.—The Industrial Chemistry Division of the Department of Chemistry had a successful first year. The following courses were presented: Food Technology, Beverages and Fermentation, Soaps and Cosmetics, and Leather Tanning. A long list of the products prepared in the Industrial Chemistry Laboratories is available in the annual catalog.—Letters of commendation were sent to the Faculty of the Ateneo de Manila from: President, Manuel L. Quezon; Vice-President, Sergio Osmena; Secretary of Agriculture and Commerce, Eulogio Rodriguez; Director of Plant Industry, Hilarian S. Silayan; and Technical Advisor at Malacanang, Arthur F. Fisher.

Fordham—Chemistry Department

FORDHAM UNIVERSITY. Department of Chemistry.—Rev. Francis W. Power, S.J., presented a paper at the meeting of the American Chemical Society at Chapel Hill, N. C., on April 14th, before the members of the Microchemical Section. The subject: The

Probable Error of the Microdetermination of Carbon and Hydrogen.

Five papers were presented at the Spring Meeting of the American Chemical Society by members of the Department; one by Dr. Freudenberg, two by Fr. Power, and two by Dr. Cerecedo and his associates describing their new method of isolation of pure vitamine B_1 crystals from rice polishings, wheat germ, and brewer's yeast.

At the invitation of Dr. Pichler of New York University, Fr. Power led a discussion on April 1st before the local section of the Microchemical Society on the application of statistical methods in analytical chemistry. The subject seemed to arouse considerable interest among the members and Fr. Power was urged to write the matter up to submit it for publication in the Analytical Edition of Industrial & Engineering Chemistry.

Several of our graduate students have recently accepted very promising positions in the chemical industry and indeed there are more jobs being offered than we have men to recommend for them.

Dr. Stekol's new course in the chemistry of nutrition is being carried out in a very thorough manner; the students do all the regular chemical analyses in foods and do the biological tests on their own experimental animals besides learning the technique of a standard type of respiration apparatus for determining the basal metabolic rate. Dr. Hynes and Dr. Yanowski are continuing their investigations of the various compounds found between luteo cobaltamine chloride and different anions; the micro-photographs of the crystals formed are very striking and have a technical perfection not often seen in such pictures.

GEORGETOWN UNIVERSITY OBSERVATORY

Eclipse Expedition to the South Seas

Selected as one of the scientists to accompany an expedition into the Pacific to study the sun eclipse next June, Dr. Paul A. McNally, S. J., director of the Georgetown University Observatory, is hoping for better luck than he encountered on a similar mission last year when he said he traveled "half way around the globe merely to see a Siberian rainstorm."

Dr. McNally will be Georgetown University's only representative on the National Geographic Society-United States Navy Expedition. Among the members of the expedition are some of the most distinguished astronomers in the United States.

The longest total eclipse of the sun visible from the earth in 1,200 years will take place June 8, and American scientists under the National Geographic Society and the United States Navy will have front row seats for the phenomenon.

As the moon passes between the earth and the sun, bringing about the eclipse, these scientists will be watching from a tiny coral atoll in the Phoenix Islands, far out in the Pacific Ocean and just south of the equator.

Dr. S. A. Mitchell, director of the Leander McCormick Observatory, University of Virginia, will be the scientific leader of the expedition. Capt. J. F. Hellweg, superintendent of the United States Naval Observatory, will be in charge of the Navy's part of the expedition.

Other members of the expedition will include Dr. Paul A. McNally, director of the Georgetown College Observatory; Dr. Heber D. Curtis, director of the Michigan University Observatory; Dr. Floyd K. Richtmyer of Cornell University; Dr. Irvine C. Gardner, National Bureau of Standards; John W. Willis of the Naval Observatory, and a photographer from the National Geographic Society. A naval surgeon qualified to carry out the work of a naturalist probably will join the party in Hawaii.

To Study Flash Spectrum

Dr. Mitchell will devote his attention to observing the flash spectrum, which becomes visible during a few seconds just after the moon's disk completely covers the sun, immediately before the sun begins to emerge from behind the moon. Dr. Curtis will observe the spectrum of the sun's corona. Dr. McNally will photograph the corona with light of different colors by using various types of filters. Dr. Richtmyer will measure the total light of the corona.

Dr. Gardner will take with him the same eclipse camera of his own design which he took to Russia, which employs a new type of lens and with which he obtained successful photographs of last June's eclipse. He also will make photographs in color. The Naval Observatory party will be especially interested in observing the exact time at which the eclipse begins and ends. This will serve as an important check on calculations of the movement of the heavenly bodies.

Schedule of Broadcasts of the National Geographic Society and U. S. Navy Eclipse Expedition of 1937 to the South Seas. All broadcasts will be over the National Broadcasting Company networks.

Broadcast No. 1. Tuesday, March 30, 6:35-6:45 p. m., E. S. T. Red Network.

Speaker: George W. Hutchison, Secretary, National Geographic Society.

Subject: Announcing the Eclipse Expedition.

Broadcast No. 2. Saturday April 10, 6:00-6:15 p. m. E.S.T.

Subject: Science Prepares for an Eclipse. Speakers: Admiral William D. Leahy, Chief of Naval Operations; Dr. Lyman J. Briggs, National Bureau of Standards; and Rev. Paul A. McNally, Director, Georgetown University Observatory.

Other broadcasts:

Thursday April 15, 9:00—9:15 p. m., E.S.T.
Wednesday, April 28, 10:15-10:30 p. m., E.D.S.T.
Thursday, May 6, 5:00-5:15 p. m., E.D.S.T.
Monday, May 10, 9:00-9:15 p. m., E.D.S.T.
Sunday, May 16, 4:00-4:15 p. m., E.D.S.T.
Saturday, May 22, 7:45-8.00 p. m., E.D.S.T.
Tuesday, May 25, 10:00-10:30 p. m., E.D.S.T.
Sunday, May 30, 10:00-10:15 p. m., E.D.S.T.
Tuesday, June 1, 10:00-10:30 p. m., E.D.S.T.
Monday, June 7, 7:45-8:00 p. m., E.D.S.T.
Tuesday, June 8, 1:00-1:15 p. m., E.D.S.T.
Tuesday, June 8, 3:15-3:30 p. m., E.D.S.T.
Tuesday, June 8, 10:45-11:00 p. m., E.D.S.T.

BULLETIN OF THE AMERICAN ASSOCIATION OF JESUIT SCIENTISTS

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