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S.J.B.

A. M. D. G.

BULLETIN

of the

American Association of Jesuit Scientists

(Eastern Section)

For Private Circulation

LOYOLA COLLEGE
BALTIMORE, MARYLAND

VOL. XI MAY, 1934 NO. 4

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EDITORIAL

Science is preeminently the expression of **truth.** Our knowledge of science comes from the discovery of **facts;** and progress in science is the discovery of new facts. The most recent facts in any particular branch of science are made known to scientists by periodic conventions. The method of presentation is simple, direct and straightforwad. Occasionally theories are put forth and these theories are founded on discovered facts.

How are these new facts recorded and reported? Successful research problems from the various laboratories are printed in the proper scientific journals. The general public are given distorted facts by unscientific and inaccurate reporters, who feel they must be sensational in telling the world new scientific discoveries.

A recurrence of this condition goes on perennially. Recently the members of the American Chemical Society had their annual spring meeting at St. Petersburg, Florida. The various newspapers and periodicals had their usual number of reporters, who were eager and intent, actually glowing with desire to tell the whole world about the new discoveries in the field of chemistry. Journalistic enthusiasm expressed itself in this way on March 30, in **The New York Times:** "Superman evolved by drugs is predicted", "Chemist sees profound power for good and evil tapped in a few generations, building up brain power"; "the coming of the super-man and the super-race may not have to wait for the tortuous and uncertain processes of evolution, **taking hundreds of thousands of years,** but may be brought about within a few generations through organic chemistry. A prophecy to this effect, that there would be **a synthetic super-man** in the not too distant future, was made here to-day."

It was actually stated: "that organic chemistry was gradually learning the relationship between certain chemicals and their influence on man's behavior. It was learning more and more about the chemical constitution of living matter and to synthesize products in which it improved vastly on nature."

Surely, the issue is apparent! Examples could be multiplied 'ad infinitum'. How often we have seen the headline: "Cure for Cancer Discovered"; "Successful Antidote for Carbon Monoxide Poisoning".

Unfortunately the lecturer does not get the opportunity to read the reporter's version of the scientific paper presented. Then too, the reporter is not a scientist and so cannot report accurately that which requires extreme accuracy. Goethe well said: "The first and last thing required of genius is the love of truth". This principle is applicable to all phases of endeavour, scientific or otherwise. Perhaps someone of our readers could suggest a method of correcting this unscientific method of reporting scientific facts.

"Man is the interpreter of nature, science the right interpretation".

R. B. S.

SCIENCE AND PHILOSOPHY

ESSENTIAL AND ACCIDENTAL DIFFERENCES

Rev. John J. Toohey, S.J.

In writing his interesting paper on "Essential and Accidental Differences" in the March **Bulletin**, I understand that Father Lynch was assuming the role of an **advocatus diaboli**, that he had no intention of presenting his own position, but the position of a certain school, and that he wished to set forth that position to the best advantage, so that anyone who should argue against it would not be speaking at random, but with a clear understanding of what he was attacking. Consequently, in setting down the following points, I do not consider that I am dealing with arguments which have the sanction of Father Lynch, but with the arguments of the school whose position he is describing.

In a discussion of this kind, the words "essential" and "accidental" cannot be intelligibly employed until we have asked the question, Essential **to what?** or Essential **in what respect?** or Essential **for what purpose?** And the same question must be asked with reference to the word "accidental." Until this question has been answered, the use of the words "essential" and "accidental" will be meaningless or misleading.

One and the same thing may be viewed as a member, now of one class, now of another; and what is essential to it as a member of one class will be accidental when it is considered as a member of another class. For example, Brown, Smith and Jones may be classified as men or animals or as creatures. If we classify them as men, rationality is essential. If we classify them as animals, rationality is not essential. If we classify them as creatures, neither rationality nor animality is essential. In other words, in order that a thing should be an animal, it does not have to be rational; and in order that it should be a creature, it is not necessary that it should possess either rationality or animality.

The word "essential," in its most rigorous use, means that which must be kept in view in a given classification; it is that upon which we have concentrated. In a wider sense, it includes everything that is necessarily connected with that which must be kept in view. It is in this wider sense that the word is used when we speak of essential and accidental differences. "Accidental" means that which should be disregarded in a given classification; that is, it is neither such that it must be kept in view, nor is it such that it is necessarily connected with what must be kept in view. "Accidental" is the same as non-essential, and the word "irrevelant" is a synonym for it in this connection.

The selection of a particular quality as a basis of classification is largely arbitrary. The quality itself is not arbitrary, but its selection is. It may not be arbitrary in the case of a given investigator,—others may have made the selection for him,—but it is arbitrary in the case of the particular group of scientists with whom he has associated himself. If a scientist selects atomic structure as his basis for classifying bodies, then everything that is not necessarily connected with atomic structure is for that scientist accidental or irrevelant to his classification. Because of the particular quality upon which he has concentrated, he will call every difference of atomic structure essential, and everything unconnected with difference of structure, accidental. And for the most part he is right, so far as his point of view is concerned; but he must remember that his is not the only point of view. There are a thousand ways of viewing material substance, and in many of them any given atomic structure will be non-essential.

What we have just been saying is borne out by Father Lynch in the following passage: "It is of the essence of rock salt, for instance, to form crystals of a definite pattern—it is of the nature of ice to form crystals of a different pattern, and so on. **From this viewpoint** then it would seem that we should consider the difference between the solid and the liquid state in the case of crystalline substances as essential" (p. 133, italics mine). The words I have underlined contain the kernel of my contention, and it is not necessary here to comment minutely upon the whole passage. Everything hinges on the viewpoint and, therefore, the viewpoint cannot be omitted from the discussion. To use the term which is the subject of this paper, the viewpoint is **essential** to the discussion. Without reference to a viewpoint, the words "essential" and "accidental" are inapplicable and pointless.

It is one thing to ask what is essential in order to have a **body**; it is quite another to ask what is essential in order to have **such** a body. The chemist or physicist will put aside many qualities as non-essential when his aim is to investigate the ultimate constitution and structure of all bodies; but he will insist upon many of those qualities as essential when his aim is to secure suitable instruments and materials for his investigation. You may say that it is accidental to the constitution of a body, viewed as a **body**, that it should have thirteen positive particles balanced by thirteen negative particles; but to the constitution of **Sodium** this is essential. If a given substance is constituted by a particular arrangement of particles, then that arrangement is essential to the given substance. Moreover, all the properties which are necessarily present along with that arrangement are also essential.

Father Lynch writes on page 134: "Sodium and Neon are as unlike in their properties as night and day, whereas Sodium and Potassium are very much alike." All properties are qualities. Shall we say that the properties of Sodium do not reveal that it is different **in nature** from Neon? Why, then, are the properties permanent? Do not the properties reveal the nature of a thing? How otherwise can you differentiate between a proton and an electron, between positive and negative particles? Is not the very **arrangement** of the particles in a given substance a property of the particles in that substance?

Again on page 134: "Physically and structurally there is a difference of only one brick in the structures of Sodium and Neon and a difference of eight bricks in the structures of Sodium and Potassium." Here **structure** has been selected as the point of comparison. If we take **color** as our point of comparison, there is a wider difference between Gold and Platinum than between Gold and Sulphur. Are we going to view Sodium merely as a structure, and leave out of account the many properties which necessarily accompany its structure? The scientist has not answered all the pertinent questions that may be asked about Sodium when he has told us what its structure is. Besides, long before we knew the structure of Sodium, we recognized it as Sodium, and we could only recognize it by qualities which are essential to it. In the last three decades we have heard much of the transmutation of metals. How is the scientist to judge that one metal has been converted into another, unless the difference in the essential qualities of the two metals reveals to him that the conversion has taken place?

A theory or hypothesis is never a thing to be entertained for its own sake; and it must not be allowed to blot out the essential qualities which we have always known to exist in a substance and the presence of which the theory was devised to explain. An explanation ceases to be an explanation when it explains away and obliterates the very thing that called for an explanation.

Intense preoccupation with one particular aspect of a subject may easily warp a man's judgment and rob him of all sense of proportion, so that he dismisses as unimportant everything that does not bear intimately upon the aspect under which he is viewing the subject. There is a story of a man who claimed that there was nothing in the world like leather. He had constituted leather the standard by which to measure the worth of everything under heaven. Unless we keep our wits about us, any of us may fall a victim to a similar delusion.

The Editor expressed a wish that this paper should appear in the present issue of the BULLETIN. On this account, it has been thrown together in great haste, and it will, therefore, make demands upon the indulgence of the reader for its incompleteness and its other imperfections. I hope Father Schmitt will allow me space in a future issue to expand what has here been set down in outline.

STATISTICAL LAWS AND CAUSALITY

Rev. Joseph P. Kelly, S.J.

In classical Physics, a law of nature is: "a generalization, which expresses an observed relationship of constancy and uniformity of action in nature." Such a law has always been considered intrinsically valid. As an objective interpretation of natural phenomena, it has been regarded in science as having a very high degree of probability. Such a law found its rational justification in the principle of causality and the uniformity of nature. In the application of a law of nature to a particular physical body, e. g., in determining the velocity of a falling body, at a given moment, the body in question was treated as if all its mass were concentrated at the center. Likewise, a chemical compound was explained by the union of the atoms that made up the component bodies.

In recent years, and especially in our own day, these notions are undergoing some modification. One cannot read scientific text books without noting the tendency of many scientists to put less stress on the absolute nature of physical laws and to attribute to them something of a statistical character. Investigations and research work on the inner nature of the atomic structure, the division and subdivision of what was thought to be physically indivisible, seem to have shaken, to some extent at least, scientific faith in the absoluteness of the laws of nature. And although these laws appeared to "govern" large bodies, even when considered as concentrated particles, they do not seem to have the same validity when applied to the real atom. What was true in the macrocosmic order, does not seem to be so true in the microscopic world. As a solution for this difficulty, some scientists have been led to deny the absolute validity of the laws of nature and they now hóld that they are only statistical laws. Whether this really solves the problem or is merely an "ad hoc" solution to be proved or disproved by further experimentation, we leave to the scientists to decide. What we wish to discuss here is a further conclusion that has been drawn, viz: that the statistical nature of physical laws has destroyed the validity of the principle of causality. Two citations will suffice to show the presence of this attitude of mind on the part of some men of science. Miller, "Introduction to Physical Science", after some discussion on the Principle of Indeterminism, concludes: "The independent existence of position and velocity, however, would seem to lie at the very basis of our scientific thought. Our ability to predict the future behavior of a physical system would seem to depend on our knowledge of the present state of the system, i. e., on the present position and velocity of the constituent parts. The belief has been freely expressed in some quarters that this new principle, (of indeterminism), undermines the very concept of strict causality in physical phenomena". p. 361. And Eddington, "The Nature of the Physical World": "In recent times some of the greatest triumphs of physical prediction have been furnished by admittedly statistical laws, which do not rest on a basis of causality. Moreover, the great laws hitherto accepted as casual, appear on minuter examination to be of statistical character". p. 298. (c. f. also, Jeans, "The Mysterious Universe". p. 30, sq. "Atomic Physics". Physics Staff of University of Pittsburgh, p. 317.sq.)

In the relations that exist between Scholastic Philosophy and Science, and especially in the sphere of Cosmology, the importance of the principle of natural causation is abundantly evident. And since so many of our philosophical conclusions depend on this principle, one does need a syllogistic proof to realize the necessity of a clear understanding of causality, both in its scientific and philosophical import. What then, is the relation of causality to statistical laws? Are these laws founded on the principle of natural causation in the same sense as the strict, physical laws of classical physics? We should bear in mind that these statistical laws are not simply laws of averages and probabilities, in which is stated that out of a given number of possible events, one must happen; e. g., if a pair of dice are thrown on the table, the chances are one to six that face "one" will turn up. We believe that an examination of the notion of a statistical law, as expressed by leading scientists, will reveal far more than this. It seems to be something between the strict physical law and the law of averages, perhaps containing some of the elements of each. With respect to the principle of causality, our contention is, that not only is the principle of causality not destroyed but that a statistical law, by its very nature, demands the the principle of natural causation. Moreover, the essential difference between a strict, physical law and a statistical law, as here understood, is a lack of knowledge on our part and not a failure of natural causation. Let us prove our assertion.

In Scholastic Philosophy the principle of causality is defined thus: "What ever begins to exist, or comes into existence, must have an efficient cause."

According to the principle of causality, as commonly accepted in science and applied to natural beings, if certain, definite factors are present, a definite effect or effects will follow. There is some natural, intimate nexus between these, so that if the antecedent conditions are fulfilled, the result will inevitably follow, saving a miracle. This connection between present factors and the consequent result, we call causality. Perhaps this mode of expressing the fact would not be accepted by many scientists but it cannot be denied that it is followed out in practice, and the validity of this internal nexus is the basis of all scientific predictability and the foundation of what they term the Order of Nature. This necessary causality of natural objects is also known as physical determinism. A particular law, such as the law of gravity, expresses this same notion in a limited field of action and among a certain group of individuals. If we know the height from which an object fall, under the influence of gravity, we can predict its velocity or position at a given moment and the time when it will reach the ground. The same is true, mutatis mutandis, for other physical laws. It sometimes happens that our predictions are not valid for a particular individual but for a number of indetermined individuals of a large group. We can say that a certain effect will be produced in some individuals among a large number without being able to specify, in advance, these particular beings. When we formulate a general rule, with regard to a result of this sort, we have a statistical law. An example will clarify this statement. (The theory of statistical laws in science arose out of the study of gases. The basis of the following example is statistics. This difference in foundation does not change their relation to the principle of causality.)

An insurance company examines the record of deaths from a certain disease, over a period of time, say, twenty years. From this is determined the ratio of the number of deaths to the number of persons afflicted with the ailment. On the basis of this ratio, a law is formulated that will read somewhat as follows: Out of every thousand persons afflicted with tuberculosis, one hundred will die each year. This is a generalization of statistical experience, a statistical law. Such a law will apply with more or less accuracy to a group of individuals, one thousand, although it does not determine beforehand who these individuals will be. Such a law, we assert, is based on a physical determinism and a strict causality, just as the law of gravity or any other physical law. It is true that it supposes that the general state of health of the group will continue the same for the coming year as it was in the past, either because of climatic conditions, lack of sanitation, neglect, or other necessities of life. Supposing these, the ultimate basis of the law is the inevitable action of the tubercular germ, which will act in the future as it has acted in the past. There is a necessary connection between antecedent factors, the germ and unhealthy lungs, and the consequent effect, death. The causality is present and will obtain in these cases as in others. We freely admit that in cases of sickness, certain precautions may be taken to prevent death, for these are elements that are under the control of the free will of man. For this reason it is more difficult to foretell the particular persons who will be subject to the effect. But that element has always been present in the past and has been provided for in the statistics upon which the law was founded. Consequently, the principle of causality is just as potent here as in other laws. There is a marked difference in the predictability, according to this law, and that according to other laws, such as the laws of gravity. But this difference is in no way due to the natural causality of material entities but to an ignorance on our part of antecedent factors. The validity of causality may be shown by a "post factum" examination after the death has taken place. For it is often possible to trace the causal nexus of the various vents that led to the death. Moreover, if one were to consult the medical staff of a tubercular hospital, one would find that by comparing a present case with previous cases in which the symptoms were similar, the doctors could predict with a fair degree of accuracy, the individuals who would not survive the disease for the next twelve months. This proves that in a statistical law, there is no question of the validity of the principle of causality and that the inaccuracy of prediction is not due to an indeterminism in the objective working of nature but to a lack of knowledge of the causal elements in a particular case. All predictability in the physical order presupposes a knowledge of previous conditions. To make an accurate prediction of an eclipse, the astronomer must know with certainty the position of the sun, moon and the earth, at some time previous to the eclipse. If these are unknown, he will be unable to foretell the exact time of the phenomenon. This is evident from the history of science. We should remember that predictability of events according to a law is quite distinct from the law itself, or the operation of the law. For long centuries before the evolution of the natural sciences and the increase of knowledge of laws of nature, the predicting of natural events was limited and imperfect but no one denied the activity of nature, according to the laws of nature. Predictability may be a property of the law that follows the nature and essence of the law but it does not constitute the law.

In the light of the history and development of science, and the philosophical principle of causality, we assert that the principle of natural causation is demanded by statistical laws just as much as any other law of nature. The ultimate accuracy cf the law depends on the causal nexus in individual cases. This last is dependent on the reality of the physical determinism of the course of nature, when there is question of activity outside the free will of man. It depends also on the absolute validity of causality in the individual instances from which the law is formulated. The belief in this principle of causality is the reason, in the final analysis, why a concern like an Insurance Company is justified in carrying its business operations according to such statistical laws, and feel sure that the venture will yield a profitable return. As in our last discussion of the Laws of Nature, (c. f. Bulletin, Dec. 1933, p. 76), we made the distinction between the objective working of nature, that is independent of our knowledge and the interpretation of the scientists with regard to nature's activity. We saw that our knowledge might change with greater experience and that a law might have to be reformulated. This is a purely subjective point of view and does not affect the natural operations. The same is true in the present question.

Nature does not work in a statistical way, if we may employ such an expression. It is fixed and constant. Our interpretation of nature may be couched in terms which have a statistical character and a wider knowledge of the subject may enable us to change our expression into absolute terms. Hence we believe that the conclusion which states: "that the statistical character of natural law has destroyed the principle of causality", is not warranted either by the principles of science or philosophy. That this opinion is prevalent among many scientists is clear from their writings. For example, Planck, says: "The fact that we have statistical laws, is dependent on the assumption of the strict law of causality functioning in each case. Our lack of knowledge or lack of data may prevent us from applying the principle of causality but that does not at all mean that the principle has failed". "Where is Science Going". p. 145. In the same tone writes Wulf: "This law of causality says that in its application to physical processes, we can specify the condition of a material particle at some future time if we know it at some earlier time. In the above instance, (in the Principle of Indeterminism), we can never know the conditions at any one time and so we can never express it at any other time. This only means that we cannot apply the principle of causality in these circumstances. Even if we were sure that we could never be able to express these states or conditions exactly, yet there is a great difference between whether the causality of a process can be proved and whether a process happens according to the law of causality". "Modern Physics". p. 463.

In conclusion, let us sum up; when we formulate the law of causality in its application to the physical world, we say: if we know the present exactly, we can predict the future. But this seems to fail in the case of a statistical law. The failure lies in the premise of the statement and not in the conclusion. The principle of causality is valid and the causal nexus remains but we are ignorant of the present circumstances and cannot foretell the future. In a later paper, we hope to resume this discussion in its relations to Heisenberg Principle of Indeterminism.

ASTRONOMY

AN INTERESTING EXPERIMENT

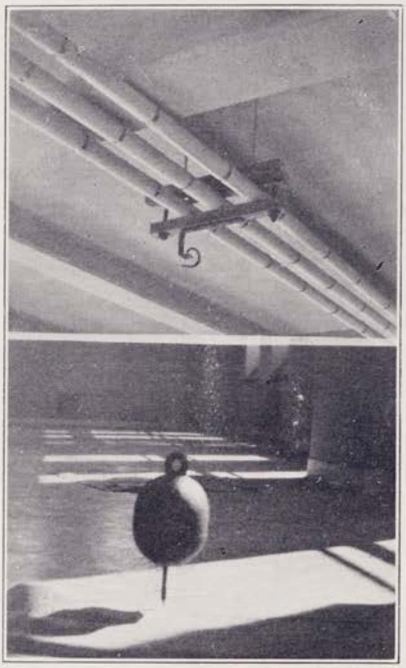
William G. Perry, S.J.

On the thirty-first of May, 1851, Leon Foucault performed his celebrated pendulum experiment in the Pantheon at Paris. Since that day the experiment has been repeated many times and with many variations, and yet the interest and enthusiasm which is aroused upon viewing the experiment has never lessened. Though there are many methods which can be employed for demonstrating the earth's rotation, such as deviations of projectiles, the trade winds, and the vorticose revolution of the wind in cyclones, there are none which can compare with the pendulum experiment for direct and, in a sense, sensational results. Therefore, with no intention of obtaining remarkable experimental results, but merely to have the satisfaction of actually observing the earth rotating on its axis, we decided to construct a Foucault pendulum at Woodstock.

The requisites for complete success in this experiment are given by Foucault himself:

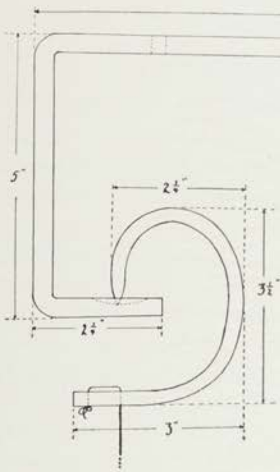
1. A rigid suspension point;
2. Homogeneous, flexible and elastic wire;
3. An homogeneous bob;
4. Complete symmetry of the entire system;
5. Sufficient weight to overcome air resistance and to minimize the effects of the bob's jiggling movements;
6. The height should be at least forty feet so that results will be distinctly visible;
7. The amplitude of the first oscillation should not exceed one-seventh of the length of the wire;
8. In order to insure starting without jerking, the bob should be fastened by a string at a distance equal to one-half an oscillation from the vertical center of equilibrium. The string should be burned when the bob is absolutely at rest.

Of all these conditions the rigid point of suspension and the homogeneous bob present the greatest difficulty. Therefore, although a certain amount of care was exercised in the preparation of the apparatus, we realized that we were by no means constructing a precision instrument and expected no startlingly exact measurements. The first thing to be obtained was a suitable room. After much discussion and measuring of various parts of the house, the basement of the O'Rourke Library was chosen for the experiment. Since the pendulum was not to be a permanent fixture, we did not wish to drill holes in the ceiling for the suspension. However, there are three asbestos-covered water pipes which run approximately in a north-south direction across the ceiling and we decided to place the pendulum at a point where three braces from the ceiling support the pipes.



Three pieces of wood, two inches square and twenty inches long were bolted across these braces, making a single unit of the pipes. Though not as rigid as was to be desired, this arrangement was found to be quite satisfactory for our observational purposes. It was later found that the pipes were most rigid when the pendulum was started swinging in the north-south plane, the ends of the pipes being fastened to the walls in this direction; in the east-west plane the pipes swayed slightly with the swing of the pendulum. A flat piece of iron, five-sixteenths of an inch thick, one and a quarter inches wide, and eighteen and a quarter inches long was bent in the manner shown in the figure. In the smaller bend a shallow saucer-shaped cavity was drilled and filed to receive the pivot. This piece was fastened with three bolts to the wooden blocks.

The pivot was made from a round piece of iron one-quarter of an inch in diameter and bent in the form of a "C" as shown in the figure;



the upper end of the "C" being ground to a point. Directly opposite the pivot-point a small hole was drilled to receive the pendulum-wire. This pivot-point arrangement was defective in two ways: it was made from rather soft iron instead of hardened steel, thus causing a certain amount of friction. Further, whenever there was any torsional stress in the wire (often due to the slight rotatory impulse given by the string to the bob upon starting) the "C" had a tendency to skew around on its pivot causing larger deviations than would be expected. If Foucault's fourth condition had been carefully observed, this twisting would probably have been easily eliminated by a conterbalance on the lower end of the "C".

An old iron ball weighing forty pounds served as a suitable bob. This bob was more elliptical than spherical, having a diameter of nine inches from end to end, and a diameter of six inches through the center. The lack of symmetry in this bob was responsible in some measure for the slight torsion which was noted quite frequently in the wire. In the bottom of the bob a hole was drilled and tapped to receive a three-eighths pipe, three inches long, which had been fitted with a pencil and spring arrangement to form a stylus. This permitted the use of a flat board for tracing deviations instead of a curved one corresponding in curvature to the length of the pendulum as radius. However, with regard to methods for recording deviations I am of the opinion that the use of sand is better than pencil and paper, since there is an appreciable amount of friction between the pencil and tracing board, and if too light a string is used, in an attempt to eliminate this friction, the traces can hardly be seen.

The bob was suspended from the pivot by a phosphor-bronze wire (gauge number 20) fifteen feet long. A high-carbon steel wire (gauge Number 22) was used at first, but its elastic limit was reached too soon. The bob was always tied to the wall four or five hours before being used so that it would be absolutely at rest, and was set in motion by burning the string. All things considered, the results were quite satisfactory; and the many persons who viewed the experiment at different times, especially the Physics class, found it interesting and instructive. The deviation at our latitude should be approximately nine degrees per hour and the results which were roughly noted were between ten and thirteen degrees.

There are three interesting articles treating of Foucault pendulum experiments which I would like to mention. In the July-August 1932 issue of the **Journal of the Royal Astronomical Society of Canada**, Stephen Stoot tells us of a simple device he has tried with success to prevent the pendulum from deviating from a straight swing soon after starting. This device consists of a small ring placed a little below the actual point of suspension so that the pendulum wire touches the inside of the ring at each stroke; and depends for its action on the damping effect due to the friction on the ring. Father Hagen, S. J., also treats of this motion of the pendulum ball along an oval orbit due to the initial lateral velocity in **Popular Astronomy** for July-August, 1930. This article also provides a very good description of the photographic work done by Father Pigot, S. J., in regard to deviations in the southern hemisphere.

For those who may have occasion to demonstrate this experiment to an audience, an article by S. R. Williams, Professor of Physics, Amherst, Massachusetts, in **Popular Astronomy** for May, 1932, might prove of interest. By using a short-focused concave mirror the displacement between successive turning points of the bob may be magnified and projected on a screen. This would amount to increasing the speed at which one may observe the change of angle between the plane of vibration of the pendulum and some fixed line on the earth, because a displacement in the magnified image may be recognized sooner than in the actual movement. The article also shows very well that the angular displacement is a function of the sine of the latitude.

BIOLOGY

WINTER QUARTERS

Frank C. Garvin, S.J.

'"**Coluber Constrictor**" is his scientific name. Impotent ever to constrict, of late this Black Racer scarcely merits the title, "rat-snake". His bill of fare over the Xmas holidays has tallied 13 ft. 4 inches of his fellow ophidians—in assorted flavors. Linnaeus may have forgotten (in misnaming this species) his Latin for "cannibal".'

The above observations are found in the author's note-book on pages concluding the "business" of 1933. This article will concern itself with the activities of several snakes, forced to abstain from the long Winter's sleep which Nature, in temperate climes at least, has ordained for her cold-blooded children. The subjects of this experiment were both adult reptiles and the young of last year's broods. It had been assumed by most snake fanciers with whom I had spoken that raw egg was diet sufficient for non-hibernating snakes; either they had offered their charges nothing in the line of solid food, or if they did, it was refused. But to stock the cupboard?

White rats would supply an essential article of diet, so I procured a pair. A number of water snakes snared last summer were tolerated, in the hope they would tempt the Racer when Soracte was knee-deep, etc. A goodly number of salamanders were kept in a terrarium and tadpoles of the **Rana clamitans** variety were put on a starvation regimen that they might more quickly metamorphose. So was stored the larder.

Young snakes present a continual problem. Exactly what sustains the young Pilot and Racer in their early months of life is still a question unanswered by the best of the herpetologists. The latter ophidian especially is a puzzle, as the maturing and adult "Mountain" Blacksnake feeds entirely on warm blooded prey. How I partially solved the problem of keeping these youngsters I shall discuss in the course of this paper.

Of the adult reptiles, we can start with a most satisfactory Garter snake, T. sirtalis; her measurements, January 1, 1934:

Total length	31 inches
Length tail	6¾ inches
Length head	1¾ inches
Width head	¾ inches

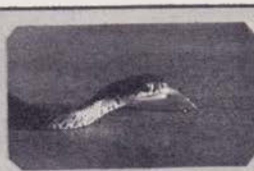


FIG. I

FIG. II

FIG. III

FIG. IV

FIG. V

FIG. VI

Fig. I. *C. constrictor*, born Sept 15. 1933, is taking a small red-bellied dace. Note the pattern of the young Blacksnake.

Fig. II. *C. constrictor*, 54 inches, eating a young Garter snake.

Fig. III. *C. constrictor* starting on a thirty-inch Garter snake.

Figs. IV. and V. Illustrating the method employed in feeding the recalcitrant Pilot, thirty-seven inches in length. The rat's leg is fast disappearing in Fig. V.

Fig. VI. Betty, *T. sirtalis*, has a well-seasoned dinner, a Leopard Frog.

(Photographs taken February 3, 1934.)

This specimen had borne a very lively family numbering 24 on the ninth of last August, after which she fed steadily on a diet of toads and frogs (**R. sylvatica and clamitans**), numerous worms and an occasional fish. This feeding continued until the close of October. Then began what she imagined would be a winter fast, which persisted till the twentieth of December. At this time she accepted several red-bellied daces about two inches in length. An orgy followed. Her summer appetite had been suited "a la carte" but she partook "table d'hote" from that winter day to the middle of March.

Fish, for which she had evinced during the summer months but little liking, were eagerly taken. Because of a strong acid secretion from the skin of Rana pipiens, the Leopard Frog, this species was excluded from the summer menu. But we have a picture showing Betty with a meal—well-seasoned. Nor had salamanders been appetizing before the new year. But there are none of the large amphibians left, they assumed a new form,—of that substantiality, **Thamnophis sirtalis.** From March 16th to 21st this snake devoured nine full-grown Wood Frogs; her finicky ways are again manifesting themselves. She now closes an imaginary eyelid to the salamanders I offer, and to fish I deem her supercilious. Fitting conduct for a lidless brute.

Then there is the strange case of "Moe", a Pilot Blacksnake.

Total length	61 inches
Length of tail	10¼ inches
Length head	1⅞ inches
Width head	¾ inches
Width body	1⅛ inches
Height body	1⅜ inches

His is a checkered career. Capture was effected very late in the snake season at the hands of no less than five of the brethren to whom I am indeed grateful, but at whom I was no little amused as they recounted the thrilling, chilling time they had in getting him. "Moe" is the most easy-going Pilot I have handled.

This specimen was injured as to his neck in that exciting endeavor, but has recovered control of the portion so necessary in the "strike". The unlucky field mouse will have no intimation of that old wound.

The sleek form declared him provident anent provender for that protracted siesta. The reddish skin showing between the rows of scales stifled any anxiety I may have had at his refusal to eat thru long months. It was not until the nineteenth of January that he took his first meal at our table. Then it was a half-dozen white rats, just two weeks old. On the twenty-seventh of the same month he engulfed four more of a different brood. But his real gustatory proclivities and potentialities were not revealed until the sixteenth of March. In twelve days twenty-eight young rats trickled down that lengthy esophagus—in batches of five or six. These rodents were the equivalent in size of mature mice. How many more he would have eaten I do not know because my supply of young rats was exhausted.

An unusual interlude is recorded for December the eighth. This five-foot Pilot Blacksnake became the stock and trade of the "Snake Charmer" at an annual "bazaar". Journeying to Washington he became a bread winner for the young ladies of Georgetown Visitation Academy. But he was glad to get back to dear old Woodstock. He told me so.

A young Pilot, most probably two years old, and measuring thirty-eight inches has a disposition the reverse of the big fellow's. The specimen soon fretted away any fat he had when I first caught him and refused to eat. With much more patience than I believed I possessed, I induced him to ingest enough food to keep him in good condition. The limb of an adult rat was placed in his mouth; perhaps he would several times in anger shake it free. But again and again he was gently handled and coaxed to down the morsel. At last one's efforts were rewarded. The complete set of a rat's appendages constituted a meal. After the first battle was won, the snake seemed to click and the remaining courses were readily accepted. This performance frayed my nerves and filled his stomach about every three weeks for four months.

Losing none of his nervousness, this snake on March 23rd—of his own accord—swallowed five young rats which distended his jaws as a chipmunk would stretch those of a five-footer. Rotund of body, he bordered on the uncouth; my worries are over in his regard.

Of the large snakes, there remains but that Black Racer an account of whose cannibalism opened the proceedings.

This specimen was "fished" out of the St. Mary's River, just an hour after we arrived at Inigo's last July. For a Racer he tamed rather quickly and was indeed sufficiently docile to be exhibited during Fr. McClellan's lecture at Leonardtown some two weeks later.

Field mice and sparrows formed the bulk of his diet thruout the summer and early fall. About the middle of October he fortified himself again the coming winter with a monstrous meal of fifteen sparrows, consuming seven one afternoon, eight the following morning. Then a fast until the closing days of the old year. What happened after that has been related, or will be.

On January nineteenth this cannibal watched the Pilot put away five young rats, with seeming indifference to follow suit. As the real con-constrictor was engaged in its sixth helping, it so happened that another rat tumbled across its coils. Which automatically contracted, suffocating the rodent. Before the Pilot had completed the process of ingestion, Mr. Racer plucked number seven from its coils carried it to a deserted corner of the cage and nervously swallowed it.

When the heavy snake had ensconced himself in a hollow log, the speedy one leisurely made away with the remaining three rats. Again on the twenty-seventh of the month the two snakes dined together. But thereafter for a month and a half the Racer refused all food. I was necessitated to force an egg down his throat. An occasional meal of fish was given which was taken decently enough.

On the fourteenth of March he managed two rats, on the twenty-second five more. Easter Monday I caught a yearling **Natrix sipedon.** After this tid-bit had been accepted from my hand, six full-grown Wood Frogs were packed away.

This species is a delicate captive, developing for one thing superficial sores all over the body. I made inquiries as to a remedy for the ailment, only to find from competent authority that such elaborate measures are taken as the preparation of a vaccine from the matter taken from the pustules. When the annual ordeal is a thing of the past I shall try the hand at the work.

The specimen in my care measured, January 1, 1934:

Total length	54	inches
Length of tail	11	inches
Length of head	1¾	inches
Width of head	¾	inches
Width of body	1 1/16	inches
Height of body	1	inch

It is interesting to compare the measurements of the two species of black snake. Note in particular the relative width of head and height of body.

Each of these snakes sloughed twice in the period of observation. The Racer is the lone exception. But good reasõn for the more frequent change of coats is seen in the betterment of the skin condition.

Let us look to the Junior members of our community.

The baby garter and ribbon snakes were not so difficult of management. Indeed five hours after birth, several of the garter snake brood had managed to swallow toads which had just absorbed their tails. All immediately displayed that fondness for earth worms which is a lifelong characteristic of the genue **Thamnophis,** with a few exceptions. The Ribbon snake falls into this latter class so that fresh fish were trapped throughout the winter for them. Worms from a large culture, with a plethora of fish, kept the interesting garter snakes in the finest fettle.

The water snakes were fed fish and Leopard Frogs until it came their turn to play the part of "turkey" in the Racer's scheme of Christmas festivities.

Three young Pilots were retained for trial runs. One died in early December; dissection revealed an obstruction of the bowels. The other two came along nicely, being fed in the manner similar to that which I shall describe for the young Racers. Again intestinal congestion caused their deaths on the thirteenth of March. The food however had been properly digested.

The incubating Racer eggs began to hatch on the fifteenth of September. I kept for Winter feeding only two of the batch.

One of these mastered a freshly hatched ring-necked snake two days after his own birthday. It was the only food seized by either snake. They are spoiled, spoon-fed children.

It is a ticklish job feeding these little chaps. The mouth must be pried open—very gently; food is then inserted between the jaws. But patience is rewarded, for the little jaws work along the food in normal fashion, the neck muscles contract, they really do eat but you have to lead them. The tibia bone from a rat's leg with a sliver of meat upon it is a meal for a week. Larva of salamanders, the Daces and now a Spring Peeper lend variety to the table. They each have grown two inches in the last nine weeks. Wood Frogs are now being raised for them, watch us grow.

We are now leaving Winter Quarters. Hunting mates for each of the mature specimens is the order of a sunshine holiday. There is yet another point to be settled in this experiment. It is a known fact that the frog's mate before touching food in the spring. Judging from the sites of hibernating dens, away from feeding grounds, one surmises the same of snakes. How the late feeding of my specimens will affect this other function remains to be seen.

NERVOUS CONTROL OF RESPIRATION

Rev. Clarence E. Shaffrey, S.J.

There has been some interesting work done of late in an effort to determine what, if any, influence the carotid sinus and the carotid body may have on the respiratory reflexes. The fact that the carotid sinus has a very definite relation to blood pressure, and that the respiration has seemed to be affected at the same time that pressure changes were brought about by stimulation of the sinus gave rise to some nice work directed to ascertain the effects of both pressure in the sinus and the nervous mechanism connected with the sinus and with carotid body.

By the carotid sinus is understood the bulb-like enlargement of the sinus just below the bifurcation of the common carotid artery into the internal and external carotid. The carotid body is a small oval gland about the size of a wheat grain located in the bifurcation of the common carotid.

That there is a constant flow of afferent impulses from the periphery to the respiratory center in the medulla is well known. The sudden effect of heat, cold and mechanical stimulation of the skin on the respiration shows that the phenomenon is reflex. The first breathing in the new-born is brought about in this way.

To appreciate the experiments under discussion it will be well to recall in a few words the well *established* facts concerning normal respiration. We know that the respiratory center is located in the medulla below the floor of the fourth ventricle of the brain. Its location has been determined by sectioning the medulla at different levels from above downward. It lies at a level just above the apex of the calamus scriptorius, for sectioning at that point stops respiration entirely. There is a center on each side and destruction of one does not cause respiration to cease, either one being capable of giving rise to impulses to the centers for the respiratory muscles of both sides.

It has long been known that the respiratory reflex depends upon the concentration of the carbon dioxide in the blood, that is to the number of hydrogen ions present due to the dissociation of the H_2CO_3, and of other acids as well, probably lactic acid produced in the center itself. When the CO_2 concentration becomes high enough the center is stimulated and an impulse is sent to the centers of the respiratory muscles, i. e., the diaphragm, intercostals, scalenes, sternocleidomastoid, etc., causing contraction with the consequent enlargement of the chest cavity. The air rushes in and the alveoli of the lung expand, and in doing so pinch the terminal filaments of the vagus nerve which are distributed throughout the alveolar wall. This gives rise to an impulse which travels along the vagus to its center in the medulla from which inhibitory impulses are sent to the respiratory center to depress it and stop inspiration. If both vagi are cut the respiration continues but the depth of inspiration is increased, as is the expiratory effort. Expiration is to a great extent passive, i. e., it is a relaxation of the inspiratory muscles, but it has been shown by stimulation of the cut vagus at the central segment that the respiration may be stopped completely. But depending on the type of stimulation, we may increase the inspiratory movements, as by stimulation with a weak electric current, or increase the expiratory movements, as by using a stronger current. This seems to show that the vagus contains both inspiratory and expiratory afferent fibres. It is known too that the vagus contains some efferent fibres which pass to the muscles of the bronchi and bronchioles controlling their lumen by action on their muscular wall.

The fact that section of the nerves of the carotid sinus causes an increase in the tension of the blood vessels shows that impulses traveling over those nerves. Hence the sinus reflex as far as blood pressure is concerned is an inhibitory one. An increase in the blood pressure may be accompanied by apnoea, complete cessation of breathing, while a fall in blood pressure is accompanied by a hypernoea, or rapid breathing. These effects do not occur if the nerves of the carotid sinus are destroyed.

The carotid sinus reflexes affecting respiration may be divided into:

a) Those initiated by mechanical stimulation, as pressure, etc.

b) Those initiated by chemical stimulation.

From a histological study of the carotid sinus and the carotid body de Castro suggested two possibilities, one, that the nerve endings in the carotid sinus are responsible for pressure reflexes, and the other that those in the carotid body are sensitive to chemical changes in the blood. Carl F. Schmidt performed an experiment which seems to bear out these conclusions. He showed that ligation of the occipital arteries at their origin removed the chemical but not the pressure reflexes. Since the occipital arteries supply the carotid body, this work gives additional evidence that the carotid body is concerned with chemical reflexes.

The importance of the pressure reflexes on respiration has been the subject of much debate. Heymans and his co-workers showed that an increased pressure in the sinus caused apnoea, while a decreased pressure or a section of the sinus nerves caused hypernoea. He expressed the view that these reflexes are just as important in the maintenance of normal respiration as are the depressor reflexes in the maintenance of normal blood pressure. In short, the sinus mechanism exerts a tonic inhibitory influence upon the respiratory center. However, Schmidt holds theory to be erroneus for the following reasons: 1. The hyperpnoea resulting from the section of the nerves is only temporary, whereas the hypertension of the blood vessels is permanent. This shows that respiration can be controlled by some nervous means other than that of the sinus mechanism.

2. Changes of the blood flow in the respiratory center alter respiration more than pressure changes in the carotid sinus. He concludes that the pressure changes accomplish nothing that cannot be accomplished quite as well without them by changes in the central flow.

The experiments employed in the study of the effect of sinus reflexes on the chemical regulation of the respiration were of two general kinds:

1. The determining the extent to which the respiratory mechanism responds to the inhalation of CO_2 or N_2 and how much that response is modified by the denervation of the carotid sinuses.

2. Crossed perfusion and crossed circulation experiment in which the donor animal was made to breathe appropriate gas mixtures.

From the first experiment it was found that after denervation of the sinuses the hyperpnoea resulting from the inhalation of CO_2 persisted, while the hyperpnoea resulting from the inhalation of N_2 no longer occurred. This led to the conclusion that CO_2 excess acts centrally, i. e., in the respiratory center, while oxygen lack, produced by breathing N_2 acts reflexly through afferent nerves in the carotid body.

The crossed circulation experiment consisted in isolating the carotid sinus with the nerves intact, of one animal and allowing the blood of a donor animal to flow through it while that animal was made to breathe CO_2, then N_2 and to rebreathe alveolar air. It was found that when the donor was made to breathe N_2, causing apnoea, there was a marked hypertension in the recipient animal. Breathing CO_2, by the donor, however, failed to cause reflex hypernoea in the recipient. Thus we find that the experiment leads to the same conclusion as the first, namely, that the reflexes of the carotid body are initiated by oxygen-lack, producing hyperpnoea.

CHEMISTRY

DEUTERIUM

Rev. Richard B. Schmitt, S.J.

The discovery of the isotopes of hydrogen during the past year has startled the scientific world, not only those interested in the field of inorganic and physical chemistry, but also the allied science of physics and biology. The importance of the discovery and preparation of the isotopes of hydrogen, named "deuterium" and "tritium" may be far greater than the discovery of some of the elements. It seems quite certain that in years to come this will be ranked among the great discoveries in science. It is the starting point in developing far-reaching new fields in chemistry, physics and biology.

Deuterium was discovered by Dr. H. C. Urey, Dr. F. G. Brickwedde and Dr. G. M. Murphy. The Willard Gibbs Medal for 1934 was awarded to Dr. Urey of Columbia University primarily for his brilliant work in the discovery of deuterium. He has been a prolific contributor to the subject of atomic chemistry and physics, and his consideration of the several theories involved led to the prediction that the hydrogen isotope H^2 must exist. Water prepared with this additional hydrogen isotope is called "heavy water".

Properties of Heavy Water:

Formula $H^2 H^2 O$
Freezing point + 3.8° C
Boiling point 101.42° C
Vapor pressure at 100° 38.4
Specific Gravity 1.1056 at 25°
Heat of vaporization is 259 calories per mole greater than ordinary water.
Viscosity is 25% greater at 20°
Solubility of Sodium Chloride 15% less at 25°
Solubility of Barium Chloride 19% less at 20°
Lower Dielectric Constant
Surface Tension 20° (dynes/cm) is 67.8

Production of Heavy Water. Quantity production of heavy water was first achieved by methods devised by Dr. E. W. Washburn. He planned to produce from six to ten gallons of 95% deuterium water per year. — In January, Dr. Wells A. Webb organized "The California

Isotope Co.," 2319 McGee St., Blekeley, California, which manufactures deuterium and deuterium compounds. After six months of research, he developed a commercially practical method for obtaining deuterium oxide of high purity. Starting with the electrolytic method first used by G. N. Lewis and Ronald MacDonald, Webb evolved an efficient method for separating the isotope. Heavy water that has been partially concentrated in the electrolytic cells of concerns making hydrogen gas by electrolysis is used as the raw product. This is put into a battery of cells and by a process of continual fractional electrolysis the concentration of heavy water is increased continuously until the ultimate of nearly pure isotopic water is reached.

Although the loss of deuterium in the process is negligible, the yield of pure deuterium oxide is about 50% less than the apparent theoretical yield. This is explained by the fact that in the heavy water of low concentration which is used as raw material, approximately one-half of the increase in density is due to the concentration of oxygen. Upon continued electrolysis the concentration of the oxygen isotope remains approximately constant and the concentration of deuterium alone increases. While nearly all of the deuterium is retrieved and obtained in the pure state, the discharged water of the plant remains "heavy water". The increase in density of this waste water is due to the oxygen isotope only.

During the past six months Webb, assisted by Laurence T. Gray, has supplied a small number of orders for heavy water in concentrations up to 95%. He has also supplied orders for some compounds of deuterium.

Monodeuterium methane, 80% pure, was made by heating a mixture of 80% deuterio-soda lime with anhydrous potassium acetate. An equilibrium mixture consisting of the mono—, di—, tri— and tetra-deuterio methanes was made by passing a mixture of H^1 H^2, H^2 H^2 and carbon monoxide through a hot platinum catalyzer. To make deuterium cyanide, heavy sulphuric acid was brought into contact with sodium cyanide. A mixture of the deuterium ammonias was made by utilizing the isotope reaction of G. N. Lewis. Ordinary ammonia was passed into heavy water of low concentration, boiled out of it, and passed into heavy water of higher concentration. This process was repeated until the evolved heavy ammonia was 50% pure in deuterium. Thus an equilibrium mixture of the mono—, di—and trideuterium ammonias was obtained.

The capacity of the California Plant is about 4 grams of pure heavy water per week. Orders for 99.5% deuterium oxide have been accepted at $80.00 per gram.

On March 15th, announcement was made from "The Ohio Chemical and Manufacturing Co.", 1177 Marquette St., Cleveland, Ohio,—that heavy water can be obtained at greatly reduced prices. The new prices for deuterium oxide are: 95% or better: $40.00 per gram; approximately .5% water at $20.00 per gallon.

Research Laboratories. No scientific achievement in our day has had such an immediate and wide-spread influence upon research programs or given rise to a more highly competitive race. It is really surprising to note the large number of papers to be found in the literature on the subject. A chronological bibliography of the papers dealing with the hydrogen isotopes is found in The News Edition of **The Journal of Industrial and Engineering Chemistry, January 10, 1934.**

On Tuesday March 27, at the meeting of the members of the American Chemical Society at St. Petersburg, Florida, the Division of Physical and Inorganic Chemistry held a symposium on the Isotopes of Hydrogen. The topics discussed were quite comprehensive. Cf. the program of the Florida Meeting.

Triple Weight Hydrogen. Dr. Hugh S. Taylor and his co-workers at Princeton University have searched carefully for the latest isotope of hydrogen, i. e., the triple weight hydrogen, called "tritium", which Lord Rutherford recently announced had probably been synthetically produced by bombardment experiments with deutons. Their results indicate that tritium does not occur in ordinary water more plentiful than one part in 500,000,000. The mass spectograph researches of Dr. Walker Bleakney and Dr. A. J. Gould also show that in the purest heavy water thus far obtained, the concentration of tritium is less than one part in 50,000. They also demonstrated that deuterium occurs only one part in 5,000 in the hydrogen of the atmosphere.

LITURGICAL CHEMISTRY

REV. MICHAEL J. AHERN, S.J.

In the worship and liturgy of the Catholic Church certain materials are used, such as bread, wine, oils, balm or balsam; metals, such as gold, silver; texties, such as silk, linen, flax, wool and cotton; wax; and other materials, for candles; and various gums from which incense is manufactured.

Liturgical bread must be made from wheat; the bread is unleavened in the Latin rite, but may be used in the leavened state in some of the other rites. Any variety of true wheat may be used, and any flour made from such varieties. Sometimes a difficulty arises from the fact that the name "flour" is given to the materials ground from other grains, such as rye, oats, barley, Indian corn or maize. Flours from these last named grains are not valid liturgically, and here the chemist, helped by the botanist, may be of substantial help, as he may be in determining adulterants of wheat flour.

Wine used in the Catholic rite of the Mass must be wine of the grape—"vinum de vite" or "de genimine vitis", according to the Latin specifications. Hence the fermented juices of other fruits, such as cider and similar beverages, cannot be used. Fermented wines may vary in alcoholic content from around five to about 18 per cent. The chemist is often called upon to determine the alcoholic content of Mass wines; also to detect impurities, and to determine whether by a secondary fermentation acetic acid has been formed or not; for a soured wine may not be used for liturgical purposes. Occasionally a wine has to be pasteurized, and the control of this process is left to the chemist; as is indeed the whole process of the manufacture of the wine. This manufacture is allowed only to those who have satisfied the ecclesiastical authorities that the wines they manufacture are genuine. Their vineyards and wine-presses are regularly inspected by these same ecclesiastical authorities, who frequently call in the chemist to help in the inspection. Sometimes the vineyards themselves are maintained by ecclesiastical institutions, as by the ecclesiastical seminary of the doicese of Rochester, N. Y., and the Jesuit Novitiate of Los Gatos in California. In these cases the wines are manufactured under bond to the Department of Internal Revenue of the Government of the United States, as in any similar wine-press.

Olive oil and balsam are used in the preparation of the three oils which are used in the administration of the sacraments. The Oil of Catechumens is used in the rite of baptism, in the ordination of priests, and in some other now rather rare consecrations, such as the consecration of a king. It is made of pure olive oil. The Oil of the Sick, also of pure olive oil, is used in anointing the sick when in danger of death in the Sacrament of Extreme Unction; also in the blessing of bells for church purposes, when the outside of the bell is anointed with it. The Sacred Chrism is a mixture of olive oil and balsam, used in the sacraments of Baptism and Confirmation, and for various consecrations, such as of the sacred vessels used in the Mass. of the altars on which the Mass is celebrated, and of the inside of a bell. The purity of the oil and balsams are matters of chemical control.

Pure water and various pure metals used in the liturgy are subject to the well-known analytical control usual with these substances, so that nothing more need be said about them now. The same may be said regarding textiles; for the latter the microscope is widely used in the control of the right materials for vestments and other ornaments. Much chemical work has been done also on the proper dyestuffs for these vestments, so as to attain the proper liturgical colors, which are gold, black, white, green, red, purple and rose. Silver is sometimes substituted for white. And in recent years some attempts have been made to restore the chemical technique of dyeing with vegetable colors, which reached a remarkable peak of perfection in the middle ages, as witnessed in some of the vestments of rare beauty which have been in use in some of the churches of Europe for hundreds of years with their colors still fresh and beautiful.

In certain parts of the Catholic liturgy wax candles must be used. This is officially interpreted to mean a minimum of 51 per cent beeswax. The other 49 per cent may be of any suitable adulterant such as stearic acid, paraffin, vegetable wax, etc. Any larger percentage of beeswax than 51 may of course be used. Manufacturers are in the habit of giving a guarantee of the percentage of beeswax in their candles, and of stamping the percentage on each candle. Because of suspected adulteration of wax candles in some localities, Dr. Dunleavey of Yale University, and Dr. Power, S. J., and Mr. Hauber, S. J., of Weston College, undertook about five years ago the analysis of many brands of wax candles. Dr. Power analyzed over one hundred samples in our laboratory, and developed a method by which an accurate analysis could be made in a little over three hours. Stearine, i. e., commercial stearic acid, and aprffin, usually make up the non-beeswax content of the candles. Now when beeswax is mixed with these three substances it is not possible to separate them completely, for any solvent which will dissolve one of them completely, will also dissolve portions of the others, and so that complete isolation of one from the other is not attained. So an indirect method of analysis has to be used. Briefly this method consists in finding the "Ester number" which is nothing more than the result obtained when the "acid number" of the candle is subtracted from its "saponification number". An equation was devised by which, when these three numbers were substituted therein, the proportions by weight of the three ingredients, beeswax, stearine and paraffin were found.

If one should wonder that there should be such difficulty in analyzing such a common material as beeswax, it must be remembered that beeswax is not a simple material, but a rather complex mixture of organic substances. This mixture is secreted by the common bee, known to entomologists as Apis mellifica, or in plain language the "Honey Bee", as also by other species of bees, as a product of digestion; it serves the bees as the material for building up the honey combs. Beeswax consists chiefly of a mixture of crude cerotic acid, containing, according to some observers, about 30-40 per cent of homologous acids, as well as number of alcohols and esters, and normally, several hydrocarbons, some of these to the amount of over 17 per cent. The crude wax is then the product as it comes from the bee-hive, which is melted, strained from foreign matter, bleached and moulded into the forms required by the various liturgies. In the production of these forms the beeswax is frequently adulterated. The adulterants may be water and mineral matter, such as ochre, gypsum, etc.; also flour and starch; or they may consist of tallow, Japan wax, stearic acid, paraffin wax, cerseicn, rosin, spermaceti, carnauba wax, insect wax and wool wax.

Dr. Power, to whose direction and initiative the method developed at Weston College owes most of its efficiency, has the following remarks to make regarding this interesting phase of "liturgical chemistry":—

"The practice of using beeswax candles in the liturgy of the Catholic Church can be traced far back into Christian antiquity, but the actual decree of the Sacred Congregation of Rites which gives rise to this particular analytical problem dates from 1904. The passage of interest to the chemist may be translated as follows: "....the Paschal candle, the candle used in blessing the baptismal water, and the two candles lit on the altar during Mass are to be of beeswax, at least in largest part (maxima parts); the other candles on the altar should be either in greater part or of a notable proportion of the same wax." This "maxima pars" is usually taken to mean 51 per cent. The following compositions are common in American candles sold for church use:

	%	%	%	%	%
Beeswax	100	60	51	13	15
Stearic Acid	..	20	30	37	15
Parafin	..	20	19	50	70

In examining candles made by any reputable American manufacturer it may be assumed that they contain only these thre substances.. * * * * * In case the candle seems to be composed of other substances than the three mentioned, the chemist will find the problem (which may become very complicated) treated in the chemical literature of Fats and Waxes."

Father Power recommends that, if there is a suspicion that there are other ingredients present, special methods be used; but that in any case a test for glycerine should always be run on a large sample of all candle mixtures to see if any Japan wax is present from which "synthetic beeswax" may be made. This may simulate exactly the analysis of real beeswax. He remarks further "It has been our experience, however, that candles notably below par in beeswax content are made so by the addition to the beeswax of unduly large amounts of stearic acid and paraffin, rather than by the substitution of any other ingredients for the beeswax itself. In fact so far we have not met with any indications of dishonest practices in cases where the beeswax content was stamped on the candle."

The liturgical reasons for which the ecclesiastical specifications of these various materials are chosen is not a matter of chemistry, so nothing has been said about them. In conclusion it may be said that for the first time in any language a book on this subject has recently been published by the Rev. Rudolph Fattinger, Professor of Religion in a Gymnasium in Linz in Austria. The book is in German and is entitled "Pastoral chemie"; this word is in English literally "Pastoral Chemistry", better translated perhaps, "Liturgical Chemistry". The book is admirably written and deserves an early translation, if for no other reason than that it illustrates and describes the methods by which chemistry may directly serve religion, a service which is both welcome and valuable.

MATHEMATICS

DEFINITION OF A LOGARITHM IN TERMS OF AN AREA

Rev. Frederick W. Sohon, S.J.

In the usual form of presentation, the logarithm is defined as the inverse of the exponential function. The exponential function is obtained logically by a process of progressive redefinition in the systematic generalization of the positive integral exponent which was itself originally directly defined by continued multiplication. This procedure has often been condemned as both unsound from a pedagogical standpoint and highly inconvenient from a theoretical standpoint. The objections are first reviewed, and then the proposed alternative procedure is explained.

As taught at present, the student is first told that an exponent signifies the number of times the quantity to which it is attached is taken as a factor. Logically, then, the only possible exponents are positive integers. Next the mathematical laws for these exponents are proved. Then the student is told (or perhaps he is not told explicitly) that he must generalize his concept so as to include exponents that are not positive integers, and the generalization if carried out step by step as it should be is a long and elaborate process every step of which is logically essential. When he is asked to generalize his concept of an exponent this means that he has to discard entirely his original definition. What is given him to replace it? Merely a list of properties—the algebraic laws of exponents. These properties do indeed define a functional relation, but one must admit that such a definition of a concept, though common enough in mathematics, is rather abstruse for a beginner especially as it is not usually pointed out that the list of properties is to be called by the old name. The student probably never abandons his original notion that an exponent represents the multiplicity of a factor and in such a case he is logically involved in a contradiction when he speaks of zero, negative, fractional and irrational exponents. If he does not feel the contradiction it is because he is not thinking and his proofs are a logical farce. Yet with the concept that he has grasped, he is and should be lost in contradictions.

Hence it is argued with some force that in as much as the student probably does not grasp the idea that an exponential is a function defined by a set of algebraic laws and that the definition that he has had to learn must now be totally abandoned under pain of self-contradictions, the logarithms and exponentials according to their historical development are an imposition on the credulity of the student and tend to discourage critical thinking. The student is not entirely to blame if he does not understand the situation. He expected a straight game, but as soon as he got started the meanings of the symbols were suddenly changed, which is really unfair considering his inexperience.

The classical procedure is unnecessary as we shall show presently. It is most inconvenient from a theoretical standpoint, because the complicated logical structure must be traversed step by step if we want to prove a theorem about exponents. This makes the proofs long and complicated unless we propose to fake them. Hence it is not only from a pedagogical standpoint that the treatment is unsatisfactory .

We can now look at the other side of the picture. Logarathims are not simple in any case. It is proposed to define the logarithm as the area under a rectangular hyperbola. As will be seen, a knowledge of neither trigonometry nor analytical geometry is required, let alone the calculus. The notions of abscissa and ordinate help to shorten the statements of the theorems and proofs, and these notions are usually explained in algebra anyway. The addition theorem concerning areas is handled by limits and the proof is logically simpler than that of certain theorems in plane geometry. But let us see what can be done.

To Construct a Rectangular Hyperbola

If a point moves in such a way that its distance from one line is inversely proportional to its distance from another line, it describes a curve that is called an hyperbola. If the two lines form a right angle, the curve is called a rectanguler hyperbola.

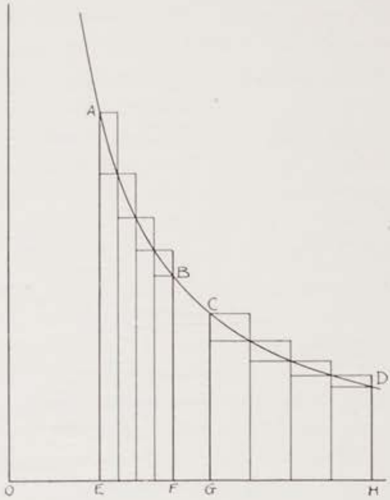
To construct the hyperbola, we have to have given the two lines and the constant of proportionality. Let two lines be drawn at right angles, one horizontal and the other vertical. Let us call the distance to the right of the vertical line x, and the distance above the horizontal line y. Then if the points are to lie on a rectangular hyperbola we must have for every point $y=k/x$ where k is the constant of proportionality. (The procedure of plotting the points can here be explained, and the notions abscissa and ordinate. This is all the analytical geometry that is presupposed.)

The given horizontal axis is called the X-axis. The perpendicular dropped from a point on the curve to the X-axis is called an ordinate. The part of the X-axis included between the ordinate and the other given line is called the abscissa.

Theorem

Under the hyperbola $xy=k$ the area of the segment above the X-axis between the ordinates at $x=a$ and $x=b$, is equal to the area of the segment between $x=ca$ and $x=cb$.

In the figure the curve ABCD is the hyperbola. OE=a, OF=b, OG=ca and OH=cb. It is required to prove that the area ABFE is equal to the area CDHG.



Proof: Divide the two intervals EF and GH into the same number of equal parts, say n. Construct the inscribed and circumscribed rectangles as in the figure. Let the base of one of the rectangles in the interval EF be h. Then $h=\frac{(b-a)}{n}$. But the base of one of the rectangles of the interval GH is equal to $(cb-ca)/n=c(b-a)/n=ch$. The rectangles in GH are just c times as wide as those in EF. Now compare the heights. Take the first large rectangle in EF. Its height is equal to k/a. The height of the corresponding rectangle in GH is equal to $k/(ca)$. Hence the rectangle in EF is exactly c times as tall as the corresponding rectangle in GH. This means that the two rectangles have the same area since $hk/a=chk/(ca)$. In the same way it can be proved that every rectangle of the interval EF is equal to the corresponding rectangle of the interval GH.

Let A = area of segment ABFE
A' = area of segment CDHG.
R = sum of the inscribed rectangles, which is the same in both cases.
S = sum of the circumscribed rectangles, which is the same in both cases.

Then since the whole is greater than its part:

$$R < A < S$$
$$R < A' < S.$$

We shall now show that A' cannot be greater than A. Since S is larger than A' and R is less than A, if we subtract R from S and A from A' the result will be still more unequal so that

$$(A' - A) < (S - R)$$

Now we can find the value of (S-R). It is equal to the sum of all the little rectangles lying on the curve and it is equal to

$$h\left(\frac{k}{a} - \frac{k}{b}\right).$$

The size of S-R depends on n the number of subdivisions, or what is the same thing, by taking h=(b-a)/n small enough we can make S-R as small as we please. It follows from this that the difference A'-A cannot be greater than zero, because by taking h small enough we can make S-R smaller than any number greater than zero. But A'-A must always be smaller than S-R, and hence it must be smaller than every number greater than zero.

We now repeat the proof to show in the same way that A-A' cannot be greater than zero. From this it follows that the difference between A and A' can neither be greater or less than zero. Hence A'=A.

Corollary. *The area from $x=1$ to $x=u$ plus the area from $x=1$ to $x=v$ is equal to the area from $x=1$ to $x=uv$.*

Proof: Let a=u, b=uv, c=1/u.

Then the area from x=a to x=b is the area from x=u to x=uv.

The area from x=ca to x=cb is the area from x=1 to x=v, and these two areas are equal by the theorem just proved. Now if we add the area from x=1 to x=u to the area from x=u to x=uv, we get the whole area from x=1 to x=uv. Thus

Area (1 to u) + Area (1 to v) = Area (1 to uv).

Definition of logarithm.

The logarithm of a number N is the area under the hyperbola xy+k between the ordinate at x=1 and the ordinate at x=N. Instead of writing Area (1 to N) we write log N, but we mean the same thing. We have just proved

Log u + log v = log uv

which means that instead of multiplying numbers we can add their logarithms.

The base of a system of logarithms is the number whose logarithm is equal to unity. By changing the value of k we can get the logarithms of numbers to different bases. If k=1 the logarithms are said to have a natural base e etc.

This is enough to show what can be done. How it would work in practice, I am not prepared to say. It might be worth trying. At least a good case can be made out in its favor. I might suggest that a box might be made with a glass front with a hyperbolic left hand side and the X-axis pointing upward. The addition theorem for areas could be shown by floating water on top of mercury and controlling the level after the fashion of an Orsat apparatus. In this way the properties of logarithms could be verified mechanically. Whether or not this method is better than the old, it seems to me that it has one advantage in that it makes the logarithm something tangible.

THE LATITUDE AND LONGITUDE OF WESTON COLLEGE

REV. HENRY M. BROCK, S.J.

An attempt was made last fall by the members of the Surveying class at Weston College with the cooperation also of Father T. J. Smith and Mr. J. J. Sweeney, to determine geodetically the latitude and longitude of the cross on the college dome. No precise astronomical determination of our position has yet been possible as we have not the necessary instrumental equipment though some observations have been made in the past with a sextant and surveyor's transit. Fathers Blatchford and Barry and their associates in their occultation work used coordinates scaled off on the topographical map of the district (Framingham Sheet). We also use map values on the monthly reports of our cooperative weather station.

The theory of the geodetic method may be found in any textbook on geodesy as for example Hosmer's "Geodesy". A more elementary treatment is given in Johnson-Smith's "The Theory and Practice of Surveying" and in Breed and Hosmer's "The Principles and Practice of Surveying", vol.II. Those who may be interested will also find it worth while to consult the following publications of the U. S. Coast and Geodetic Survey; "Manual of Triangulation Computation and Adjustment"; "Manual of Second and Third Order Triangulation and Traverse"; "Formulae and Tables for the Computation of Geodetic Positions". The latter work is used in computing positions as it gives not only the necessary formulae and their proof but also tables of the necessary constants.

The principle of the method is simple. Suppose that A is a point whose latitude and longitude are given and X is a point whose coordinates are to be determined. It is only necessary to find the length and azimuth of the line from A to X. This line forms the Hypothenuse of a small right triangle on the surface of the so-called Clarke Spheroid, its azimuth giving one angle. The legs represent the differences in latitude and longitude between A and X. Their values computed, in seconds of arc by means of suitable formulae, are added algebraically to the co-ordinates of A and we thus obtain the position of X. The azimuth difference giving the azimuth from X to A may be found at the same time. It is hardly necessary to state that the azimuth of an object from a given point is its direction measured in degrees clock-wise from the south point of the horizon. The term "bearing" is more commonly employed in surveying. The difference between a direct and back azimuth is not exactly 180° on account of the convergence of the meridians. In practice two points A and B with known coordinates are selected forming a triangle with the unknown point X. The length, azimuth and back azimuth of the line connecting A and B must also be given. The angles at the extremity of the line are measured and the triangle is solved. This gives directly the lengths of the lines from A to X and from B to X. Their azimuths are obtained from the given azimuths and the angles of the triangle. The position of X is then computed from both A and B the agreement of the two values serving as a check.

The accuracy of the final result depends upon the accuracy with which the angles are measured. This requires careful plumbing of signal poles and a transit of sufficient precision. The U. S. Coast and Geodetic Survey classifies triangulation according to the magnitude of the closure error. This is the differerence between 360° and the sum of the measured values of the angle and its explement. In first order work the average closure allowed is 1″, in second order 3″ and in third order 6″. When, as is often the case, a triangulation net is established, another criterion is the discrepancy between the measured length of a check line and its length as determined by triangulation from a given base. In first order work this should not be greater than one part in 25,000 and in third order work it should not be greater than one part in 5000. First order triangulation is of course of the highest accuracy. Special theodolites are used whose circles are read by means of microscopes. Angles are usually measured at night, electric lamps with very small filaments serving as sighting signals. Some thirty-four first order stations have recently been established in the neighborhood of Boston with an average closure of 0.9″. Such stations are used as controls for second and third order triangulation.

Our first task was to find two suitable known points for the corners of our triangle. A number are available, the trigonometrical survey of Massachusetts having been begun as early as 1831 by Simeon Borden and continued in later years by the U. S. Coast and Geodetic Survey and by the Land and Harbor Commission—now the Department of Public Works—of the Commonwealth. In addition to hundreds of triangulation marks, the boundary marks and lines of the state itself and of all cities and towns have been accurately located. All these data may be found in U. S. C. & G. S. Publication No. 76 "Triangulation in Massachusetts" and in the various state boundary Atlases. After visiting several hills, Prospect Hill in the city of Waltham and Reservoir Hill in the town of Lincoln were selected. They form a good triangle and besides are convenient of access by car.

For sighting purposes a signal post was built by our carpenter. It was a wooden pole 2x4 inches in cross section and 12 feet long mounted on a triangular base. It was painted alternately black and white and a white flag was attached to the top. The angles were measured with a large Buff Triangulation Transit whose verniers read to 10″. The usual method of repetitions was employed. The verniers are set near zero and the upper motion clamped. The cross wires are set on the left mark and the lower motion clamped. The upper motion is then unclamped and the wires are set on the right mark. The upper motion is clamped and the wires are again set on the left mark. Six repetitions are made in this way and the verniers are read. One-sixth of the mean reading gives a first value of the angle. The telescope is then reversed and the explement is measured in the same way (clockwise). This subtracted from 360° gives a second value. The mean of the two gives the best value. Several angles were measured in this way at each station and the one giving the best closure was used in the computation.

Prospect Hill was the first station occupied. The mark is a copper bolt in the ledge on the summit. A double wooden tower was recently built over it by the coast and Geodetic Survey for triangulation purposes. A tall iron fire tower stands a little to the west of it. Our signal pole had previously been erected at Lincoln Reservoir, but it so happened that neither it nor the cross on the college dome could be seen from the mark on account of the foliage which was still on the trees. An eccentric position was accordingly selected at a distance of 16.33 meters. The best angle here had a closure of 5.5″. It had to be reduced to centre. To obtain the correction a plumb line was set up over the mark and the angle between it and the cross was measured. A surveyor's transit was used at it is only necessary to read to minutes. Another plumb line was then set up over the eccentric point and the distance between the two lines was measured with a steel tape. The reduced angle was 58° 15′ 9.2″.

At Lincoln Reservoir the transit was placed directly over the mark which is a small hole in a marble block at the north east corner of the empankment of the Reservoir. The signal pole was not set up on Prospect Hill. It would have been difficult to see it on account of the wooden tower already mentioned. Two angles were measured. The first, which had a closure of 3.4″, was beetween the middle point of the small top of the inner wooden tower and the cross on the dome. The assumption that this point was in line with the mark did not seem altogether justified and so the angle between the finial on the fire tower and the cross was also measured. Favorable conditions gave a closure of 1.7″. The angle reduced to centre was equal to 56° 55′ 24.3″. The reduced value differed from that measured directly by only 0.7″. This close agreement was of course partly accidental but it served as a good check.

The solution of the triangle gave the following:

Lincoln to Weston College; distance 5677.5 meters; azimuth, 18° 16′ 32.1″.

Prospect to Weston College; distance, 5594.5 meters; azimuth 83° 7′ 49.8″.

The following values for our position were obtained from the co-ordinates of the two known points:

From Prospect Hill	From Lincoln Reserevoir
Latitude: 42° 22′ 57.073″	Latitude: 42°22′ 57.076″
Longitude: 71° 19′ 18.129″	Longitude: 71° 19′ 18.128″

Furthermore the computed azimuth from the college to Lincoln increased by the angle at the college agreed exactly with the computed azimuth from the College to Prospect. This a second check. At Weston 1″ of latitude corresponds to 101.3 ft. and 1″ of longitude corresponds to 75.1 ft.

The agreement between the two above sets of values was closer than we expected to get. Due credit for this must be given to the excellent transit at our disposal. It had kindly been loaned to us for the purpose by Mr. L. F. Buff of the Buff & Buff Manufacturing Company of Boston, well known makers of surveying instruments. It may be noted that in the illustrative examples for third order triangulation given in the references already cited the agreement between the two sets is either exact or the difference is 0.001″. To obtain the most accurate results it would be desirable to measure all the angles of the triangle a certain number of times and then take the mean of those having the best closures. This would permit an adjustment of errors. It would also be well to use more than one triangle as a check. Under the circumstances the most probable values for the position of the cross on the college dome appear to be the following:

Geodetic Latitude:	42° 22′ 57.07″
Geodetic Longitude	71° 19′ 18.13″
	$4^h\ 45^m\ 17.21^s$

In connection with this work the distance and direction of the Boston State House and of some familiar objects on our horizon were also determined by triangulation.

PHYSICS

UNIVERSAL LAW OF MIRRORS AND LENSES

DANIEL LINEHAN, S.J.

The following derivation of the "Universal Law of Mirrors and Lenses" was presented to the students of physics following the B. S. Course at the College of the Holy Cross during the past two years. Since these students have studied physics in their respective College Preparatory Schools, they have had some introduction to the wave theory of light, and so wave demonstration in deriving this law is not too strange to them. Moreover, since many of the advanced books on optics employ wave demonstration in depicting phenomena, a use of the same demonstration at this time in their course of studies would prove to be of great assistance to them.

As we shall be dealing with curved surfaces we must remember that, 'the sagitta of an arc may be taken as the approximate measurement of the curvature of the arc'. This may be shown from the equation for the spherometer, where,—

$$s = \frac{d^2 + s^2}{2r}$$

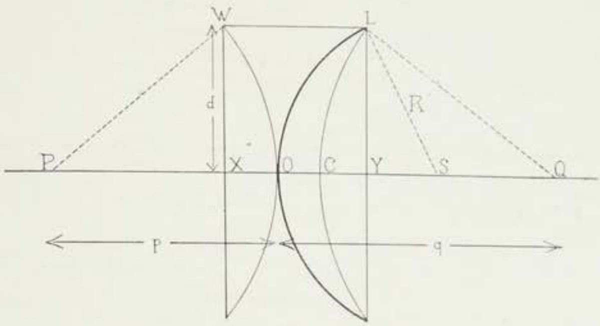
where s=sagitta (or difference between the length of the screw and legs of the spherometer)
d=distance from legs to screw
r=radius of curvature of the surface to be measured

In the case of mirrors and lenses of large radius of curvature 's' is quite small in comparison with 'd' and 'R'. s^2 is much smaller still and can be readily eliminated, So,—

$$s = \frac{d^2}{2r} \qquad \text{(Eq. 1)}$$

We shall take our basis a single refracting surface. Then we shall formulate our equation which will be applicable to both a reflecting surface or a refracting surface, either single or double.

FIG. I



Derivation:

Imagine a surface LO which separates two different media, with the velocity of light in the medium to the left of LO=v; and that in the medium to the right of LO=v′.

Imagine a point P as a source of light sending out spherical waves, and travelling with respect to LO, from left to right. Such a wave front would be WO.

If v′ is less than v, then the wave is retarded, and since that section at O strikes the new medium before the section at W, it will travel more slowly than W and the wave front will change its shape. The section at O will travel the distance OC, while W will travel the distance WL and we have the new wave front LC.

The proportion between the distances travelled and their velocities is,

$$\frac{WL}{OC} = \frac{v}{v'} \qquad \text{(Eq. 2)}$$

We can see that the new wave front is converging towards the point Q and will form there the image of P.

For brevity let PO=p; OQ=q; OS=R (radius of curvature); and WX=d.

From	the	diagram	OX	is	the	sagitta	of	the	arc WO
"	"	"	OY	"	"	"	"	"	" LO
"	"	"	CY	"	"	"	"	"	" LC

Let us express these sagittae as h, h′, and h″ respectively. From Eq. 1 we know that they may be taken as approximate measurements of their arcs.

Fig. I must be used as a typical figure for all problems, varying only to show the difference between a reflecting or refracting surface. Note that the source of light is to the left of the surface. If we regard the point 'O' as the origin, our signs will follow those customarily employed in rectangular coordinates, i. e., all distances on the right are positive

(+); all on the left are negative (—). E.g. q, R, h′ and h″ are (+); while p and h are (—).

So, $WL = -h + h'$, or $h' - h$
$OC = h' - h''$

Eq. 2 now will read, $\frac{h'-h}{h'-h''} = \frac{v}{v'}$

$$\text{or} \quad h' - h = \frac{v(h' - h'')}{v'} \qquad \text{(Eq. 3)}$$

From Eq. 1, $h = \frac{d^2}{2p}$; $h' = \frac{d^2}{2R}$; $h'' \frac{d^2}{2q}$ and substituting these values in Eq. 3, we have,

$$\frac{d^2}{2R} - \frac{d^2}{2p} = \frac{v}{v'}\left(\frac{d^2}{2R} - \frac{d^2}{2q}\right)$$

but $\frac{v}{v'}$ = the index of refraction, so—

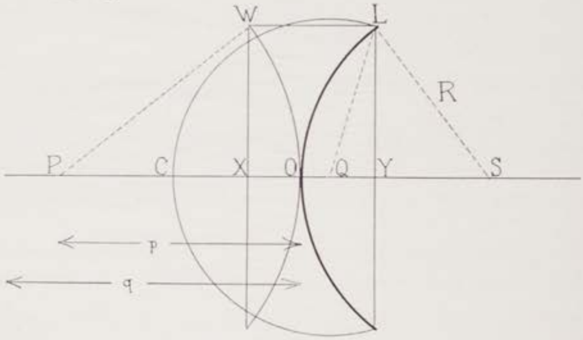
$\frac{d^2}{2R} - \frac{d^2}{2p} = \frac{nd^2}{2R} - \frac{nd^2}{2p}$ multiplying this equation by $\frac{2}{d^2}$ we shall have,

$$\frac{n}{q} = \frac{1}{p} + \frac{(n-1)}{R} \qquad \text{(Eq. 4)}$$

This Eg. 4 is the "Universal Law" governing mirrors and lenses, since it may be accommodated to suit either a reflecting or a refracting surface.

The Law Applied to Spherical Mirrors

FIG. II



In Fig. II

Let LO be a spherical reflecting surface.

WO be a diverging wave emanating from the point P.

LC be a diverging wave reflected from the surface LO.

Now Fig. II is almost identical with Fig. I excepting the wave LC is traveling in the opposite direction. Also, the two waves are travelling in the same medium and with the same velocity.

$$\text{So, } \frac{WL}{OC} = \frac{v}{v} \text{ or } WL = OC$$

$$\text{and } h' - h = h'' - h'$$

$$\text{or } h' - h = -(h' - h'') \qquad \text{(Eq. 5)}$$

Comparing Eq. 5 with Eq. 3 we can see that the only difference is the substitution of -1 for $\frac{v}{v'}$ or n.

Performing the same substitutions and simplifing as was done in Eq. 4 we shall have,

$$\frac{1}{q} = -\frac{1}{p} + \frac{2}{R} \qquad \text{(Eq. 6)}$$

Eq. 6 is the general mirror equation.

Mirrors may be put under two types,

Convex; the center of curvature of the mirror is on the side opposite to the source of light.

Concave; the center of curvature is on the same side as the source light. (In this case R would be (—))

Characteristics of images:

An examination of Eq. 6 will clearly show whether we are to expect a virtual or a real image, depending on the distance of the object from the mirror.

Concave mirror: If the object distance from the mirror is greater than R/2, then the image is 'real'. I. e., if p is larger than R/2 then q is (—). Accordingly, if the distance is within R/2, then the image is 'virtual' or (+). I. e., p will be less than R/2.

Convex mirror: In this type, whether p is greater or less than R/2 there will be like signs, and q will always be (+) or virtual.

In both concave and convex mirrors, as p approaches infinity, q approaches R/2. This distance is called the focal length of the mirror. Therefore $\frac{1}{2}R = f$.

The Law Applied to Lenses

We can use the formula of Eq. 4 for finding the images of lenses, but instead of using it for a single surface, we must now use it for two surfaces. The image from the first surface becomes the object for the second, i. e., $q=p'$. The 'n' used in Eq. 4 is, of course, the index of refraction for the new medium.

Hence, $\frac{n}{q} = \frac{1}{p} + \frac{(n-1)}{R}$ will determine the image from the first surface. To find that of the second surface we must proceed from the object for this surface, viz., p'. But $p' = q$

$$\text{So } \frac{n}{p'} = \frac{1}{p} + \frac{(n-1)}{R} \quad \text{or} \quad \frac{1}{p'} = \frac{1}{np} + \frac{(1-1/n)}{R}$$

Now the ray of light is passing from the second medium back into the first again, and n will become $1/n$. To determine the new image distance q', according to Eq. 4,—

$\frac{n}{q'} = \frac{1}{p'} + \frac{(n-1)}{R'}$ then substituting for n and $1/p$ their determined values,

$$\frac{1}{np'} = \left(\frac{1}{np} + \frac{1-1/n}{R}\right) + \frac{1/n-1}{R'}$$

multiplying by 'n' and simplifying,

$$\frac{1}{q'} = \frac{1}{p} + (n-1)\left(\frac{1}{R} - \frac{1}{R'}\right)$$

In practice q' will be the only image distance necessary and may be called q.

$$\text{So, } \frac{1}{q} = \frac{1}{p} + (n-1)\left(\frac{1}{R} - \frac{1}{R'}\right) \qquad \text{(Eq. 7)}$$

Eq. 7 is the general lens equation.

As in the case of mirrors, so in lenses. As p approaches infinity, $1/p$ approaches O, and q approaches $(n-1)\left(\frac{1}{R} - \frac{1}{R'}\right)$. This distance is called the focal length of the lens. Therefore, $(n-1)\left(\frac{1}{R} - \frac{1}{R'}\right) = 1/f$

$$\text{or } \frac{1}{q} = \frac{1}{p} + \frac{1}{f} \qquad \text{(Eq. 8)}$$

In practice the equation for mirrors and the one for lenses must be taken as they have been stated above. The position of the object, image must be arranged and the type of mirror and lens noted as in Fig. I. The signs to be employed in the working formula must then be determined. E. g.—In a double convex lens the radius of the first side is (+) and that of the second is (—), as a diagram will clearly show. So,

$$\frac{1}{f} = (n - 1)\left(\frac{1}{R} - \frac{1}{R'}\right)$$

f would be (+). A similar example, but with the signs reversed would show why a double concave lens has f as (—).

If this consideration is always shown in dealing with problems, the physicist need but know the signs of two of his factors and the sign of the third will appear in his result.

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..........(b)—A Laboratory Reproduction of the Viscose Process. VIII-1171 (1931).

Jordy, L. C.—Explosives—A Burlesque Lecture. VII-653 (1930).

Kiley, M. M.—A Short and Effective Demonstration of Nitrogen Fixation. VII-2167 (1930).

Law, S. D.—High-School Projects in Chemistry. VI-1139 (1929).

Lebowitz, S. H.—A Demonstration Working Model of the Frasch Process for Mining Sulfur. VIII-1630 (1931).

Oelke, W. C.—A Chamber Sulfuric Acid Plant for Lecture Demonstration. VII-1668 (1930).

Schaeffer, H. F.—Suitable Projects in Plant Chemistry. IX-1103 (1932)

Schichenmyer, H. L.—Mirrors and B-Batteries as Student Projects. IX-1648 (1932).

Simer, D. M., and Brock, M. G.—A Demonstration of Electric Nitrogen Fixation for High-School Chemistry. VII-2169 (1930).

Stone, C. H.—Some Projects in Chemistry. VII-1656 (1930).

Taft, R., and Stareck, J.—The Growth of Lead Crystals in Silica Gels. VII-1520 (1930).

Walters, P. S.—Some Unusual Student Projects. VII-358 (1930).

Williams, H. R. (a)—A Working Model By-Product Coke Plant. VI-745 (1929).

...............(b)—From Corn to Karo. VII-1147 (1930). Excellent.

...............(c)—Fertilizer from the Air. VIII-462 (1931).

RECENT BOOKS

The books mentioned in this column are recommended by our Science Professors as suitable for the Science Libraries.

BIOLOGY

Bumblebees and Their Ways.
O. E. Plath, The Macmillan Co., New York.

The Myxomycetes.
T. H. Macbride, The Macmillan Co., New York.

Diet and Personality.
L. J. Bogart, The Macmillan Co., New York.

CHEMISTRY

Structure of Matter. Four Lectures by P. Debye, Director of the Institute of Physics, University of Leipzig. S. Hirzel, Leipzig, 1933. (German.)

Outlines of Organic Chemistry. F. J. Moore, Late Professor of Organic Chemistry, M. I. T., Revised by W. T. Hall. John Wiley & Sons, Inc., New York.

The Foundations of Nutrition. Mary Swartz Rose, Ph. D. The Macmillan Co., New York.

Food Products. Henry C. Sherman, Third Edition. The Macmillan Co., New York.

Die Technik der Chemischen Operationen. Dr. Walter Bader, Chemical Engineer, Basel. Pub. B. Wepf & Cie., Basel.

The Laboratory Workshop. Apparatus Making and the Use of Tools. E. H. Duckworth and R. Harries. Pub. G. Bells & Sons, Ltd., London, 1933.

Organic and Bio-Chemistry. R. H. A. Plimmer, D. Sc. Longmans, Green & Co., New York.

Fortschritte der Biochemie. II Teil (1924-1931) Felix Haurowicz, Prague. Pub. Theodor Steinkopff, Residenzstrasse 32, Dresden-Blasewitz, Germany. 1932.

The Lyophilic Colloids (Their Theory and Practice), Martin H. Fischer and Marian O. Hooker. Pub. Charles C. Thomas, 300 E. Monroe Springfield, Ill.

A Textbook of Inorganic Chemistry for University Students. Fourth Edition, J. R. Partington. The Macmillan Co., New York.

Phase Rule Studies. J. E. Wynfield Rhodes. Pub. Oxford University Press, London, 1933.

The Conductivity of Solutions. Cecil W. Davies, D. Sc. Second edition revised and enlarged. John Wiley & Sons, Inc., New York. 1933.

Annual Review of Biochemistry. Vol. II. Edited by James Murray Luck, Stanford University. Stanford University Press, California, 1933.

Landolt—Bornstein, Physikalisch-Chemische Tabellen

(Funfte, umgearbeitete und vermehrte Auflage)

In zwei Bänden, XV und IV	1923. (gb. R.M. 106.00)
Erster Ergänzungsband, X	1926. (gb. R.M. 114.00)
Zweiter Ergänzungsband	
Erster Teil, VIII	1931. (gb. R.M. 75.00)
Zweiter Teil, XIV	1931. (gb. R.M. 169.00)

Berlin und Wien: J. Springer.

MATHEMATICS

The Mongean Method of Descriptive Geometry.........W. H. Roever
New York: The Macmillan Co., 1933.

Higher Mathematics for Engineers and Physicists...I. & E. Sokolnikoff
New York: McGraw-Hill, 1934.

Tables of Integrals and other Mathematical Data........H. B. Dwight
New York: The Macmillan Co., 1934.

Tables of Functions...........................E. Jahnke & F. Emde
(Second Revised Edition—Text in German and English)
Berlin: Teubner, 1933. (R.M. 16.00)

PHYSICS

Introduction to Theoretical Physics...............J. Slater & N. Frank
New York: McGraw-Hill, 1933. ($5.00)

Introduction to Modern Physics........................F. Richtmyer
New York: McGraw-Hill, 1934. (Second edition.)

Theory of Thermionic Vacuum Tubes......................E. Chaffee
New York: McGraw-Hill, 1933. $6.00)

Electricity ....J. Pilley
New York: Oxford University Press, 1933. ($2.50)

Handbuch der Physik (Geiger-Scheel)

Band XXII (Zweite Auflage)

Erster Teil: Elektronen—Atome—Ionen. 1933. (R.M. 42.00)

Zweiter Teil: Negative und positive Strahlen. 1933. (R.M. 32.00)

Band XXIII (Zweite Auflage)

Erster Teil: Quantenhafte Ausstrahlung. 1933. (R.M. 32.00)

Zweiter Teil: Rontgenstrahlung. 1933. (R.M. 54.00)

Band XXIV (Zweite Auflage)

Erster Teil: Quantentheorie. 1933. (R.M. 76.00)

Zweiter Teil: Aufbau der zusammenhängenden Materie. 1933. (R.M. 126.00)

Berlin: J. Springer.

BOOK REVIEWS

STRUKTUR DER MATERIE (STRUCTURE OF MATTER). Four lectures by P. Debye, Director of the Institute of Physics, University of Leipzig. S. Hirzel, Leipzig, 1933. 50 pp. 21 Figs. 15×22 cm. Paper bound: RM 3. In German.

For some fifteen years P. Debye has conducted a series of researches bearing directly on the atomic and molecular structure of matter. Four major fields have been investigated and in each he has obtained results of the most fundamental importance. The fields are: X-ray determination of the arrangement of atoms in single molecules, X-ray investigation of the arrangement of molecules in liquids, the relation of dipole moments to chemical structure in liquids, and the behavior of strong electrolytes. In each of the fields he has correlated the results of physical measurements with the chemical behavior of matter.

During 1932 Prof. Debye gave a series of lectures on his researches at Massachusetts Institute of Technology, Ohio State University, and the University of California. After the lecture tour he wrote the four lectures of this booklet in response to a demand for a non-technical review of the work in the four fields mentioned above. The lectures are written in popular style and none of the (sometimes difficult) mathematical reasoning is included. He stresses applications to chemical behavior in each.

Lecture one is an account of the author's work on X-ray interference from single molecules. When a beam of X-rays is passed through a gas the molecules scatter independently because of their random arrangement. However, peaks in intensity are found in the radiations from some gases. Debye showed these to be due to interference in the rays scattered by separate atoms within the molecule and established a method for the determination of interatomic distances from the X-ray pattern. Measurements have been made on many of the simpler molecules and the space structure determined. The results confirm the structures long postulated by stereochemistry for methane derivatives, for cistrans isomers, and for the benzene ring.

The second lecture is on dipole moments and their relation to structure. Permanent and induced moments are simply explained and experimental methods are cited whereby the two may be separately detected. A bit more experimental detail might be appreciated by the lay reader but this information is readily obtainable in American journals. A few specific applications of dipole moment data to chemical structure are given.

In lecture three Prof. Debye delves a little deeper into the structure of liquids. After pointing out that the Van der Waals' equation cannot describe the condition of molecules in a liquid, he cites two experiments as proof that the molecules in a liquid are very regularly arranged and even approximate the condition of a solid. When supersonic waves are passed through a liquid the vibrations of the molecules set up such standing waves that the liquid acts as a reflection grating and spreads white light into a spectrum. This is related to a tightly bound condition of the molecules. When a beam of X-rays is allowed to strike a mercury surface the reflected rays show interference peaks. These may be used to calculate a probability curve for the arrangement of the atoms. Certain positions, roughly corresponding to a packing of hard spheres, are found most probable from the calculation. Thus he shows that the liquid has a quasi-crystalline structure.

Lecture four is a review of the fundamental developments in the now famous Debye-Huckel theory of strong electrolytes.

The booklet is too brief for a thorough review of any subject but does provide a good survey of recent accomplishment.

W. C. P.

RECENT ADVANCES IN PHYSICAL CHEMISTRY. By Samuel Glasstone. Second edition. 14×21 cm.; viii+498 pp. London: J. and A. Churchill, 1933. Price 15 shillings.

This well-planned and well-written summary of recent advances in physical chemistry has won for itself a place in the library of most advanced students of the subject, and the appearance of a second edition will be heartily welcomed. No change has been made in the general plan of the book, except that the chapter on solubility, perhaps the least necessary or important chapter in the former edition, has been omitted; and the space which has thus been made available has been more than used up in expansions of the remaining chapters. The groundwork of the book remains largely unchanged, although here and there certain paragraphs have been rewritten or modified, and the value of the present edition as compared with its predecessor lies in the new matter which has been inserted. The new subjects discussed include: wave mechanics and its applications to problems of valency and the calculation of energy of activation; nuclear disintegration and the discovery of the neutron and the positive electron; the influence of free and restricted rotation on dipole moments; molecular beams and their uses; potential energy curves; atomic reactions; the kinetics of photochemical reactions; activated and discontinuous absorption; surface potentials; the mobility of surface molecules. In the case of a number of these subjects many will, perhaps, feel that the treatment is rather slight and inadequate, but even if this may be so, the discussion of the various topics, all of considerable interest at the present time, will direct the attention of the serious student to the paths along which the subject is advancing and will help him to take up the fuller study of one or more of the subjects discussed. More than this can scarcely be demanded of such a book as the one under review.

A. F.

NEWS ITEMS

Loyola College, Baltimore, Maryland

Chemistry Department

On March 6th, Dr. Roger C. Wells, Chief Chemist of the United States Geological Survey, Washington, D. C., lectured to the members of the Loyola Chemists' Club on the subject: "Chemistry of the Ocean".

"Free Radicals in Organic Chemistry", was the subject of the lecture delivered by Dr. Frank O. Rice, Professor of Chemistry, of the Johns Hopkins University, on March 20th. Dr. Rice demonstrated the existence of "Free Radicals" by experiment.

Dr. A. Benedetti-Pichler and Dr. Joseph B. Niederl of the University of Graz, Austria, and New York University, lectured to a large audience in the Chemistry Lecture-hall on Tuesday April 17th. The subject was: "Special Applications of Micro Analysis". The Lecturers performed several quantitative experiments by the micro-method in inorganic and organic analysis. The Chemistry Lecture-hall was too small to accommodate the large number of students and guests from the local colleges and universities.

The lecturers were assisted by Dr. Herbert Alber, also of the University of Graz. In the audience were Chemists from the National Bureau of Standards, Washington, D. C., Georgetown University, The Johns Hopkins Medical School, The Johns Hopkins University, Maryland University, Goucher College, and Industrial Organizations.

This was the final lecture of the series of Non-Resident Lecturers of the Scholastic Semesters of 1933-1934.

Georgetown University

Honors

On Founders' Day, the medal of the **Angelo Secchi Academy of Science** was bestowed on Dr. Sophie A. Nordhoff-Jung. Dr. Nordhoff-Jung is one of the leading gynecologists in the country and was for many years an associate professor at the Georgetown Medical School. Some years ago she founded an endowment for cancer research. The awarding of the medal is decided by a board of prominent European physicians and educators. The 1931 award was given to Dr. Alexis Carrel of the Rockefeller Institute for Cancer Research in New York City.

Curriculum

In several features the science courses have been affected by recent changes in the curriculum. Examinations for Juniors and Seniors in all subjects except philosophy will be disposed of by May eleventh, so as to allow time for Philosophy Repetitions, as in our Scholasticates. Thirty-five-hundred-word essays are required in a Major Subject for the A. B. and B. S. degrees. Fifteen of the Seniors have chosen a subject in the field of Chemistry for their essays.

Lectures

On March 28th, Walter Bradford Cannon, A. M., M. D., Sc. D., the George Higginson Professor of Physiology at Harvard University, delivered the **Annual Kober Lecture** in Gaston Hall. His subject was: "The Story of the Development of Our Ideas of Chemical Mediation of Nerve Impulses".

Father Paul A. McNally, S. J., Director of the Georgetown College Observatory, has recently given illustrated lectures on **The Universe in Which We Dwell** to an audience of seven hundred at Marywood College, Scranton, Penna.; to eight hundred at the Scranton Chamber of Commerce, this lecture being held under the auspices of St. Thomas College; and to an audience of four hundred at College Misericordia, Dallas, Penna.

An informal illustrated address on the same subject was delivered on Francisco de Vico Evening in Copley Hall at Georgetown University before His Excellency the Apostolic Delegate, Bishop McNamara of Washington and other distinguished guests. This lecture was followed by a reception in honor of Captain Hellweg, Director of the United States Naval Observatory. Similar lectures were delivered by Father McNally at Vassar College, St. Andrew-on-Hudson, Shadowbrook, Wernersville, Regis High School, etc.

Instruments

The two-way plate-holder recently designed and built for the twelve-inch refractor, has been devoted to securing photographic positions of newly-discovered comets, from which an orbit and ephemeris will be computed by Father Thomas D. Barry, S. J. Father William O'Leary, S. J., the present Director of Saint Ignatius College Observatory, Riverview, Sydney, Australia, has constructed an improved astronomical clock of his own design for Georgetown College Observatory. It may be well to note that Father O'Leary seems to have been the original inventor of the free pendulum clock, forms of which are so highly esteemed in scientific circles today under the name of the Shortt Synchronome Clock. When Father O'Leary was Professor of Physics at Milltown Park, Dublin, he tried in vain to interest several firms in his invention and was told that there was no market for it; only to find a similar invention patented and put on the market some time later. Since going to Australia, Father O'Leary has improved his design by a novel brush impulse mechanism. The new O'Leary Free Pendulum Clock gave definitely superior results over a rather long period of time when tested against the best of the free pendulum clocks.

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THIRTEENTH ANNUAL MEETING

of the

AMERICAN ASSOCIATION

of

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