A. M. D. G.

# BULLETIN

of the

## American Association of Jesuit Scientists

Eastern States Division
(Founded 1922)

(for private circulation)

Published at
COLLEGE OF THE HOLY CROSS
Worcester 3, Massachusetts

Vol. XXVI MAY, 1949 No. 4

# Contents

# Bulletin of the American Association of Jesuit Scientists

## EASTERN STATES DIVISION

VOL. XXVI MAY, 1949 NO. 4

# Science and Philosophy

## A HISTORICAL NOTE ON GRAVITY

REV. JOSEPH P. KELLY, S.J.

Why are bodies heavy and light? What makes them fall to the ground? These are not new questions. The moderns are asking them just as did the medievals and the ancients. All down the ages we find discussions on such problems. To-day we seem to be no nearer the solution of the mystery of gravitational attraction than were our forbears in philosophy and science. Perhaps the early scientists showed shrewd sense in deciding not to consider the nature of gravity but to devote their intellectual efforts to its manner of working, to the velocities and accelerations of falling bodies. For, these could be worked out in numbers, in mathematical formulas and were more satisfying than essences, ethers or vortices.

Yet some one had to lay the foundation, to clear away confusion of concepts before the mathematical superstructure could arise. And this is perhaps much of the value of the discussions found in the writings of Albert the Great, Thomas, Suarez and a host of other Schoolmen who were interested in the events of their surrounding world. So, they observed the fall of physical objects and the motions of the heavens, to speculate on the reason for these facts. A body falls because it is heavy. A body rises because it is light. What could be more obvious? Gravity then was "heaviness." It made bodies fall to the surface of the earth; it made water flow downhill. They had a theory that all things had a natural place and left to themselves, these bodies tended to that natural place. The natural place of heavy bodies was on the surface of the earth or below it. "Gravity is that quality of bodies in virtue of which they are destined to occupy a low place." High and low were relative to the earth's surface or to the center of the earth. Gravity or heaviness was an innate quality; it belonged to the bodies. They were difficult to lift; if you let go of them they fall by their heaviness. Not all the Scholastics were of this opinion. Some thought that the falling was due to some influence of the heavens and others to some sort of a medium (like the ether or a vortex). Suarez tells us, however, that the more common opinion ascribed gravity to bodies as an inherent quality, and this was the active principle of natural motions downwards. (*Disp.* 18; *Sect.* VII, no. 21). Of course, the opposite was lightness, (levitas), which belonged to those bodies which moved upwards, like smoke or steam vapor. These had a natural place above the earth and through their levity they tended to this place. These Scholastics were not acquainted with the later theories of bouyancy, or relative atmospheric pressures which explained upwards motions and the relations of light and heavy bodies.

What precisely is gravity or gravitational attraction? That is still the mystery even in modern science. We know how many a wordy battle has been waged over this question. Is gravity an inherent quality or not? Since the Scholastics argued from what appeared to them, it seemed most obvious that gravity was a property of the bodies. Newton rejected the idea of the inherent quality as we know from his letter to Bentley. He says: "You sometimes speak of gravity as essential or inherent to matter. Pray, do not ascribe that notion to me; for, the cause of gravity is what I do not pretend to know and therefore would take time to consider it." (*Principia,* p. 633.) Yet Newton's Law of Universal Gravitation: "Every material body attracts every other material body", etc., if taken in the obvious sense of the terms, would seem to attribute gravity to the bodies themselves. Certainly, his contemporaries accepted this interpretation, though after the publication of his work Newton repudiates the notion. And today, even the scientists speak in the same tone. On the other hand, according to the Theory of Relativity, we can no longer say that gravity is a property of indivdual beings but belongs to the "field". But might we not ask: how does the field get this quality? What is the relation of the body to the gravitational field? To transfer the force of gravity from the body to the field is hardly a real solution and in the last analysis we have not advanced much towards resolving the problem.

Despite these rather vague notions about the nature of the force of gravity, the Scholastics had other clearer ideas on the question. They did recognize the center of the earth as the center of gravity. True, they made it the center of the universe because they believed in the geocentric system of the world. It was evident that bodies fell to the ground. They argued that they would fall likewise on the other side of the world, because the center of the earth was the center of attraction for all bodies. How far can a body fall? Adelard, of Bath, in his book called *Natural Questions*, knew that the earth was round, with the center of attraction at the center of the earth. He proposed this question: "if there was a hole clear through the earth and a stone were dropped in, how far would it fall?" He replied that it would fall as far as the center. This showed a very clear understanding of the problem and we should note that it was given in the twelfth century, some four centuries before Newton. Many of the Greek philosophers taught that the earth was round; so also the Arabs, although some there were who believed that it was flat. The majority held to the rotundity of the earth. Most of the medieval philosophers followed this doctrine. Aristotle taught that the element, *earth*, must have its *natural place* in the center of the universe. There cannot be many worlds, he argued, because all bodies must gravitate towards the center. They would really constitute one world. Again we see the influence of the geocentric theory but his conclusion was in principle correct. But Nicholas Oresme, in 1377, wrote the opposite opinion believing that other worlds were possible beyond our visible world.

In this case, he asserted, each world would have its own center and all the bodies of each would tend toward its own center. Suarez has an interesting discussion on the point. He also taught that the center of the earth was the center of gravity. Developing this point, he goes on to say: "All parts of the earth, as far as they can, tend to the center and gravitate towards it. Hence the earth became solidified by its own weight, (gravitate sua), and is equally compressed on all sides; thus by its own nature it became round. Likewise, the water on the surface of the earth assumes a circular shape, because all parts of the water gravitate towards the center of the earth." (*De Opere Sex Dierum*, Lib. I; *Cap.* 10, no. 4.) This was published in 1621, after the death of Suarez but represents current Scholastic doctrine, before the growth of what we call modern science.

The position of the earth in space excited some speculation among the medieval philosophers. We find it among the many problems discussed by the Encyclopedists of the fourteenth century. For example, Matthias Farinator, a Carmelite, issued a volume, really a small encyclopedia, in 1477, called *The Light of the Soul*, (*Lumen Animae*). He asks what keeps the earth suspended in midair. He says: "There is an equal pull (of gravity) on all sides by the stars and this keeps the earth in equilibrium". This may have been taken from Averroes who taught: "Heavenly bodies exert an attractive force on the earth like that of a magnet on iron. Since the earth is equally attracted, it remains suspended on all sides; it remains suspended in the center of the universe". This last is due again to the influence of the geocentric theory. Yet in this we see some indication of a knowledge of a universal theory of gravitation to account for the relative positions of the heavenly bodies. Suarez also has a suggestion of universal gravity to account for the motions of the heavens. In his day, many of the Scholastics followed the theory of St. Thomas that the celestial bodies were moved in their orbits by intelligent spirits, the angels. Suarez recognized the authority of Thomas in this but saw many difficulties in the doctrine. As an alternate opinion, he feels that the heavens may be moved by some natural force. "Even in inanimate objects, there may be motion from within, by an innate impulse, as the earth by gravitation and consequently, they will not need an extrinsic mover like intelligent spirits". Continuing this line of argumentation he says: "Even if we judge the heavenly bodies to be moved by intelligent spirits, it is not possible from such motions to conclude (with certainty) to the existence of abstract intelligences. For, there does not seem to be any sufficient reason for saying that the heavens may not be moved by an intrinsic and natural impulse, as the earth by gravitation, without these extrinsic movers. . . . We would then conclude that heavenly bodies are effectively and proximately in motion by an innate and conatural quality". (*Disp.* 35; *Sec.* I, no. 16.) He then goes on to state that ultimately this motion would be due to the Creator who endowed these beings with this innate impulse. His thought would be that God created the heavenly bodies as He did the earth. He endowed them with this inherent property like gravity and their motions could be accounted for by this quality just as the natural motions of bodies on the earth are explained by gravity.

Examining the writings of the Scholastic philosophers we find many other notions about gravitational force. Albert the Great mentions that the natural motions of falling bodies are swifter at the end of motion than at the beginning, and that they may be uniformly accelerated, although he makes no mention of a measure of these motions. Others offered theories of the resistance of the air, e.g. Tharentinus. Still others spoke of the gravitational attraction of the moon to explain the tides. Thus we see that the Scholastic philosphers had some sound notions about this mysterious problem. It is said that Nicholas of Cusa proposed the experiment of "timing the fall of objects from towers of equal heights, taking into account the resistance of the atmosphere", but there is no evidence that he ever carried out this proposal.

It is not the purpose of this paper to convey the impression that the Scholastic doctrines on gravity were the forerunners of modern scientific theory, nor to derive any intimate *nexus* between them. We wish merely to indicate that the problem of gravity was not unknown to the medieval mind and that they also had some definite notions on the question. What may have been the influence of the middle ages on modern science, is a much disputed question. That Galileo, for example, was well acquainted with Aristotelian philosophy and the Scholastic commentators of those days, could hardly be denied. Otherwise the boasted revolt of Galileo against Aristotle would scarcely have any meaning. His dissatisfaction with the Physics of Aristotle appears too frequently in the pages of *Two New Sciences*. Galileo was not the discoverer of accelerated motion; that was well known among the Scholastic philosophers. As he says in his *Two New Sciences*: he was not seeking the cause of it although "various opinions concerning it have been expressed by various philosophers . . . the purpose is merely to investigate and to demonstrate some of the properties of accelerated motion". (p. 166). I believe that the same may be said about many other of the early scientists. We are not detracting from the genius of these men by saying that they may have been influenced by the thought of their predecessors. For such has been the history of mankind. No great intellectual movement has an abrupt beginning. It is a growth, an unfolding. It is the flowering of the germinal ideas of a previous generation. Modern science is no exception to this rule. Recent studies and investigations of medieval thought are revealing that there exists a far closer connection between Scholastic Philosophy and Modern Science than was supposed in the recent past. The whole question of the relation between the middle ages and our civilization needs rehabilitation. The fashion of ridiculing the culture of four or five centuries ago is passing. Historical research in recent years has discovered many hitherto hidden documents and manuscripts and a critical examination of these is beginning to show the medieval ages in a new light. Science, law and medicine are found to have been much more advanced than the Renaissance literature revealed. These studies and investigations of the origins of our western civilization are bound to have a profound influence on future judgments of medieval times. As Lynn Thorndyke writes: "Every intelligent person should, if necessary, revise his former estimate of the middle age, and think of it at its height and best, especially in the life of the towns, as having much closer and more vital connections with our present civilization and way of looking at things than used to be held". (*Science and Thought in the Fifteenth Century,* p. 10.)

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## MEMBERSHIP IN THE A.A.A.S.

REV. BERNARD A. FIEKERS, S.J.

A survey of the *Directory of the American Association for the Advancement of Science, 1940-1948* discloses that twenty-seven members of our own ASSOCIATION are members of that organization too; and fourteen of these are listed as "fellows" as well. Investigation into the conditions for fellowship reveals the following: "Members of the American Association for the Advancement of Science are eligible to election to fellowship by two methods: Upon nomination of the Section Committee of the Section with which he is affiliated, or on the nomination of three fellows."

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## DOCTORATES IN THE NATURAL SCIENCES EARNED BY JESUIT ALUMNI 1936-1945

REV. BERNARD A. FIEKERS, S.J.

The data for the following table have been taken from the *Baccalaureate Origins of the Science Doctorates Awarded in the United States 1936-1945*, compiled by the Office of Scientific Personnel, National Research Council, Washington, D. C., June 1948. The table has been set up according to the four sciences that are of interest to most readers of the BULLETIN. The column for psychology has been added because of the significant number of doctorates in this field. The column for the "other natural sciences" includes astronomy, geology, geophysics, engineering, seismology and the like. In the chemistry column, doctorates for biochemistry and chemistry are included. Many of the biological sciences are included in the biology column. Strictly professional doctorates like those in medicine and dentistry are not included. The figures given are absolute values and no attempt at correlating enrollment and graduation data over the period is made. The data for the original work were checked from various sources. The compilers of it estimate the error with respect to total numbers to be about 0.5 percent.

TABLE.—STATISTICS OF JESUIT ALUMNI WHO HAVE EARNED THE PH.D. DEGREE IN NATURAL SCIENCES 1936-1945

| Page Reference | College or University | Biology | Chemistry | Mathematics | Physics | Psychology | Other Nat. Science | Totals |
|---|---|---|---|---|---|---|---|---|
| 20 | Boston College | 1 | 8 | | 1 | 1 | | 11 |
| 39 | Canisius College | 1 | 6 | 1 | 2 | 2 | 1 | 13 |
| 20 | Creighton University | 1 | 3 | 2 | | | 1 | 7 |
| 38 | Detroit University | | 5 | | | | 3 | 8 |
| 21 | Fordham University | 9 | 15 | | 1 | 4 | | 29 |
| 21 | Georgetown Univ. | 1 | 2 | | 1 | | | 4 |
| 41 | Gonzaga University | | 4 | 2 | | | 2 | 8 |
| 28 | Holy Cross College | 2 | 6 | | | 3 | | 11 |
| 42 | John Carroll Univ. | 1 | 1 | | | | | 2 |
| 42 | Loyola Coll. Balto. | 1 | 2 | | | | 1 | 4 |
| 37 | Loyola Univ. Chicago | | 6 | | | | 3 | 9 |
| 42 | Loyola Univ. Los Ang. | | 1 | | | | | 1 |
| 37 | Loyola Univ. N. Orl. | | 1 | | | | | 1 |
| 37 | Marquette Univ. | 10 | 7 | | 2 | | 1 | 20 |
| 55 | Regis College | | 1 | | | | | 2 |
| 44 | Rockhurst College | | 2 | | | | | 2 |
| 45 | St. Joseph's Coll. | 1 | 2 | | 2 | | | 5 |
| 23 | St. Louis University | 4 | 8 | 1 | 3 | 1 | 2 | 19 |
| 45 | St. Peter's College | 2 | 1 | | | | | 3 |
| 38 | San Francisco Univ. | 2 | 2 | | | | | 4 |
| 38 | Santa Clara Univ. | | | | | | 1 | 1 |
| 46 | Scranton University | 1 | 4 | | 2 | 1 | | 8 |
| 46 | Spring Hill College | 1 | 1 | 1 | | | | 3 |
| 47 | Woodstock College | | | | 1 | | 2 | 3 |
| 47 | Xavier University | 1 | 5 | 1 | 1 | 1 | 1 | 10 |
| | Totals | 39 | 93 | 8 | 16 | 13 | 18 | 187 |

This table is offered to readers of the BULLETIN not in the spirit of criticism, but rather in one of optimism. For at many meetings among Catholic Educators a great deal of energy is devoted to this topic without factual support. Here we have a fair sampling of facts.

# Anthropology

## TEPEXPAN MAN: A NOTE AND A PLEA

Rev. J. Franklin Ewing, S.J.

A recent Viking Fund publication (H. de Terra, J. Romero, T. D. Stewart: Tepexpan Man. Viking Fund Publications in Anthropology, No. 11. New York, 1949) inspires me to summarize briefly the information on this find of early man in America for the readers of the Bulletin, and to ask for suggestions concerning a problem somewhat similar to that presented to de Terra. The geophysical methods employed in the search for human and animal remains at Tepexpan may be adaptable to my problem, or they may inspire ideas for some similar technique.

The village of Tepexpan (pronounced Tepéspan) is some 34 kilometers by road northeast of Mexico City. The discovery in that vicinity of ancient beach gravels and soils, indicating fluctuations of level in a prehistoric lake, and the unearthing of fossil elephant skulls stimulated intensive research in the area. Since a waste flake of obsidian, presumably removed from an ancient tool, was found under one of the elephant skulls, the possibility of finding human tools and even human remains was also attractive.

The various earths, indicative of periods of greater humidity and precipitation, are here rather neatly separated by layers of *caliche* (a local name). This *caliche* is a limey layer, which seems clearly to have been produced during a period of relative dryness; it appears along a disconformity, and therefore represents an interruption in soil formation and a time of erosion and gullying; all the evidence adds up to the conclusion that the *caliche* was laid down during a dry period and at a time when the local lake was at low level. The soils and the *caliche* layers, therefore, allow of correlation between glacial fluctuations, on the one hand, and pluvial and interpluvial stages, on the other. The human remains were actually unearthed from a formation called the Younger Becerra Alluvium. This de Terra makes out to have been formed during the waning of the last pluvial of Pleistocene time; he correlates it with the recessional moraines of nearby mountain glaciers. All in all, he dates Tepexpan Man as pertaining to the very end of Upper Pleistocene; in years, he would estimate 9000 to 10000 B.C.

The overall picture of the find and its attendant geology and paleontology indicate that the skeleton was stranded on the edge of a marsh; it may well have been that the man was hunting elephant in an area where the large beast would come to feed and might often have been bogged down. The skeleton was found face down, and a number of bones were missing (e.g., vertebrae); it is true that Archaic graves were often supplied with no funeral furniture, but the absence of such furniture here certainly does not argue for a deliberate burial. The number of elephant remains found in similar formations to the right and the left of the human remains indicate that good hunting was to be found there, especially as other parts of the territory were drying up.

The remains are those of a male, of advanced age (between 55 and 65 years old), with teeth showing extreme wear. The cranial index (proportion of length and breadth of skull expressed as a percentage) is 79.89. This is indeed the only surprising characteristic, since one should expect a longer-headed specimen from such an early age. However, one skull does not make a population. As Stewart remarks (p. 145), this new find, taken together with the older ones of more or less well authenticated antiquity, indicates that the immigrant Indians of the period around the close of the Pleistocene and the beginning of the Holocene came to America looking very much like modern Indians. This may surprise some Americanists, but should hardly startle those who have studied Man in the Old World, and who realize that Lower Aurignacian Man was already practically modern in appearance.

Those who desire further details about Tepexpan Man, and about the meager archaeological finds in the neighborhood, can consult the publication; in which, I may remark, it is a pity more room was not given to the geology of the region. I should like to mention, in passing, that the Viking Fund is very generous with its publications, and with the facilities of its institute; these facilities include photographic, draftng, microscopic, etc. Those interested will find the Research Director (Dr. Paul Fejos, The Viking Fund Inc., 14 East 71st Street, New York 21, N. Y.) most willing to be helpful. The Viking Fund supplied large grants in aid to the Boston College-Fordham University Expedition to the Lebanon.

It is the geophysical work at Tepexpan I should like to expose more in detail. This was done by Dr. Hans Lundberg. The "linear electrode method" was employed. The equipment was: 1,200 meters of naked seven-strand wire; 300 meters of rubber insulated seven-strand wire; 2 6-volt batteries; 1 transformer (Lundberg); 1 audio amplifier (Lundberg); 1 pair of earphones; 2 metal searching rods; 150 metal stakes; 300 wooden stakes.

An alternating current of low frequency was sent into the two non-insulated cables, which were staked to the ground parallel to each other. In the field between these two cables, metal searching rods were introduced; a buzzing sound in the earphone ensues. The points at which no sound was heard are marked as points of equipotentiality; they are marked with wooden stakes, and then plotted on a chart. Homogeneity of the ground will make these lines parallel to the two cables; greater or lesser conductivity will result in deflections, with convergent lines at places of greater electrical resistance, and divergent lines at localities of greater conductivity.

The actual excavations at Tepexpan were made at points of maximum anomalies. These anomalies were caused, in general, by the slopeward movement of groundwater, and, in particular, by the configuration of the *caliche* as marking the edge of the old marsh. The margin of the old marsh was the most favorable area in which to search for the accidentally buried ancient man; the geophysical method succeeded in narrowing down the area of excavation.

This is far from what I desire as a method, in the specific set of circumstances which I have in mind. I will be dealing with the possible presence of human remains in a more limited area, measured in square meters rather than kilometers. I will have an alluvial terrace by the side of a small stream which is dissecting a drumlin. The terrace will be not more than a meter deep, composed largely of soil, but quite possibly containing some of the drumlin boulders, which, incidentally contain a fair amount of iron. The terrace is superimposed on masses of such boulders. Would it be possible for me to sink metal electrodes into the ground, and send such electrical impulses between them as could be differentially interpreted, according to reception, as passing through mere soil, rocks,, or bone? I should be looking specifically for bone, not for artifacts. Some such method would eliminate a great deal of costly and time-consuming digging, and would also materially reduce the possibility of breakage.

I have quizzed an electrical engineer about this. He came up with two suggestions: the use of audible-frequency waves, for which the apparatus would probably cost several thousand dollars; and a chemical searching method. This latter would involve sinking pipes into the ground at intervals of, say, a meter, and then analyzing the "cores" extracted from the soil for concentration of phosphate; the theory being that phosphate from the bone would be leached out into the soil, and a higher percentage would indicate propinquity to bone.

Can anyone make a better suggestion? I cheerfully admit I am looking for a lazy man's method; but also I want one which would afford the maximum of exploratory efficiency, thus cutting down on expenses of digging, expenditure of time, and such danger of harming the remains as is inherent in digging a large area in as short a time as possible.

# Biology

## PROTOPLASMIC MOVEMENT I.

William D. Sullivan, S.J.

Protoplasmic movement is a fundamental property of all living organisms, Heilbrunn (1943) says, "primitive men, and probably children, regard movement as the essential criterion of life, and believe that all moving objects are alive." This criterion is not so erroneous as it may seem, for our criterion of living organisms is often based on movement. That living organism which does not show movement of some kind is rare.

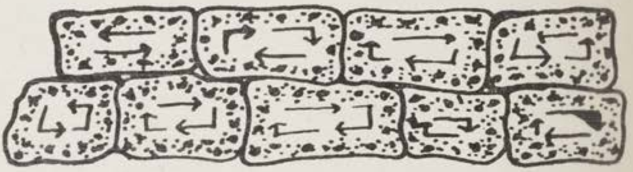
Though the different types of movement are many, this paper is concerned with protoplasmic movement only. The different types of such movement are as follows: 1) *Streaming,* which is characterized by movement in definite currents within the limits of the cell. In this type of movement, locomotion and change in the form of the cell are excluded. 2) *Amoeboid movement,* which involves a change in the contour of the cell; 3) *Ciliary movement,* which is manifested by cell protuberances; 4) *Muscular movement,* which is a very highly developed modification of protoplasmic movement; 5) *Euglenoid movement,* which resembles in some way peristalisis. It has been explained as a motion displayed by the naked cell when it rounds up, stretches out lengthwise, becomes sharply constricted, and goes through other contortions, always returning to the original form. 6) *Sliding and Gliding movement,* which is found in some of the diatoms, bacteria, blue-green algae, etc; 7) *Independent movement,* which is movement of the cell parts such as mitochondria, nucleus, etc. There is no definite movement involved in this last type, and any such movement is really the result of protoplasmic movements. Under this heading may also come *chromosomal movement* described by the cytologists. Though some of the investigators do mention amoeboid movement in the protoplast, it is highly improbable that such is the case and is by no means authenticated.

Of these seven different types, the first four only will be considered in this paper since they are of the most common occurrence in living organisms.

### I. Protoplasmic Streaming

Protoplasmic streaming, first noted by Corti in 1774, may be exemplified in many forms. a) *Agitation* is a general term describing a general feeble type of activity. This type has no definite organization, but is brought about, according to some authors, by such an activity as osmosis. Though unorganized it is present in all physiologically active cells. A second type of protoplasmic streaming is b) *circulation*, or spiro-gyra streaming. In this type of streaming the protoplasm is generally distributed throughout the organism. A central mass of protoplasm is connected by strands with the peripheral mass. These strands form definite pathways to the periphery of the cell. And though there is a haphazard direction of movement, the protoplasmic currents are quite definite. A third type of protoplasmic streaming is c) the *shuttle movement*, which has a one way flow with no visible return flow at the same time as the forward flow takes place. Later on the backward flow may be noted. This type of protoplasmic movement is quite common in the coenocytic forms such as myxomycetes. d) The *sleeve* form of protoplasmic streaming is another type of movement characterized by a forward core and a sleeve of return flow. The last, and by no means the least important, type of protoplasmic streaming is e) *rotational* movement, or better known as *cyclosis*. It is a type of streaming in which the movement of the protoplasm follows the contour of the cell (fig. 1). It is an organized type of movement and its study has been the basis of fundamental work on protoplasmic movement. Such movement is clearly manifested in the leaves of Elodea.

Fig. 1



DRAWING OF ELODEA LEAF
Arrows show the direction of the moving protoplasm.

The following are a few experiments performed by the author on the Elodea leaf:

1. First of all cyclosis was observed in the Elodea leaf under oil immersion objective. The direction of flow throughout the tissue was noted to be either clockwise or counter-clockwise (fig. 1). In the individual cell the direction was constant at all times. If the direction of flow was observed to be clockwise in a single cell at the beginning of the observation, at the end of twenty minutes the direction of flow was still observed to be clockwise. This proved to be the case in a number of cells in a single leaf and in a number of cells studied in different leaves. The chloroplasts do not present the same pattern in any leaf. Those close to the center of the large vacuole move and shift their position slowly, finally moving to the periphery of the cell where they flatten out and join the streaming movement of the pro-

toplasm. However, at no time in their shifting of position do they move against the direction of flow of the cytoplasm. Their shifting of position is rather a rotatory movement which tends to place them in position along the periphery of the cell.

2. In the following experiment several cells of the Elodea leaf were studied. After the length and width of the cells were determined, a single distinctive chloroplast was timed as it traveled first the length and then the width of the cell. The chloroplasts under consideration were usually the fastest moving chloroplasts, relatively uninhibited by other protoplasmic granules in its path. The results show that the rate of protoplasmic streaming in the cells of an Elodea leaf is the same for each cell. However, this could not be tabulated as an indication of a constant rate of flow of protoplasm in the Elodea leaves since there is a discrepancy in the timing of the movement. One factor that possibly causes, at least the mathematical discrepancy, if not the actual physical discrepancy, is that the chloroplast in moving along the periphery of the cell tends to bunch up with the other chloroplasts and thus retard its rate of movement. (Table I.)

TABLE I.

| Elodea Leaf | Size | | Time | |
|---|---|---|---|---|
| | Length | Width | Length | Width |
| 1. | 0.1472 mm. | 0.0294 mm. | 29″ | 5.7″ |
| 2. | 0.1680 mm. | 0.0252 mm. | 26.9″ | 5.6″ |
| 3. | 0.1706 mm. | 0.0252 mm. | 27.5″ | 5.3″ |
| 4. | 0.1980 mm. | 0.0219 mm. | 29.5″ | 5.2″ |

RATE OF PROTOPLASMIC STREAMING IN ELODEA LEAVES

Table I. indicates the time in seconds it took the chloroplasts to travel first the length and then the width of the cell. One chloroplast was observed in each of the four cells.

3. The effect of temperature was also noted in respect to protoplasmic movement. It was first observed at room temperature, which at the time of the experiment was 24° C. The temperature was gradually lowered. With a decrease in temperature there was noted a decrease in the rate of streaming. Once the lowest degree of temperature was reached, it was impossible to follow a chloroplast completely around the periphery of the cell. The chloroplasts were beginning to clump (fig. 2). All movement ceased at 6° C. Heat was then applied gradually. Streaming again became perceptible at a point slightly below 10°C. Movement continued, though not at the same rate corresponding to the descending rate, until room temperature was reached. Streaming continued for four degrees above room temperature, followed by a clumping of the chloroplasts. At 33° C. the cell was completely injured. According to some authors the increase in rate of streaming may be due to the decrease in viscosity at the higher temperatures, and hence there is what is known as viscosity-temperature relationship.

4. The effect of chemicals on protoplasmic streaming was also noted by the author. Elodea leaves were mounted on slides under a cover slip. The testing fluid was drawn under the cover slip by placing filter paper at the edge of the cover slip and a drop of solution at the opposite edge. To be sure that the observed effects were due to the ions and to a difference in tonicity, it was necessary to use isotonic solutions. Due to the amount of the original culture fluid remaining on the slide, 0.05 N solution was found to be the most adequate working solution. 0.03 and 0.10 N were also used, but with less success.

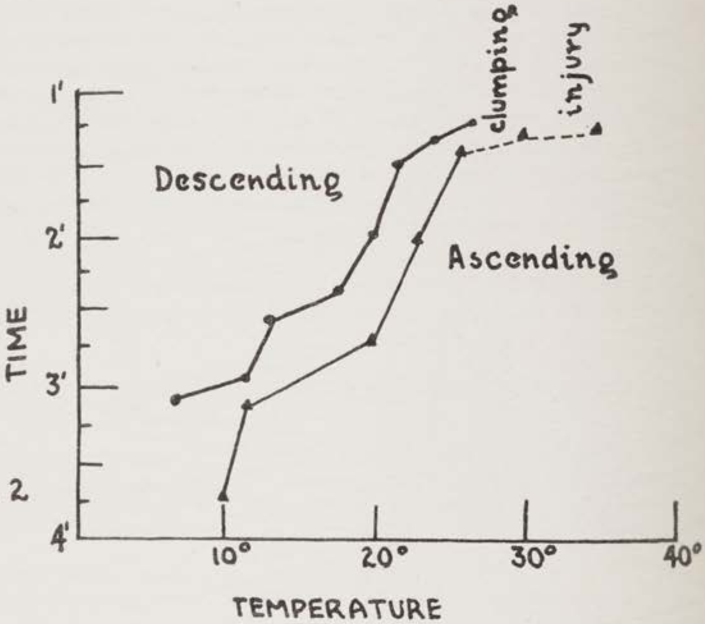



Fig. 2

EFFECT OF CHANGING TEMPERATURE ON THE RATE OF CYCLOSIS IN ELODEA

a) When KCl was added to the Elodea leaf, the cellular contents moved away from the periphery of the cell and formed a clump in the center of the cell. In some cases two clumps of different sizes were formed; in other cells one long clump was formed.

b) When NaCl was added to the slide, the cellular material again clumped in the center of the cell. The clump was more irregular in outline than in the former experiment with KCl. Brownian movement could be observed in some of the cells. The chloroplasts were discernible.

c) When $CaCl_2$ was added to the slide the chloroplasts in each cell formed a dark green clump in the center of the cell, which was in contrast to the lighter green of the rest of the cellular contents.

d) When $MgCl_2$ was drawn under the cover slip the cellular contents drew away from the periphery of the cell, and clumped in the center. The chloroplasts were still discernible.

5. When Elodea leaves were exposed to direct sunlight, the protoplasmic streaming continued for about ten seconds and then stopped entirely. After a lapse of about twenty seconds the streaming again began.

## Summary

Cyclosis is a phenomenon definitely connected with plant life. Within each individual cell the direction is constant; within the plant tissue it is variable. The rate of movement can be determined by measuring the length of time it takes a particle in the cytoplasm to travel a definite distance. It cannot be said that this rate is constant for the entire tissue observed; a mathematical average can be computed, however, for each section of tissue studied. Increase in temperature up to a critical point increases the rate of flow. A decrease in temperature decreases the rate of flow, until a complete cessation takes place close to zero degrees. Too high a temperature destroys the cell completely. Chemicals containing K, Na, Ca and Mg tend to cause plasmolysis of the cytoplasm in varying degrees. Sudden flashes of light will cause temporary stoppage of protoplasmic streaming, but not for any appreciable length of time.

As yet no adequate theory has been proposed to explain "cyclosis" in plant cells. Surface tension, osmosis, myelin processes, sol-gel reversibility, differential hydration, autonomous propulsive forces of particles, electric, magnetic, and electro-magnetic forces have all been proposed at some time or other as possible explanations of this type of protoplasmic movement.

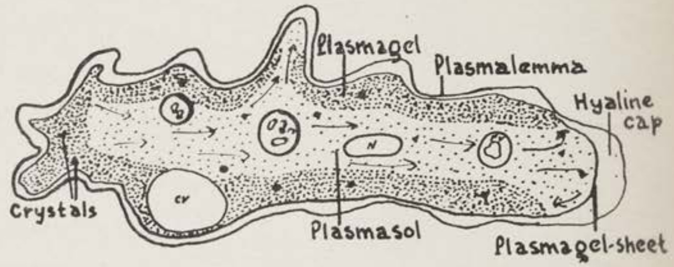
Authors also differ as to its function. Some say that it is for the transport of food materials, while others say that it aids in the transport of growth hormones and other chemicals. There are some who even contend that not all cells manifest protoplasmic movement. They claim that it is an unusual phenomenon manifested by injured cells alone.

## B. Amoeboid Movement

There is a sharp distinction between cyclosis and amoeboid movement. Though protoplasmic flow is had in both cases, the flow of protoplasm in cyclosis is around a central vacuole with no resulting change in the shape of the cell; in amoeboid movement the flow is such that there is a change in the shape of the cell. Not only is there a change in the shape of the cell but there is a change in the position of the cell as well, i.e. locomotion. Though there are organisms in every phylum exhibiting amoeboid movement, we shall restrict ourselves to the study of the one cell animals, *Amoebia proteus* and *Pelomyxa carolinensis,* since it is through the study of these animals that the fundamentals of amoeboid movement have become known to us.

Before one can grasp a clear understanding of the theories of amoeboid movement he must first have a clear understanding of the structure of an amoeba. To the best of our knowledge the most adequate description has been given by Mast (1926). A very thin and delicate membrane surrounds the entire animal. It is called the plasmalemma (fig. 3). Immediately inside this membrane lies the hyaline

Fig. 3




layer. It is described as a clear area, and, believed by Mast to contain a colorless fluid. This same layer is more clearly manifested at the tip of the advancing pseudopod, where it is much expanded. At this point it is called the hyaline cap. Inside this layer is the plasmagel, granular and non-moving. It constitutes a wide margin about the entire cell except at the tip of the pseudopod where it is lacking or at most present as a very thin sheet, and here it is known as the plasmagel-sheet. In the very center of the animal is the plasmasol, granular and moving. It is believed by Mast to be of a more fluid nature than the plasmagel and hence can be seen to flow. This portion of the protoplasm seems to flow as if in a tube with the plasmagel forming the walls of the tube. Besides containing granules, these two layers, the plasmagel and the plasmasol, also contain crystals occurring in two forms, platelike and bipyramidal. According to both Mast and Doyle (1935), the former are made of leucine, an amino acid, and the latter may be magnesium salt of a substituted glycine.

In Mast's description of the amoeba the plasmagel is that section of the protoplasm which does not show streaming when the amoeba is in motion. According to Heilbrunn (1943) "this is hardly a proper definition. One can scarcely define a material as gel because it is not in motion. It may be quiet because of a lack of force upon it. Moreover, when a liquid flows through a narrow tube, the portion of the liquid close to the walls of the tube remains motionless because of friction. This is well known in the case of blood flow through capillaries, and the motionless blood adjacent to the walls of the capillary is called the 'inert layer' ". Whether properly defined or not, Mast's term *plasmagel* formerly known as *ectoplasm,* distinguishes this non-flowing layer from the *plasmasol,* the flowing layer and formerly known as *endoplasm.*

To this day no clear picture of amoeboid movement has been offered. Therefore, even the theory of Mast, accepted by most authors today, contains hypothesis which are by no means conclusive.

Jennings, in 1904, worked on the *Amoeba verrucosa* to determine the type of movement manifested by this animal. He found that from a polar view a forward movement of the upper surface was to be noted. By proper focussing of the microscope toward the center of the animal, here also the protoplasm was noted to move forward. The movement of the lower surface, however, was observed to be stationary. In other words, there was a type of rolling movement or tractor thread movement which was peculiar to this animal and to no other. Dellinger, in 1906, proposed that this is not the case in *Amoeba proteus;* Mast says that such movement may be observed occasionally in *Amoeba proteus,* but it is by no means a movement peculiar to amoebae in general. Dellinger set up his experiment so as to observe the animals from the side and noted a walking type of movement. The amoebae are supported by pseudopods which extend forward. He does not explain the reason for the extended pseudopods, which is the very question of amoeboid movement. Berthold, Schaeffer, Verworn, Buetchli, Jensen and others proposed the surface tension theory, which says that the projection of pseudopods is due to the lowering of surface tension in that section where the pseudopods are formed. According to Schaeffer, the plasmagel furnishes a stiff tube on which the backward movement of the protoplasm can gather traction for the forward movement of the plasmasol. The plasmasol is a *self-acting system,* i.e. autonomous. The theory of surface tension does have a fundament in that it can be very nicely demonstrated in such models as droplets of oil and mercury. Heilbrunn showed that when the surface tension of these droplets was lowered in one section, projections much like the pseudopods of the amoeba bulged out. However, it also has its drawbacks, in as much as in these same droplets the upper surface moves backwards when the surface tension is lowered at the advancing end. This is certainly not the case in the amoebae. It must also be kept in mind that models can never explain adequately the functions of a physiological organism.

The more acceptable theory today, is that proposed by Mast himself. Mast, first of all, made a complete study of the structure of an amoeba so as to collect all the details necessary for movement. He then studied locomotion in detail. This was followed by a thorough study of pseudopod formation and sol-gel transformation in both the amoeba and pelomyxa. His theory of sol-gel transformation was hinted at in the previous literature, but was by no means as detailed and organized as Mast's theory.

It was possible to observe many layers in the animal body. He noted that the plasmagel did not come into contact with the plasmalemma in the anterior end. Just posterior to the plasmalemma at this end he postulated the plasmagel-sheet. Also, the amoeba is a turgid system with water continually flowing in. The osmotic concentration of the plasmasol, he found to be higher than that of water. The granules at the posterior end are pushed into the plasmasol from the plasmagel, while the granules at the anterior end of the plasmasol are pushed to the sides of the animal and sent into the plasmagel. Therefore a solation of the plasmagel at the posterior end and a gelation of the plasmasol at the anterior end was postulated. Knowing these facts, he then studied the contractility of this turgid system, and he postulated that due to this contractility the animal moved forward. The contractility, he found, to be due to a difference in the elastic strength throughout the body of the amoeba. He claimed that if the elastic strength were the same in all parts of the body, the animal would be a perfect sphere. Such is obviously not the case. Hence he concluded that the highest elastic strength is about centro-posterior; the lowest at the anterior end, and the intermediate strength at the posterior end.

The formation of pseudopods, he claimed, is due to a weakening and solation of the plasmagel. When the gel is sufficiently weakened, the plasmasol at point of weakening bulges through the gel and the plasmalemma is extended at that point. Meanwhile, contractility is going on. Furthermore, according to Mast, unless the plasmalemma were attached in some way or other to the substrate, locomotion would be impossible. There must be something for the action of the pseudopod formation to work against or on which to gather traction. Without this substrate, the flowing of the sol may continue, but there would be no locomotion. Just how the amoeba attaches itself to the substrate, Mast does not know. The fundamental points in Mast's theory are as follows:

1) Hypertonic solution surrounded by a semi-permeable membrane (plasmalemma).
2) Localized swelling at the tip of the pseudopod formation of the plasmagel with a decrease in the elastic localized strength.
3) Contraction in the rest of the plasmagel with a solation on the inner surface of the posterior end, resulting in the forward flow of the protoplasm.
4) Gelation of the plasmasol at the outer posterior end and at the anterior surface of the plasmasol.
5) Adhesion of the plasmalemma to the substrate and to the plasmagel.

Most authors now agree that the sol-gel transformation is responsible for amoeboid movement, even though no clear explanations are given for this transformation. Theories have been proposed. Some of the authors have said that it is due to an acid condition at the tip of the pseudopod in formation; though here again there is no conclusive evidence for the presence of such an acid. The contractility theory and the theory of difference in elastic strength of the plasmagel, as proposed by Mast, is the more accepted explanation. It is rather definite that the presence of Ca determines the rigidity of the gel and hence the force of contractility.

Experiments performed by the author on protoplasmic movement as seen in the *Amoeba proteus* and *Pelomyxa carolinensis* follow.

1) Movement in General:—The forward movement of the plasmasol within the central core of the body was first observed. It flowed as in a tube with the plasmagel forming walls in all parts except in the anterior and where it formed a slight film of plasmagel, known as the plasmagel-sheet.

The rate of movement of the granules in the plasmasol differed in various regions. The average rate of movement of a granule in the anterior section was found to be 11 micra per second. In the posterior end the granules moved at a slower pace, 3.5 micra per second, showing the more viscous nature of the plasmasol in the posterior end. The rate of movement of a granule was observed to be much more rapid in the center region of the plasmasol than it was in the plasmasol bordering the plasmagel. It was concluded from these observations that the friction and the mixing, to a small extent, of the more viscous and rigid plasmagel retarded the movement of the plasmasol close to it. In fact, it was frequently noted that the granules close to the plasmagel would move, stop, move and stop. Some even became granules of the plasmagel.

The streaming of the layer close to the periphery of the animal was next observed, i.e. the plasmagel. The thickness of this layer was observed to be fairly uniform throughout, except at the tip of all pseudopods where it formed a very thin sheet. In some amoebae it was observed to be relatively thicker in the posterior end and in the sides of this end, and slightly thinner in the sides close to the anterior end. Except for a very slight movement in the region close to the plasmasol, no movement was observed in the plasmagel. The plasmagel in the inner surface of the posterior end and at the tips of the retracting pseudopods is constantly becoming plasmasol. The plasmasol changes to plasmagel at the tips of the pseudopods, when the streaming in these pseudopods reverses its direction.

2) Formation of Pseudopods:—The formation of pseudopods was observed and the gradual development of the hyaline cap was noted. Granules were observed, on relatively rare occasions, to slip through the plasmagel-sheet. The rarity of this event manifests the rigidity of the sheet. In a very active animal the number of pseudopods usually formed was found to vary from 1 to 9 within a very few minutes. Ordinarily the pseudopods formed in the direction in which the animal was moving, although the direction varied and was quite haphazard. The pseudopods, therefore, formed in what is called the anterior end and disappeared in the posterior end of the animal. No noticeable cause of their formation was observed. Some pseudopods,

especially in the middle of the animal, were seen to bend and wave like tentacles. This was more noticeable in the case of pelomyxae. The attachment of the pseudopods was especially noted in the anterior end. In the pelomyxae the regions of the plasmagel seemed to solate and be pushed out into rounded structures. It appeared that the plasmasol pressure from the streaming was responsible for this action. The plasmasol was observed to gelate further back in the amoebae. The slowing down of the moving granules in the streaming protoplasm gave evidence for this assertion, especially with reference to the posterior end of the amoeba. Liquid is squeezed out to form the hyaline cap. When the pseudopod retracts, the plasmagel-sheet begins to thicken and forms plasmasol which immediately flows back into the center of the animal.

When heat was applied and the temperature reached 30° C, the pseudopods formed much faster. The physical nature of the hyaline cap was observed to be optically homogeneous, except for the occasional presence of very minute granules, and of a clear translucent liquid nature. Brownian movement of these minute granules manifested the liquid nature of the hyaline cap, as well as its rolling movement in formation.

3) Nature of the Plasmalemma:—Carmine particles were added to a slide containing several amoebae. Focusing with the low power objective showed which particles were attached to the amoebae and which were moving in the water. It was noticed, in general, that the carmine particles attached to the surface of the amoebae followed the direction of the plasmasol movement, though they generally moved more slowly. A greater speed of these particles was noticed in the anterior end than in the posterior end. The rate of movement of the plasmasol of the anterior end was found to be 14.4 micra per second, whereas the rate of carmine particles attached to the plasmalemma in the same region was found to be 10.3 micra per second. In the posterior end a carmine particle was timed at 1.5 micra per second. A second carmine particle in the anterior end was observed to move at a rate of 3.3 micra per second. There were some in the posterior end relatively stationary. About 4 particles were observed to be ingested by the amoeba.

Carmine particles were followed around the periphery of the animal, but they were never observed to go around the tips of the pseudopods which were active. When double pseudopods were in the process of formation a particle was seen to flow along the edge and then move slowly underneath one of the pseudopods. Some particles were observed to come up from under the surface at the posterior end and move forward. One particle was noted to move forward and then sideways, then back a little and then forward again. On the under surface they would move, stop, move very slowly and stop again. When properly focussed, it was observed, under low power objective, that the particles beneath the surface and attached to the granules were relatively stationary.

All these observations leads to the conclusion that the plasmalemma has a slow gliding movement over the plasmagel which at times looks like a rolling movement. But the irregularity of the movement and the direction in the active pseudopods would seem to infer that the advancing and the retracting motions of the pseudopods have some influence in the movement of the plasmalemma.

4) Influence of Distilled Water on Amoebae and Pelomyxae:— Distilled water was added to the watch glass which contained a number of the animals. The animals were observed for approximately twenty minutes and found to undergo various forms. In general, the form most assumed after the addition of distilled water, was stellate or multipodal. As more distilled water was added and the original culture fluid lessened, they assumed an even greater stellate shape. This experiment lead to the conclusion that distilled water forced the amoebae and pelomyxae to remove their pseudopods from the substrate, and because of this stimulus, to send out more pseudopods into the water. The animals eventually acclimated themselves to the environment and their pseudopods were observed to become attached.

5) The Effect of NaCl in a N/1,000 Solution:— This solution was added to a culture containing animals with the stellate forms, induced by the distilled water. The animals rounded up and pulled in or retracted their pseudopods. The salt increased their attachment to the substrate.

6) Nucleus:— A pelomyxa was cut in two sections, one section of which contained the nucleus. Both parts were studied. The enucleated part, which was just a little more than a pseudopod, was incapable of locomotion. There was, however, a little streaming, but after twenty minutes all motion ceased and consequently life itself. The nucleated section exhibited locomotion and assumed many shapes. After a few minutes it began to round up, but continued to show motion. Later it assumed its normal shape. It was concluded from this that the nucleus is necessary for both movement and life.

*To be Continued*

# Mathematics

## MATRICES AND CONTINUED FRACTIONS

REV. ARTHUR STEELE, S.J.

The study of continued fractions, both simple and general, and including Euler's theorem on continuants, is lightened by the employment of square matrices of order 2. With simple continued fractions we set, for ease in printing:

$$A(n) = \begin{pmatrix} a_n & 1 \\ 1 & 0 \end{pmatrix}, \quad U(-1) = E, \quad U(n) = \begin{pmatrix} p_n & q_n \\ p_{n-1} & q_{n-1} \end{pmatrix}$$

and in conjunction with the development of $(P+\sqrt{d})/Q$ also:

$$V(n) = \begin{pmatrix} P_{n+1} & Q_{n+1} \\ Q_n & -P_{n+1} \end{pmatrix} \qquad D = \begin{pmatrix} 0 & 1 \\ d & 0 \end{pmatrix}.$$

The familiar recurrence formulae then become multiplicative:

$$U(n) = A(n)U(n-1) = A(n)A(n-1) \ldots . A(2)A(1)A(0),$$
$$V(n) = A(n)V(n-1)A(n)^{-1} = U(n).D.U(n)^{-1}.$$

Theorems on *reversed* or *palindromic* or *periodic* simple continued fractions now follow easily, often by mere transposition of matrices and their products, or by interrupting long products at their midpoint. Merely to identify terms on the left and right sides of the last formula gives instantaneously the connection between the $Q_{n+1}$ and the so-called Pellian Equation.

When the terms from O to h are extraperiodic, and the terms from h+1 to h+k constitute the first period, we may abbreviate to: $H = A(h)A(h-1) \ldots . . A(1)A(0)$ and $K = A(h+k)A(h+k-1) \ldots . . A(h+2)A(H+1)$, and then have for all the aforenamed purposes: $U(h+nk) = K^n H$, and $V(h+nk) = K^n\ H\ D\ H^{-1}\ K^{-n}$.

With general continued fractions and continuants, use U(n) as before and also

$$C(n) = \begin{pmatrix} a_n & b_n \\ 1 & 0 \end{pmatrix}, \quad U(n) = C(n)C(n-1) \ldots . . C(2)C(1)C(0),$$

$$S(i,j) = \begin{pmatrix} K(i,j) & K(i+1,j) \\ K(i,j-1) & K(i+1,j-1) \end{pmatrix}, =$$
$$C(j)C(j-1) \ldots . . C(i+1)C(i).$$

Euler's fundamental theorem on continuants supposes $0 \leq l < m < n < r$ and amounts to evaluating the determinant of the matrix

$$\begin{pmatrix} K(l,r) & K(m,r) \\ K(l,n) & K(m,n) \end{pmatrix}$$

Instead of the chain proof suggested by Chrystal (*Algebra* II, page 498) we prefer to obtain the result ostensively and directly, observing that this matrix shares: its northwest term with $S(l,r)$ and its northeast term with $S(m-1,r)$ and its southwest term with $S(l,n+1)$ and its southeast term with $S(m-1,n+1)$. Using therefore the constant multipliers

$$V=\begin{pmatrix}1 & 0\\ 0 & 0\end{pmatrix}, \qquad W=\begin{pmatrix}0 & 0\\ 0 & 1\end{pmatrix},$$

right or left as required, and noting their property that

$$V\begin{pmatrix}a & b\\ c & d\end{pmatrix}+W=\begin{pmatrix}a & b\\ 0 & 1\end{pmatrix}, \qquad \begin{pmatrix}a & b\\ c & d\end{pmatrix}V+W=\begin{pmatrix}a & 0\\ c & 1\end{pmatrix},$$

we recognise that the proposed matrix is none other than:

$$V.S(l,r).V+V.S(m-1,r).W+W.S(l,n+1).V+W.S(m-1,n+1).W,$$

$$=VC(r)\ \dots\ C(l)V+VC(r)\ \dots\ C(m-1)W+WC(n+1)\ \dots$$
$$C(l)V+WC(n+1)\ \dots\ C(m-1)W,$$

$$=[V.S(n+2,r)+W]C(n+1)\ \dots\ C(m-1)[S(l,m-2).V+W].$$

Finally, taking determinants and remembering the noted property of V and W:

$$K(l,r)K(m,n)-K(l,n)K(m,r)$$
$$=(-1)^{n-m+1}b_{n+1}\ .\ .\ .\ b_{m-1}K(n+2,r)K(l,m-2).$$

This is the celebrated theorem of Euler on continuants, proved essentially on the ground that matrix multiplication is associative and distributive.

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## A COMMON ORIGIN FOR REAL AND FOR COMPLEX NUMBER

Rev. Arthur Steele, S.J.

The better treatises now recognize that real and complex mathematical analysis must begin by constructing real and complex number. They recognize too that the new and the old numbers should not be conjoined abruptly, but rather by the principle of isomorphic subdomains. Nevertheless, they will suffer from disunity and from artificiality, from needless repetition and from blocked generalization, unless they co-operate fully with abstract algebra. Real numbers are constructed too often only by the Dedekind process, complex numbers too often only by the Hamiltonian couple calculus or by the geometrical parable of Kaspar Wessel. Each construction, no matter how rigorously conducted, remains something of an *ad hoc* curiosity, and the alternatives are hardly ever mentioned.

Alternatives do exist, and offer together with other advantages the no small one of constructing real and complex number by *one and the selfsame method*. They rest on the ideas of ring and ideal and class ring as met on the very threshold of algebra; and when the names are new, the things named still are familiar from elementary number theory. The set of all common integers, being self-contained with respect to addition and subtraction and multiplication, is a ring. The set of all multiples of the fixed integer p is similarly self-contained and therefore a subring—but something more as well. The product of a main ring element (any integer) by a subring element (multiple of p) is always again a subring element (multiple of p) and our subring is thus an ideal. The integers may therefore be so classified that classmates and they alone have a difference lying in the ideal, and the classes so generated enter into new sumlike and productlike relations with one another—insofar as the classes to which $x+y$ and xy belong depend only on the classes to which x and y belong. These facts are disguised under the term "congruence" and under the caption that congruence is "analogous to equality".

The *same process* manufactures the real numbers from the rational numbers! The original ring is the set of all "fundamental sequences" such as $(a_n)$ with all terms rational and $|a_p—a_q| < \epsilon$ dor $p>q>\nu = \nu(\epsilon)$. Such a sequence may very well lack a limit as yet, and have one only after the irrational reals become available; but its present specification is wholly in terms of the rational numbers with which we start. The new set constitutes a ring relative to the generalized addition $(s_n) = (a_n+b_n)$ and multiplication $(p_n) = (a_nb_n)$. The subset of all fundamental ZERO-sequences, $|a_n| <\epsilon$ for $n>\nu=\nu(\epsilon)$, is not merely a subring but also an ideal, because fundamental $(a_n)$ and zero-convergent $(b_n)$ yield zero-convergent $(a_nb_n)$. The fundamental sequences may therefore be so classified that classmates and they alone have difference sequences lying in the ideal, and the classes so generated enter into new sumlike and productlike relations—insofar as the classes to which $(s_n)$ and $(p_n)$ belong depend only on the classes to which $(a_n)$ and $(b_n)$ belong. Each such class IS a real number as constructed by Cantor. If r is rational, the iterative sequence whose every term is r must lie in some class, and the classes of this type (each containing one and only one iterative sequence together with unboundedly many non-iterative ones) form a subring isomorph to the rational ring.

An exposition which carried out both constructions would incur the duty of proving that between Cantorian and Dedekindian reals there holds biunivocal correspondence and isomorphism (parallelism of sums and products) and isotaxis (parallelism of order).

The selfsame process also manufactures the complex integers out of the real integers or all complex numbers out of all real numbers. The original ring is here the set of all polynomials in x with real coefficients, taking addition and multiplication as usual. Just as with a modulus p in elementary number theory, so also here: the subset of all polynomials divisible by the fixed polynomial $p(x) = x^2+1$ is not merely a subring but also an ideal generating classes by the rule that classmates and they alone have a difference divisible by $x^2 + 1$. Each class acts as a new mathematical entity and enters into sumlike and productlike relations with other classes—insofar as the class to which $f(x) + g(x)$ belongs, and the class to which $f(x)g(x)$ belongs, depend only on the classes to which $f(x)$ and $g(x)$ severally belong.

Let then $[f(x)]$ denote the class to which the polynomial $f(x)$ belongs. The classes of type $[r]$, where r is a real number regarded as a polynomial of degree zero, form a subring isomorph with the real number ring. This class calculus is such that $[x]$ has for its square the class containing $x^2$ and denoted $[x^2]$. Now the two polynomials $x^2$ and $-1$ differ by a multiple of the fixed $p(x) = 1 + x^2$ and hence are classmates; in other words, "$[x]^2$" and "$[x^2]$" and "$[-]$" are identical classes and identical real numbers. The class $[x]$ thus possesses a square which is the isomorph of the real number —1, but not identical with the real number —1.

All remainders modulo $1 + x^2$ must be of type $a + bx$, so that all classes are enumerated by enumerating $[a + bx]$, a class which the calculus identifies with $[a] + [b] [x]$. In view of the isomorphism between $[a]$ and a, between $[b]$ and b, we could be content with one single new symbol, namely for the single class $[x]$. That symbol, selected at a time when these constructions were not so precise, is simply the letter i. The customary $a + ib$ then stands for "the class $[a + bx]$ modulo the ideal on $x^2 + 1$ within the ring of polynomials in x with real coefficients". Fictionalism is neither desirable nor necessary!

Three features of this Kronecker construction deserve mention. First: it can be applied to any equation and not exclusively to $x^2 + 1 = 0$. Second: the non-trivial automorphism $i \to -i$ stems from the invariance of $x^2 + 1$ under $x \to -x$. Third: there is no humiliating appeal to geometry, but rather the austerest arithmetical autonomy; we do not postulate or thieve, but construct honestly.

The complete setting forth of these and other number constructions would make excellent material for a course of *simultaneous introduction* to modern analysis and modern algebra. Even the *Grundlagen der Analysis* of Landau do not offer the topic in this intent or spirit. There does, however, exist a typewritten codex of such a Course, together with a historical dissertation and a bibliography.

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## INTERNATIONAL UNION OF ASTRONOMY

Zurich, Switzerland, August, 1948 was attended by nine of *ours*: seven Fathers and two Scholastics. The Vatican Observatory was charged by the Congress with the publication of works on molecular spectra to be done in co-operation with other scientific institutes. *Memorabilia, S.J.*, 8, 132-133 (1949). A photograph of the Holy Father's visit to the Vatican Observatory and a photograph of *ours* who attended the congress appear opposite page 134.

# Physics

## WHO WAS THE "EMINENT PHYSICIST"?

Rev. Henry M. Brock, S.J.

The *American Journal of Physics* for April 1944, (Vol. XII, No. 2) contains an article by Dr. Karl K. Darrow of the Bell Telephone Laboratories entitled, "The Future of Physics, Past and Present". It was his Richtmyer Memorial Lecture given before the American Association of Physics Teachers earlier in the year. It dealt with a not very remote period in the history of Physics when many considered it practically a finished science. The great discoveries had already been made and there was little prospect of anything strikingly new appearing in the future. There was also a discussion of the question whether a similar depression, so to speak, was to be expected in the future. In the beginning of the article, the following passage is quoted, which appeared in the Annual Register of the University of Chicago from about 1893 until 1906. "While it is never safe to affirm that the future of Physical Science has no marvels in store even more astonishing than those of the past, it seems probable that most of the grand underlying principles have been firmly established, and that further advances are to be sought chiefly in the rigorous application of these principles to all the phenomena which come under our notice. It is here that the science of measurement shows its importance—where quantitative results are more to be desired than qualitative work. An eminent physicist has remarked that the future truths of Physical Science are to be looked for in the sixth decimal place". Dr. Darrow thinks that this was written by Albert A. Michelson who was professor of Physics at the University during this period. "At any rate" he says, "we can be sure that it appeared with his approval, which comes to the same thing". The preparation of this lecture gave him an occasion of looking up the history of this belief. Not having been able to discover the name of the "eminent physicist" of whom mention is made he added, "Perhaps someone in this audience knows who he was, and if that person will instruct me I will credit him in a footnote to the published version of this speech". As a matter of fact no footnote giving the name appeared when the speech was published.

Like others, I have often wondered who the distinguished individual was and I made some attempt to discover his name and the time and occasion of his remarks. I also had some correspondence with Dr. Darrow on the subject. His presumption that Michelson fully approved of the statement just quoted, if he did not actually write it, seems quite justified. Professor Robert A. Millikan was associated with Michelson at the University of Chicago for a number of years and some time after his death he published an article on his former colleague in the *Scientific Monthly* for January 1939. Among other things he said, "I first met him at the exercises connected with the dedication of the Laboratory (Ryerson) at the spring convocation of the year 1894. He had been the commencement speaker and in his address had emphasized the significance of refinement of measurement for the progress of science—a significance which subsequent years have shown to be vastly greater than he ever foresaw, inspired prophet though he was. Incidentally, in that address he used another's words, I think Kelvin's, as to the likelihood of future discoveries coming from other work than that involving the sixth place of decimals. He afterwards upbraided himself unmercifully to me for ever having done so". Moreover several years later in 1899, Michelson publicly made substantially the same statement in Boston, in his Lowell Institute Lectures on "Light Waves and their Uses". Apparently he had not changed his opinion when the lectures were published under date of 1903. In his second lecture, speaking of the use of light waves for purposes of measurement, he asks what is the use of such extreme refinement. In reply he says, "Very briefly and in general terms the answer would be that in this direction the greater part of all future discoveries must lie. The more important fundamental laws and facts of physical science have all been discovered, and these are now so firmly established that the possibility of their ever being supplanted in consequence of new discoveries is exceedingly remote. Nevertheless, it has been found that there are apparent exceptions to most of these laws, and this is particularly true when the observations are pushed to the limit, i.e. whenever the circumstances of experiment are such that extreme cases can be examined. Such examination almost surely leads, not to the overthrow of the law, but to the discovery of other facts and laws whose action produces the apparent exceptions." He gives several examples—the departure of actual gases from the simple laws of the so-called perfect gas, the discovery of Neptune, the discovery of argon, etc. He then adds, "Many other instances might be cited, but these will suffice to justify the statement that 'our future discoveries must be looked for in the sixth place of decimals'." This is obviously a quotation. Michelson was a distinguished physicist in his own right who in 1907 was the first American to receive the Nobel prize in Physics. He was not given to making rash statements. He seems to have stated the attitude of his contemporaries. I have never heard of any one seriously challenging his statement at the time.

Curiously enough, a month after Millikan's article, an address entitled "Cultural Values of Physics" appeared in the *Journal of Applied Physics*, Vol X, No. 2, February 1939. The author was David Dietz, Science Editor of the Scripps-Howard newspapers. Speaking of the future of Physics he declared that "no bigger mistake could be made than to think of the future as nothing more than an exaggerated picture of the present". To illustrate his point he continued. "How smug the nineteenth century was in this regard can be best described by borrowing a story from Dr. Millikan. He tells how, as a student in Europe, he attended the annual session of the British Association for the Advancement of Science in 1893. An eminent British physicist rose to address that august assembly and spent his time giving thanks that he had lived at the close of the nineteenth century. For, he said, the nineteenth century had seen the completion of the great edifice of physics. All the laws of nature had been discovered and catalogued. Nothing remained for the physicists of the future but to repeat the experiments of the past. Perhaps some twentieth century physicist might carry to four decimal places a determination which the nineteenth century physicist had left at three." In this passage the "eminent physicist" makes his appearance again with his reference to the decimal point. The latter however has been shifted two places. Millikan in the article quoted above, remarked casually that he thought he was Kelvin but gave no evidence. Now we are told that he was British as well as eminent and the time and occasion of his remarks are given. Furthermore the name of a well known American physicist still living is given who actually saw and heard him. The solution of the mystery seemed at hand.

I looked up the Proceeding of the 1893 Meeting of the British Association held at Nottingham. I found nothing in the Presidential address or in the papers of the Physics Section. I did not consult the other sectional reports since there was question of physics only. To make sure of the date, I looked up Millikan's biography in Who's Who. There it is stated that he was a student at Berlin and Goettingen in the year 1895-96. However I found no reference to the eminent physicist in the Presidential addresses or in the physics papers presented in the meetings held in 1895 or 1896. But what about the date given by Dietz? It may have been a misprint. Of course it is possible that Millikan visited England in the fall of 1893 in time to attend the Association Meeting. If he heard the remarks as a student in 1895 then how did the reference to the "eminent physicist" and the decimal place get into The Annual Register of the University of Chicago in about 1893, according to Darrow? It is also possible that the remarks were made in some informal speech, off the record so to speak, and that they were not published. Dietz speaks of an "august assembly" which could mean a general session and not a sectional meeting. I called Dr. Darrow's attention to the Millikan story and intimated that Millikan himself seemed the one man who could give further information and reveal the name of the physicist whom he was alleged to have seen and heard. Darrow knows him personally and accordingly he wrote to him. Strange to saay, Millikan in his reply made no mention at all of the story attributed to him by Dietz. He simply reaffirmed what he had said in his *Scientific Monthly* article viz. that he had only heard Michelson make the remark about the sixth decimal place in 1894. Had he forgotten all about incident or was the story wrongly attributed to him? Perhaps Mr. Dietz himself could give further information. I accordingly wrote to him asking if he happened to recall the occasion of the story and the time when it was told. I intimated that if the address containing it was published, it might also give some indication of the identity of the physicist. His courteous reply did not help much. He said that it was his recollection that he had read the story in one of Millikan's books and had also heard him use it in his Presidential address at the Cleveland meeting of the American Association for the Advancement of Science or in an address at a meeting of the American Philosophical Society. As I wrote to him several years after his article appeared he may have forgotten the details. However he said he would try to find the reference. I have heard nothing since. I looked through three of Millikan's books and also through the presidential address but did not find the story. Millikan has made many addresses on scientific subjects in his long career and the Philosophical Society is very old so I did not attempt to go through its reports with so slight a cue.

As is evident, I have found no answer to the question which forms the title of this paper. Neither have I come across any statement of Dr. Darrow that some reader of his article had furnished him with the information he had requested. There have been of course conjectures regarding the name of the "eminent physicist." As already stated, Millikan thinks that Kelvin was the man. Darrow in his article says that some one told him years ago that Kirchhoff the German physicist was the originator of the sixth-place-remark. Dietz in his letter said that some one once told him that the scientists to whom Millikan referred was Lord Rayleigh. But no references are given. It seems likely to me that Lord Kelvin was the "eminent physicist" in question though I have no direct proof. He was certainly one of the great physicists of the nineteenth century. Born in 1824 in Belfast, Ireland, educated at Cambridge University, England, and fifty-three years professor of Natural Philosophy at the University of Glasgow he was British and would fit into the story attributed to Millikan. He had followed the remarkable progress of science during the greater of the nineteenth century and he had himself made important contributions to physics and engineering. Moreover he was one who laid great stress on the importance of precise measurement for the advance of science. Thus in his address as President of the British Association in 1871, we read; "Accurate and minute measurement seems to the non-scientific imagination a less lofty and dignified work than looking for something new. But nearly all the grandest discoveries of science have been the reward of accurate measurement and patient long continued labor in the minute sifting of numerical results." Likewise in Chapter III of the *Elements of Natural Philosophy* by Kelvin and Tait we find a similar passage: "A most important remark due to Herschel, regards what are called residual phenomena. When in an experiment, all known causes being allowed for, there remain certain unexplained effects (excessively slight it may be), these must be carefully investigated, and every conceivable variation of arrangement of apparatus, etc., tried: until, if possible, we manage so to exaggerate the residual phenomenon as to be able to detect its cause. It is here, perhaps, that in the present state of science we may most reasonably look for extension of our knowledge: at all events we are warranted by the recent history of Natural Philosophy in so doing." Several examples are given including the discovery of Neptune. Michelson must have been familiar with this passage. One can readily imagine a man like Kelvin in his old age and in a reminiscent mood, addressing a gathering and reviewing the scientific achievements of the century with a sense of satisfaction and fruition and perhaps making the remark about the sixth decimal place. However where is the evidence that he really did so?

Perhaps some reader of the BULLETIN can supply the name of the "eminent physicist." Or can it be, that in view of the subsequent development of physics, his name by some common consent was suppressed years ago to save his reputation and that we must be content with the adjective "untraceable" which Darrow applies to him? At any rate the question is of little importance. It only has some slight historical interest as an indication of the attitude of many physicists toward their science fifty and more years ago. Certainly modern physicists find it hard to understand the point of view of their predecessors and are inclined to smile at it. The reasons for the attitude are interesting but do not pertain to the subject of this paper. Those familiar with the history of physics have some cause to wonder at the apparent lack of vision. For it is a curious fact that during the last years of the nineteenth century a series of fundamental discoveries were made which later proved to be the foundation stones upon which much of the structure of twentieth century physics has been built. We need only mention the Edison effect, the photoelectric effect, X-Rays, radio waves, radioactivity and the electron. At the turn of the century Planck stumbled upon the quantum. Then too there were the negative results of Michelson's ether drift experiments.

As a postcript, mention may be made of another more lugubrious prophecy made at the end of the nineteenth century by another eminent physicist and chemist whose name we happen to know. It is probably forgotten but it is interesting to recall it in connection with books and articles now being written regarding the possibility of a future scarcity of food stuffs in a world rapidly increasing in population. This was one of the topics for discussion at the recent Mid-century Convocation at M.I.T. In 1898, Sir William Crookes in his presidential address before the British Association, among other things discussed the future of the wheat supply which provides the staff of life for so many peoples on the earth. He said, "Under present conditions of low acre yield, wheat cannot long retain its dominant position among the food stuffs of the civilized world. The details of the impending catastrophe no one can predict but its general direction is obvious enough. Should all the wheat growing countries add to their area to the utmost capacity, on the most careful calculation the yield would give us only an addition of some one hundred million acres supplying at the average world yield of 12.7 bushels per acre 1,270,000,000 bushels, just enough to supply the increase of population among bread-eaters until the year 1931." With regard to fertilizers he seems to have considered the future depletion of the guano deposits in South America for he adds, "the fixation of nitrogen is a question of the not far future. Unless we can class it among the certainties to come, the great Caucasian race will cease to be foremost in the world and will be squeezed out of existence by races to whom wheaten bread is not the staff of life." The fixation of nitrogen has of course been a fact. Fortunately for the world, Crooke's prophecy failed of fulfilment. Many still remember the abundance of wheat and other food stuffs in this country about 1931 and what happened to some of them and also the enormous wheat crops raised on American farms during the world wars. *Deus providebit.*

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## SOLAR AND COSMIC NOISE AT RADIO FREQUENCIES

JOSEPH F. MULLIGAN, S.J.

In the past few years the subject of radio-frequency radiation from the sun and outer space has received increased attention from physicists and astronomers. This radiation is incoherent and resembles thermal radiation, and is often referred to by such terms as "solar noise" or "cosmic static". Since the radiation is concentrated in the ultra-short wave and microwave regions, this field of research has been called "microwave astronomy". and promises to extend greatly the experimental techniques available to the astronomer.

Cosmic noise was first discovered in 1932 by Karl Jansky. While investigating the causes of radio static at a frequency of 20 megacycles per second (14.6 meters), he detected a steady hiss type of static of unknown origin, which he was able to distinguish from the common burst type of static due to atmospheric disturbances. Jansky found a periodic variation in the direction of arrival of this static throughout the day, and therefore surmised that it might be due to radio-frequency radiation from the sun. In a later paper (1933) Jansky corrected this opinion, and showed that the source must be some fixed region in the galaxy or Milky Way, and that the periodicity was due to the rotation of the earth on its axis.

Before these observations our knowledge of the universe outside the earth's atmosphere was almost entirely derived from the analysis of the visible portion of the electromagnetic spectrum, from 2,000 to 8,000 Angstrom units. This narrow band, on either side of which molecular absorptions render the earth's atmosphere substantially opaque, was the only frequency range available to astrophysicists until Jansky's observations opened up the microwave and ultra-short wave regions—a whole new section of the electromagnetic spectrum to which the earth's atmosphere is transparent, and extending from 1 mm. to 30 meters. This microwave region is limited on the short wavelength side by the absorption of carbon dioxide and water vapor in the atmosphere, and on the long wavelength side by the ionosphere, which absorbs or reflects wavelengths longer than about 30 meters.

It was soon realized that this region would yield a great deal of information about the spectral distribution of the sun's radiation and a test of Planck's black-body radiation law as applied to the sun as a black-body at 6,000° K. With the coming of the war and the development of radar, attention was focussed precisely on this microwave region, and the development of more sensitive receivers and directional antennas has furthered work in this field greatly. However, the subject is still in a growing stage, and there are still many more questions than there are answers.

## *Experimental Methods*

It is clear that very sensitive radio receivers and antennas with high directivity must be used if this radio-frequency radiation is to be detected and its source located precisely in the sky. The radio as a "microwave telescope" is definitely inferior to an optical telescope working in the visible region, where sensitivity is greatly increased by using the integrating effect of photographic plates, and where the resolving power is of the order of seconds of arc, because of the short wavelengths concerned. With even the most directional antennas the resolving power in the microwave region is of the order of degrees, not seconds, of arc. These two requirements of sensitivity and directivity also work against one another in the microwave region, for it is found that at short wavelengths of the order of 10 cm. the power received from solar and cosmic radiation is small compared with receiver noise, while at longer wavelengths of the order of 10 meters, the beam width is too wide for accurate study of the spatial variation of intensity.

The antennas used in this work are of the usual radar types, linear arrays and large parabolic "dishes". The arrays are composed of a large number of dipole elements spaced approximately half a wavelength apart. In this way the antenna is made directive, for only waves coming in the desired direction reach all the elements of the antenna in phase. These antennas are more used on the longer wavelengths, for in the millimeter and centimeter range the elements would be too small for practical purposes. As a result the linear arrays have been superseded in the region below one meter by parabolic dishes of large diameter with a dipole element in the mouth of a waveguide at the focus of the paraboloid. Both these types of antenna have sharp acceptance patterns for dimensions large compared to the wavelength received, since the angular distance between nulls is proportional to $\lambda/D$, where $\lambda$ is the wavelength, and D the diameter of the "dish" or the width of the array. The acceptance pattern is entirely similar to the diffraction pattern of a circular aperture, as is clear from the expression for the angular distance between nulls. For the microwave region beam widths as small as half a degree have been obtained, and attempts are being made to decrease this by building paraboloids with diameters up to 50 ft. Greater resolving power has been obtained by Ryle and Vonberg by using an interference arrangement of antennas similar to Michelson's stellar interferometer.

Up to 1946 one of the chief difficulties in this work was the lack of absolute calibration of the receivers used. Most experimenters worked in only one frequency range, and comparisons of intensities received on two different frequences by two observers were not always valid because of the lack of absolute calibration of the receivers. This difficulty was overcome in 1946 when Dicke developed his "microwave radiometer". This is essentially a superheterodyne receiver which provides for an absolute calibration in terms of the thermal noise generated in a resister at a known temperature. This so-called "Johnson noise" has been shown by Johnson and Nyquist to yield a power output of kT df, where df is the band width of the receiver; k, the Baltzmann constant; and T, the absolute temperature. Since the radiation from the sun and outer space resembles thermal radiation, though it source is not necessarily a thermal one, Dicke's apparatus allows the solar or cosmic noise picked up by a receiver to be compared with the noise generated in a heated load at a known temperature. Hence the receiver admits of absolute calibration. Dicke has also shown how it is possible to overcome difficulties due to noise generated in the receiver itself due to shot-effect, gain variations, etc., and as a result his radiometer is able to measure powers that are only one percent of the noise power generated in the receiver itself. The minimum power detectable is $10^{-16}$ watts. Ryle and Vonberg have improved Dicke's apparatus by eliminating errors due to long-period gain variation in the amplifiers, and by making the apparatus record automatically and continuously the radiation received.

This "microwave radiometer" essentially measures the power flux from a given direction. This is actually a mean of the specific intensity over the band width of the receiver (about 10 mc.), the mean being weighed for different directions of the antenna axis according to the acceptance pattern of the antenna. Specific intensities are generally measured in astrophysics in ergs per second per square centimeter per steradian per unit band width. The given value of the specific intensity at any frequency can be matched at that frequency by the specific intensity from a black body subtending the same angle at a definite absolute temperature. This temperature, the "equivalent temperature" of the radiator, is most often used as a measure of intensity. Use of this parameter does not in any way imply that the radiation is in fact that due to a black body or that the source is necessarily thermal. Since the frequencies here considered are very short compared to optical frequencies, Planck's black-body radiation formula reduces to the Rayleigh-Jeans formula:

$$I_{\nu} \, d\nu = \frac{8 \pi k}{C^3} \nu^2 \, T \, d\nu$$

From this we can determine the black-body temperature which would correspond to any observed intensity. This is the "equivalent temperature" of the source, and will be used throughout the following discussion.

*Solar Radiation*

In dealing with solar radiation the assumption is usually made that the sun radiates as a black body at 6,000° K. Over fifty years ago Langley measured the energy in the sun's spectrum throughout the visible region and to a considerable distance either side. After corrections for absorptions in the atmosphere his results fit the theoretical black-body curve for 6,000° K. very well. Langley's work was extended to much longer wavelengths by Adel in 1942, and he again found good agreement with the black-body curve. Attempts to work in the 0.1mm. range by Reubens and Nichols gave negative results, presumably due to carbon dioxide absorption in the atmosphere. The first time that microwave radiation was observed from the sun was in 1944 when Reber detected radiation at a wavelength of 2 meters, despite the fact that Jansky and others had previously looked for it in vain. Southworth in 1945 investigated the 1 to 10 cm. range and found that for three frequencies in that range the radiation was slightly below that predicted by Planck's formula. No absolute calibration had been made in Southworth's work, and as a result he was later forced to correct his results by a factor of three, and obtained a value three times that predicted by the Planck formula. Since 1945 a great number of observations have been reported on solar radiation in the region from 1 cm. to 15 meters, many of which were made during the war incidental to routine radar searches, and others with equipment specially designed for the purpose.

These observations show without a doubt that the equivalent temperature of the sun as observed on the earth is much higher than 6,000° K. for wavelengths longer than about 1 cm. This seems surprising at first, but can be satisfactorily explained by theory. To understand this clearly it is necessary to distinguish three types of observed solar radiation at microwave frequencies:

1. The first is called radiation from the "quiet" sun. This is the minimum radiation observed on the different frequencies over long periods of time. Here the equivalent temperature of the sun appears to be of the order of magnitude of $10^4$ °K., the optical temperature, for wavelengths shorter than 1 cm., but for longer wavelengths there is a gradual rise in intensity till the equivalent temperature levels off at about $10^6$ °K. at a wavelength of 1 meter.

2. Superimposed on this radiation from the "quiet" sun is an average increase of 10 to 100 times normal intensity during certain periods. This effect has been correlated very closely with the presence

of sun spots on the surface of the sun. In such cases the equivalent temperature may rise to $10^8$ °K., but this is again observed only on long wavelengths. The radiation is circularly polarized, the direction of polarization depending on the position of the sunspot on the solar disk. This constitutes the phenomenon of the "disturbed" sun.

3. At times very short-lived bursts of radiation of tremendous intensity occur. These are closely associated with violent prominent activity of the sun, as in the case of solar flares. Here equivalent temperatures of $10^9$ °K., or higher, are often reached, but last only for a few seconds. A close correlation has been found between such violent solar outbursts and radio fadeouts and variations in the earth's magnetic field. Here too these phenomena are in general confined to wavelengths above 1 cm.

*Theory of Radio-frequency Solar Radiation*

The theory of microwave radiation from the sun is necessarily in a very tentative state because there is as yet insufficient reliable experimental data. The radiation from the quiet sun and from the disturbed sun seem to be essentially different in nature, the first being thermal, the second non-thermal, in origin.

1. The radiation from the quiet sun has been explained by Martyn and others as due to thermal causes. This explains the agreement for wavelengths shorter than 1 cm. with the picture of the sun as a black-body radiating at 6,000° K. Discrepancies at wavelengths longer than 1 cm. are explained as due to the fact that the radiation observed is not coming from the surface of the sun from the corona, or outer layer of the sun's atmosphere. This would require higher temperatures in the corona than at the surface of the sun, but this is in accord with the available experimental data. The Doppler broadening of the coronal lines indicates that the distribution of velocities is similar to that in a thermodynamc enclosure of the order of half a million degrees. Again, Edlen in 1942 identified some of the coronal lines as due to highly stripped metallic atoms that would require temperatures of about $10^6$ in the corona. This would correlate well with the temperatures demanded by Planck's formula for the observed microwave intensities in the region above 1 cm., after corrections are made for the absorptivity of the medium. It has been shown by Martyn that the opacity of the corona varies with frequency. At high frequencies its opacity is smaller, and the observed radiation is coming from the surface of the sun where the temperature is 6,000° K. At lower frequencies the opacity is greater and the radiation is coming from the high temperature coronal region. The radiation increases as the source moves out from the surface of the sun, reaches a maximum at 1 meter, and falls off on the long wavelength side because of the exponential decrease in electron density and collision frequency in the outer corona. Reber and Greenstein have given a picture of the mechanism of absorption producing the change in opacity in terms of free-free transitions of electrons in the field of protons. Martyn has

shown that such a quantum mechanical treatment agrees with his classical treatment, and since the problem is essentially a classical one ($h\nu << kT$), the classical treatment of Martyn seems preferable. This theory has been borne out by the work of Hagen and Covington which indicates that during solar eclipses radiation is still received from the solar corona at microwave frequencies.

2. In explaining the causes of the increased radiation from the disturbed sun it is necessary to reject the possibility of thermal processes, due to the impossibly high temperatures required. The radiation from the disturbed sun has been shown to arise in the solar corona by considerations of optical depth. An explanation proposed by Kiepenheuer is that there is a strong magnetic field of the order of 4,000 gauss associated with sunspots which causes electrons in the solar corona to move in circular paths, and thus emit circularly polarized radiation. Though such a magnetic field certainly exists, it is hard to see how such a mechanism can account for the intensities observed. A better explanation is that of Saha and Martyn that streams of particles associated with sunspots set the coronal medium into vibration at a frequency determined by the electron density. Transmission of the electromagnetic waves set up by these vibrations through the corona, in the presence of the magnetic fields due to sunspots, decomposes them into two components, one of which is circularly polarized and is readily transmitted by the corona. The theory here proposed is completely analogous to Appleton's theory of the propagation of radio waves in the inosphere. Both theories explain the frequency dependence and the polarization of the radiation.

A new theory has been recently proposed by Haeff who shows that space-charge interactions of electron streams can result in the generation and amplification of microwave energy. Though this theory has not yet been developed in detail for solar radiation, it seems to offer great promise in explaining many of the observed effects, especially the great intensities observed.

3. The short-lived outbursts of solar noise of extreme intensity are usually attributed to causes similar to those of the radiation from the disturbed sun. The two seem to differ only in intensity and duration, but exhibit the same circular polarization and frequency dependence. However, Hey has recently proposed that high potentials may be built up between the poles and the equator of the sun, and electrical discharges may result from these in a fashion analogous to atmospheric electricity. This might explain the high intensity bursts observed.

### *Cosmic Noise*

Though radiation from the Milky Way was observed long before radiation from the sun in the microwave region, both experimental data and theory are in a less satisfactory state here. Observations have been made by Reber, Moxon, Hey, Parsons and Phillips, and others on wavelengths from 60 cm. to 15 meters. Here the lack of resolving power in the antennas used, due to the long wavelengths, made it difficult at first to localize the sources of radiation, but the greatest intensities appeared to come from two regions in the Milky Way, one near Sagittarius, and the other near Cygnus. These are the two regions of greatest star density in the Milky Way. A great improvement has been obtained in resolving power in this region by the adaption of Michelson's stellar interferometer to the microwave region. Bolton and Stanley have used this instrument to show that the source in Cygnus has a diameter less than 8 minutes of arc, and that the radiation consists of two components, one constant and the other showing considerable variation over short and long periods. This indicates that the noise comes from a discrete source superimposed on a smooth continuum. The effective temperature is of the order of $4 \times 10^6$ °K. at 3 meters. The position of this source in Cygnus does not appear to agree with the location of any known stellar object.

Very recently Ryle and Smith have reported radiation from Cassiopeia, a constellation near Cygnus, of previously unheard of intensity. The radiation comes from an angular diameter of 6 minutes of arc, and a black body of corresponding width would have to be at a temperature of $10^{14}$ °K. to account for the observed intensities. In July of 1948 Bolton found six new sources in regions of low star-density and not associated with outstanding stellar objects. In all cases there appears to be an increase in intensity with increasing wavelength as with the sun, but there is no evidence of circular polarization. Negative results were obtained by Reber and Southworth for wavelengths shorter than 60 cm.

There are two conflicting theories to explain microwave radiation from sources in the Milky Way, Hey, Parsons and Phillips make the natural assumption that the radiation is merely the sum of the radiations from a great number of stars, and similar in origin to that of the sun. This is substantiated by the fact that the fluctuations in the radiation from Cygnus resemble those associated with sunspots. However, Henyey and Keenan have shown that the intensity of such radiation, considering the sun as a typical star radiating at its highest observed temperature during time of sunspot maxima, would be too small to account for the observed intensities by a factor of $10^{12}$. Hence a star would have to suffer disturbances $10^{12}$ times as intense as those observed in the sun if such bursts are to account for the cosmic radiation at radio frequencies.

Henyey and Keenan propose as the mechanism the acceleration of electrons in the field of protons in the inter-stellar space, assuming a temperature of 10,000° K. for the velocity distribution of the electrons. Townes has shown that their theory agrees with experimental results in the short wavelength range, but would require temperatures of 150,000° K. to account for the observed intensities on the longer wavelengths. However, it does appear that such temperatures do agree roughly with the believed distribution of electron velocities in inter-stellar space.

It appears that an adequate explanation may have to take account of both these effects, radiation from individual stars and from interstellar space, and perhaps from some other as yet unknown source.

A great deal of work on solar and cosmic radiation is being done in England by the Radiophysics Laboratory, Commonwealth Council for Scientific and Industrial Research, with stations in Australia, Canada and New Zealand. In this country work is being carried on at three places: the National Bureau of Standards, the Naval Research Laboratory and Cornell University. A symposium of all workers in this field in the United States was held at Cornell in October of 1948, and plans made for a more coordinated approach to this work in the future. This rapidly expanding field seems to offer great hope for increased knowledge of the physical conditions existing in the atmosphere of the sun and in interstellar space.

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There are also a large number of short articles on this subject appearing in *Nature* over the course of the last three years. A complete biblography of these and other articles will be found in the first two references cited. There is also to be a chapter on "Cosmic Radio Noise" by J. W. Herbstreit in a book entitled *Progress in Electronics* soon to be published by the Academic Press, Inc., New York.

## WAR SURPLUS II

A large electrical furnace for steel analysis in chemistry was acquired by one of our colleges from war surplus. But the heavy transformer that usually goes with it was missing. Research on the part of the consumer showed that a large variable autotransformer would amply satisfy its electrical requirements and that a saving of sixty percent of the price of the transformer could be made. This conclusion may come as a surprise to some. For, almost invariably, we think of the newer type of electrical control as one that must be much more expensive than the traditional tapped variety. On the material basis, pound for pound, that may be so. And that makes the reason for the substitution, of general administrative interest. Generally, fixed or tapped transformers are of much heavier design than the recommended load requirement warrants. For there is apt to be a voltage drop in a light transformer under full load. With a variable autotransformer, which is generally lightly constructed, the voltage drop under load can be offset by turning the dial, which gives almost continuous voltage increase. This difference in material content accounts in part for the differential in cost. It seems too that some manufacturers who add accessories of another brand to their own instrument increase their sales price unreasonably beyond the mere additive. The same situation seems to prevail with transformer-rectifier combinations. In the mood of the "consumer-researcher" we remember one of our Fathers buying an air pump at the time of "repeal" from a saloon supply house at, again, forty percent of the price demanded in laboratory supply. The two items were perfectly identical, except for a substitution of reduction valves, at trivial cost. In a similar vein, consumer research on paint shaking machines might prove fruitful. Sometimes such investigations are not worthwhile for the individual purchaser. Their value to our twenty-seven colleges and universities, however, might justify the time spent in them.

## REV. CARL P. MILLER, S.J.

The *Chicago Province Chronicle* for April 1949 (*13*, pp. 73-4) and the *Patna Mission Letter* carry the obituary of Father Carl P. Miller, S.J. With Father H. Sloctemyer, he founded the Jesuit Science Association in the Missouri Province. Father Miller served as secretary of the Physics Section. He initiated and edited the physical bulletin *High Voltage*. After Tertianship he joined the Patna Mission. R.I.P.

## CATHOLIC GRADUATE COURSES IN PHYSICS

The February, 1949 issue of the *American Journal of Physics* contains a list of 126 colleges and universities in the United States offering graduate courses in physics. Of these five are Catholic colleges: Catholic University with 80 graduate students in physics, Fordham with 40, Notre Dame with 38, Marquette 15 and Boston College 11. The first three offer the Ph.D. degree, the last two only the M.S. The list, which was compiled as the result of a questionnaire sent to all the colleges in the country, seems incomplete, there being no mention of St. Louis University, for example.

The article also lists the number of fellowships and assistantships open to graduate students in physics at each university for the coming scholastic year, and an indication of the work entailed and the salary offered in each case. *J. Mulligan, S.J.*

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## PHYSICS TODAY

The cover of the February, 1949, issue of *Physics Today* features a drawing of the interior of the earth by Father Athanasius Kircher, S.J. In it the earth's interior is conceived as a central ball of fire surrounded by subterranean lakes and rivers. Some of the central fire pierces through the surface to appear in the form of volcanoes, while the subterranean lakes and rivers merge into the bodies of water on the surface of the earth. The drawing is taken from Father Kircher's best-known work, *Mundus Subterraneus,* which enjoyed the greatest repute after its publication in 1678. It is revived in *Physics Today* as an illustration for an article by Beno Gutenberg on *Earth Physics,* which gives a popular account of what is now known of the interior of the earth from seismological and geological evidence.

*Physics Today*, now in its second volume, is a new publication that is an excellent compromise between the highly specialized physics journals and the over-simplified popular science magazines. It features articles by top-flight physicists on topics of significance for physicists and others with an interest in physics. Among the noteworthy articles that have appeared in the past year are: *The Physics of Metals,* by John C. Slater; *Helium, the Unruly Liquid*, by Laszlo Tisza; and *The Christmas Lectures at the Royal Institution,* by Thomas Martin. In addition the journal contains news-items of interest to physicists, book reviews, notes from the physics journals, and other items.

*Physics Today* is published by the American Institute of Physics, and is sent free to all members of the Institute or of its affiliated societies. To non-members the price is four dollars for twelve issues. It would be a worthwhile addition to the periodical rack in our college libraries. *Jos. F. Mulligan, S.J.*

# HIGH-SPEED AGITATION AND STIRRING IN ORGANIC CHEMISTRY

(a notice)

Rev. Bernard A. Fiekers, S.J.

Professor Avery A. Morton of the Massachusetts Institute of Technology is the latest exponent of high-speed stirring in organic chemistry. The history of the topic begins in 1904 with the work of E. J. Brunner in the *Zeitschrift fuer physikalische Chemie, 47*, 56 (1904). Morton has suggested that the reaction flask be creased according to his specifications so that a baffle effect can be produced in order to enhance the agitation. The Findlay Science Engineering Co. manufactures the unit according to Morton's recommendations. It consists of a one quarter H.P., up to 10,000 rpm universal motor, along with ring stand, propellor and an adapter for the Morton Flask. Sole distributors are the Nurnberg Thermometer Co., Inc. Price $225. Glascol heater and Powerstat accessories come separately. Claims are made that reaction rates are increased in many cases well out of proportion to the increase in stirring rates. In at least one case two different products may be isolated at high- and at low-speed stirring respectively. Literature and bibliography are available from the Nurnberg Thermometer Co., Inc.

## REV. HENRY J. DeLAAK, S.J.

Father DeLaak died on January 15, 1948 (sic) just twelve days before his ninetieth birthday, at Saint Louis University. Father may be said to have grown up with the development of the many uses of electricity, and he seemed fascinated with it. Quickly marked as an outstanding teacher, he soon became known outside and was consulted by industrialists. As curator of the museum, Father DeLaak arranged the exhibits in the cases and catalogued the thousands of specimens that were added to the modest collections from the old college. His verbal and written help, given to his assistants, were frequently worthy of printing. He himself printed a Bulletin of the University in 1911 on the *Mechanical Theory of Electromagnetism*. He spent sixty-three years of his life in St. Louis University, fifty-three years of these constituted an unbroken period in one house. *News-Letter, Missouri Province, 16*, 122 (1949). R.I.P.

## ANGERS, FRANCE

The Agricultural School conducted by the Society at Angers recently celebrated its goldren jubilee. A history of the fifty years appears in the *Memorabilia, S.J., 8*, 125-126 (1949). Among its alumni it can claim a Minister of Agriculture in France and a Vice-Minister in Canada, many senators, state advisers, burgomasters and professional men.

# Reviews and Abstracts

ACHIEVEMENT AND PROMISE IN VIRUS RESEARCH. *By W. M. Stanley* (Rockefeller Institute for Medical Research). *American Scientist, 36,* 59-68 (1948). This seems to be one of the most important articles in recent years on the scholastic psychology-biochemical mechanistic front. In size viruses range from ten to three hundred mu. In function they can mutate and multiply within the living cells of a given host; but not in vitro; nor do they seem to undergo metabolism. Are they organisms or molecules? Tracer experiments to study reproduction with radioactive phosphorus were negative. They show striking similarities to genes. Chemical "derivatives" of tobacco mosaic virus were inactive and could be reactivated. Author speaks of "exact patterns for reproduction" which is very suggestive of "template" molecules that have the proper symmetry to strike off copies from living tissue in indefinite repetition. *B. A. Fiekers.*

ADVANCED FRESHMAN COURSE IN CHEMISTRY. *By Stuart R. Brinkley* (Yale), *Sci. Counselor, 10,* 76 (1947). Certain minima in high school preparatory courses are recommended. Freshmen are then screened for the advanced course. The Freshman course is described.

BAL. BRITISH ANTI-LEWISITE. *By R. A. Peters* (Oxford, Eng.). *J. Chem. Educ., 26,* 85-86 (1949). BAL may be looked upon as a gycerine structure in which sulfur replaces oxygen vicinally in two of the three alcoholic groups. It competes with vicinal di-sulfhydryl groups of certain tissue enzymes for condensation with the "Lewisite" structure, eliminating HCl, and forming a stabler four-membered ring than the Lewisite-tissue enzyme derivative. It can gain the Lewisite structure by exchange. Low toxicity, ease of skin absorption, ease of elimination etc. make for ideal defense against Lewisite with this compound. It is effective up to two hours after contamination. The article also indicates the role of Lewisite in interrupting sugar metabolism at the pyruvic acid stage by attacking the pyruvate enzyme. An interesting historico-logical method of presentation is offered. B. A. Fiekers.

BOOK. ROGER BOSCOVICH, S.J.,' 1711-1787. *By H. V. Gill, S.J. 1941.* Gill, Dublin, 76 pp. The notion of the fundamental nature of matter according to Roger Boscovich has played an important role in the history of scientific theory. Yet it might well be that he himself is a prophet without honor among his own. This could be rectified in part by a perusal of a small volume by Father H. V. Gill, S.J., published in 1941. The book is a brief study of the relation of Boscovich's theories on the nature of matter to those currently entertained among scientists. It may be that because of the time at which it was published this "simple account of the remarkable way in which a theory proposed by Roger Boscovich two hundred years ago is now found to be in harmony with conclusions arrived at by methods of modern scientific research" has not come to the attention of American Jesuits just as it has missed being reviewed in the BULLETIN.

After a short sketch of Boscovich's life, including his relations with his contemporary[1] the English chemist Priestly, and his influence on the Irish physicist Kelvin, the author gives an account of Boscovich's Law of Forces. Although Fr. Gill includes chapters on Space and Time, Relativity, Non-Euclidean Geometry, and the Theory of Light, it is the Law of Forces which makes the greatest impression on the reader, just as it impressed J. J. Thomson, who refers to Boscovich explicitly in discussing allowed and forbidden orbits for an electron in an atom even prior to the proposal by Bohr of the atomic model of the old quantum theory.

The Law of Forces postulates a force field for the interaction of two particles which, as the distance between the particles increases, is alternately attractive and repulsive, permitting thus many equilibrium positions. The similarity to the Bohr atom is immediately apparent and the concept suggests more general quantization.

Fr. Boscovich made use of this law to explain the different states of aggregation of matter. It is clear today that this kind of explanation is not suitable for the gaseous state, but Kelvin in 1893 shows "how an incompressible homogeneous solid of wholly oblique crystalline configuration can be constructed without going beyond Boscovich for material."[2] And Herzfeld in 1936 speaks of the "surprisingly correct theory of the forces in crystals . . . given as early as 1760 by Boscovich."[3]

Fr. Gill ends his study with the hope that it may "at least serve as an inducement to some other to undertake a thorough study of a subject at once fascinating and inspiring, and give English readers a 'Life and Work of Roger Boscovich' worthy of so great a man." We may echo his wish and thank him that Boscovich has come to be more than just an adversary to a thesis in cosmology. *R. O. Brennan, S.J.*

GIRALAMO SACHERRI, S.J., NON-EUCLIDEAN GEOMETER. *By Rob't B. Morrissey* (Manhattenville) *Sci. Counselor, 11*, 47 (1948). Material for this paper taken from *Thought, 12* (4) 666. Bibliography of 22 items appended.

THE ISOELECTRIC POINTS OF GLYCOCOLL AND ALPHA ALANINE. *By Magoji Hiraki, J. Biochem. (Japan), 15*, 345-357 (1932). Notification of the method here used should be stressed. Titration (pH) curves for the determination of standard strong acid against standard strong base (pH versus volume of reagent added) are constructed. A small, unmeasured quantity of ampholyte is then added and the determination is repeated. Thus buffering causes new curve to be

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[1] Fr. Boscovich also met Samuel Johnson and praised his Latin conversation.

[2] *Proc.R.S.*, June 8, 1893, p. 659.

[3] *A Treatise on Physical Chemistry*, ed. by Hugh S. Taylor, Vol. I, 2nd edit., p. 75.

higher to the left of the inflection point; lower, to its right; but to cross the original curve within the range of inflection. Addition of more ampholyte raises and lowers respectively to a greater extent, on repeating the titration. But the point of crossing is *identical.* It *is* the isoelectric point. The method as stated is limited to I.E.P. value between 4 and 11. Favorable comparson with older theoretical methods is made. *B. A. Fiekers, S.J.*

LABORATORY PREPARATION OF NORMAL ALKYL BROMIDES. *By L. Joseph et al.* ABSTRACTS, (Div. Chem. Educ., San Francisco Meeting, A.C.S., 1949, p. 2E). Yield-reaction time studies show that n-propyl, n-amyl and n-butyl bromides prepared by the KBr and $H_2SO_4$ method only have to be refluxed for thirty minutes. One very common text calls for 120 minutes. *B. A. Fiekers, S.J.*

NOTES ON CATHOLIC CHEMISTS. *By Sr. M. Dafrose* (Brooklyn), *Sci. Counselor,* 5, 108 (1939).

NOTES ON CATHOLIC PHYSIOGRAPHERS. *By Sr. M. Dafrose* (Brooklyn) *Sci. Counselor, 7,* 78 (1941). Lists many Catholic physiographers of all time, among whom NN: Hagen, Tondorf, Clavius(?), Tieffentaller, Paul Cambone, Boscovich, DeVico, Perry, Scheiner, Marquette, Hubbard, Algue and Secchi. *Ed.*

WHAT IS GOOD SUPERVISION? *By G. W. Hunter* (Claremont Grad. School, Calif.) *Sci. Counselor, 11,* 9 (1948). Features a two-page (quarto) checklist for report on classroom activities of teachers in training. *Ed.*

THE STRUCTURE OF MATTER. *By Francis Owen Rice and Edward Teller,* New York, John Wiley & Sons, Inc., 1949. There have been a great many popular treatments of Quantum Mechanics which have attempted to explain the psi functions by example and analogy. There are numerous good mathematical treatments available which present the various formulations in their full rigor. This book takes a middle path. It is not a popular treatment that can be read over rapidly; but at the same time the mathematical side of the subject has been deliberately and systematically excluded from the pages. It might be called a practical treatment of Quantum Mechanics in that it attempts to present the results and conclusions of Quantum Mechanics to the physicist and chemist in such a form that he will be able to use them in the interpretation of his subject.

In what is intended as the first volume of the Wiley Structure of Matter Series, Professor Rice who is head of the chemistry department at Catholic University has joined forces with Professor Teller of the Institute for Nuclear Studies at Chicago to discuss the application of quantum mechanical ideas to subjects ranging from the hydrogen atom to the white dwarf stars. Starting with the uncertainty principle and the quantum mechanical picture of the hydrogen atom the periodic system of the elements is built up. A consideration of the behavior of atoms in electrical fields leads to a discussion of interatomic forces and a rather extensive treatment of the chemical bond. Chapters on the solid state and the magnetic properties of matter lead into a treatment of molecular spectra and the book concludes with chapters on nuclear chemistry and the state of matter in the stars.

Numerous tables and diagrams help to make the necessarily unfamiliar ideas more lucid. The book contains a wealth of matter presented in a well-organized and orderly manner. It should prove of interest to any chemist or physicist who is anxious to know the effect of the quantum mechanical ideas on his subject. It would seem too that the better students in a course in physical chemistry might find in this volume a new and useful view of their subject. *F. L. Canavan, S.J.*

# News Items

*"Magnopere juverit crebo alios de aliis certeriores fieri, ac audire quae ex variis locis ad aedificationem et eorum quae geruntur cognitionem afferuntur."*—Const. VIII., I.

## BOSTON COLLEGE

### Physics Department

This year saw the establishment at Boston College of a club for undergraduates and graduates whose extra-curricular interests lie in physics and its allied fields. This organization, Associate Members, American Institute of Physics, has for its purpose the diffusion of knowledge of physics and its applications to the advancement of human welfare. Through the Institute, members are provided with placement service, information on educational faculties, government practices and regulations, etc.

At the early meetings the work of organizing the Boston College Chapter was under the direction of Father Tobin, Chairman of the Department of Physics; a president and secretary-treasurer were elected and a constitution drawn up, approved by the Dean. At present there are over 200 members in the Chapter.

As well as pursuing the objective of the parent body, the Boston College Chapter emphasizes among its activities the religious and moral obligation of the scientist to God and society. In addition, the students themselves are afforded an opportunity to secure invaluable experience in the preparation and presentation of technical material before an audience.

Among the distinguished guests who addressed the Chapter were His Excellency, the Most Reverend John J. Wright, Auxiliary Bishop of Boston; Reverend Daniel A. Linehan, S.J., Director of the Seismological Observatory at Weston; Reverend John C. Ford, S.J. of the faculty of Weston College; Rev. John A. Tobin, S.J., and Rev. James J. Devlin, S.J., of the Department of Physics; and Dr. W. L. Harris of the Naval Research Laboratory.

## Boston College Chapter of Associate Members, American Institute of Physics Program for 1948-1949

October 11, 1948—Vincent Sweeney (Senior, B.C.), *Opportunities Afforded the Junior Professional in the Naval Research Program.* October 25, 1948—Leo Kelly (Senior, B.C.), *Wind Tunnel Research by the Navy.* November 8, 1948—Patrick Leonard (Senior, B.C.), *Underwater Research.* November 22, 1948—Rev. James J. Devlin, S.J., (Physics Dept.), *Polaroid and Its Applications.* November 29, 1948—Dr. Harris (Representative from the Naval Research Laboratory in Washington, D. C.), *The Naval Research Program at the Potomac River Command.* December 13, 1948—Rev. Daniel Linehan, S.J. (Director of the Seismological Station at Weston, Mass.), *By-Products of Seismology.* January 24, 1949—Mr. John J. Power (Physics Department), *Ballistic Research Work at Aberdeen Proving Ground.* February 14, 1949—Rev. John A. Tobin, S.J. (Physics Department), *Peacetime Uses for Atomic Energy.* February 28, 1949—Rev. John C. Ford, S.J., (Weston College), *Morality of Atomic Warfare.* March 14, 1949—the Most Reverend John Wright, Auxiliary Bishop of Boston, *Born a Man.* March 28, 1949—Mr. R. L. McFarlan, (Raytheon Corporation), *Electronic Horizons.*

April 11, 1949—To be announced.

April 25, 1949—To be announced.

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## CANISIUS COLLEGE

Mathematics majors at Canisius now enjoy the benefit of an extra-curricular actuarial class in preparation for actuarial examinations. This activity is conducted under the direction of Mathematics Professor F. J. Davenport. Actuary examinations are usually held about May 15 each year at various parts of the country and are jointly sponsored by the Actuarial Society of America and the American Institute of Actuaries in order to recruit younger people who are interested in the profession. Those who pass the first five examinations are admitted as Associates to these groups; the successful completion of three more examinations admits them as full members or as Fellows. Actuaries compile, interpret and apply statistical data. They work for example on life insurance premiums, mortality tables and the like. The class schedules a general review of mathematics from algebra through the calculus. The use of a regular actuarial text is then contemplated. *Griffin, 16* (10), 3 (1949). Canisius College also has a meteorological society. *Griffin, 16* (10), 4 (1949).

Medicine for the Missions. In January 1949 the members of the Alpha-Theta Mendel Club at Canisius College initiated an all-out drive for sample medicines, surgical instruments, and hospital equipment. All these supplies have been donated by doctors and dentists in and near Buffalo. Students collect the supplies from these generous men and then bring them to the college where they are packed for shipment to Fr. Edward Garesche, Director of the Catholic Medical Mission Board. He in turn has the supplies sorted and sent to those foreign missions which are in need of immediate relief.

What prompted the Alpha Theta-Mendel Club members to begin this zealous work was a letter from a Jesuit missionary in India, who told of the great need for medicine. He said that malaria, typhoid, dysentery, and many other diseases plagued the people of India. The success of a missionary's activity depended on the health of these individuals. Fr. Garesche's articles, pamphlets, and magazine describing the needs of the foreign missions was a tremendous stimulus to their zeal.

About the first of the year, a committee of ten men was organized under the direction of Paul Vasques, a senior pre-medical student. All realized that the success of their apostolic endeavor depended upon the unified cooperation of all. Therefore they appealed to every member of the club to contact his family doctor and dentist. The letter from the Jesuit missionary in India was printed in their monthly paper the *Kircher Review*. At the end of the letter an appeal was made to all the doctors and dentists who received the paper—about 100. About a week or two later a separate letter, penny post card, and a pamphlet given to them by Fr. Garesche was sent to each medical man on the mailing list of the *Kircher Review*. Those who received the letter were requested to indicate on the penny post card if they had medicine or other supplies to donate to the mission drive. Once the medicine or surgical instruments were received a letter of thanks was sent to each doctor or dentist. In the next issue of their paper all those who contributed were again thanked and their names mentioned. Each man on the committee had the responsibility of contacting a Medical Center in Buffalo. The success of the drive is due in large measure to this unified action of all the members. Cooperation is the way to a successful campaign.

To publicize their work they arranged to have a staff photographer of the college paper, the *Griffin*, present on the first shipping day to take a picture and to obtain an article. The committee is planning now to publicize their work in the Buffalo papers.

This drive for medicines has been most successful. Fr. Garesche has written many letters of congratulations to the Alpha Theta-Mendel Club. It is our hope that other Jesuit colleges and high schools throughout the country will catch a spark of the flaming zeal of these Canisius students and go and do likewise for the glory of God and the good of souls.

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## FAIRFIELD UNIVERSITY

Biology Department. In September 1948, the Biology Department was opened in Xavier Hall, the newest building on the campus. The

Biology Department is located on the top floor of Xavier Hall, and has a Microscope Laboratory, a Dissecting Laboratory, a lecture room, an office, a technique room and a store room. The Microscope Laboratory has accommodations for 36 students and lockers for 144 students. The Dissecting Laboratory also has accommodations for 36 students and lockers for 216 students. Twenty-five compound monocular Spencer microscopes were purchased. A binocular dissecting microscope was donated by Dr. McQueeney of Bridgeport. Cranwell Preparatory School generously loaned some valuable equipment including a life-size model of the human body, a microprojector, sets of slides, charts, skeletons, and embryological material.

At present, fifty-five Sophomore B.S. Biology students are studying Botany and Zoology. Next year the Junior B. S. Biology students will take Comparative Anatomy, Genetics and Mammalian Physiology. The Junior A. B. Pre-Medical students will take Botany and Zoology. A course in Cultural Biology will be offered to those Juniors who elect Biology as a science.

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CHEMISTRY DEPARTMENT. Our chemistry laboratory after many delays was completed in the latter part of October 1948. The new laboratory can accommodate eighty students in one laboratory period. Locker space is available for 186 students in general chemistry, and 143 students in analytical chemistry. The laboratory table tops are of wood having lead cup sinks set into them. Two different locker units have been staggered throughout the laboratory, thus making the entire working space usable by several different courses. Three six foot fume hoods of *Shelstone* are set along the walls along with several stone sinks. Adjoining the laboratory, there is a stockroom, an office, and a balance room.

During the second semester of this school year, we are offering a course in quantitative analysis to sixty three pre-medical students. This course is taught by Mr. Paul Malloy (M.S. from B.C.), who is also taking courses leading to a doctorate at Fordham University. One hundred and two students are at present enrolled in the general chemistry course taught by Father Hutchinson and Father Buck.

An organic chemistry laboratory is planned for the school year 1950-51. It is also hoped to offer a course in physical chemistry within the next few years.

Our chemical library is being built around a collection of chemical journals given by Mr. C. Weber of Milton, Massachusetts, through the kindness of Father Ahern of Weston. We still lack however, many of the early volumes of the various chemical journals, and standard reference works such as Beilstein, Gmelin and Mellor.

PHYSICS DEPARTMENT. Physics was offered this year for the first time when the laboratories in Xavier Hall became available. The Physics Department is located in the basement of this building, and has as available space: two laboratories, a lecture room, a storage room, a lecture-preparation room, and an office. The General Physics laboratory measures 56 × 27 feet, and can accommodate 60 students at tables in the center of the room, and an additional 20 at tables along the wall. The smaller laboratory, 40 × 14 feet, has a capacity of 40 students and will be used chiefly by Physics majors who are above the Freshman level. All positions in both laboratories are supplied with A.C., D.C., and gas; the smaller laboratory also has a 3-phase current available at several positions.

This year General Physics is the only course offered. Forty students are taking this course, of whom 22 are Sophomore B.S. Math. and 18 are Freshmen B.S. Physics.

The B.S. Physics program will place its major emphasis on the applied view-point. The industrial character of the region and the objectives of the majority of our Physics majors have influenced this decision.

The first gift of equipment to the Physics Department was a motor driven vacuum pump donated by Weston College in memory of Father Thomas H. Quigley, S.J.

It has been particularly difficult to obtain laboratory equipment for experiments in Mechanics. Although orders were placed more than a year ago (based on quotations promising a 3 or 5 month delivery) equipment has not yet been delivered for such experiments as Boyle's Law and Centripetal Force. Fairly rapid delivery is now being made for equipment to be used in the other branches of Physics.

Laboratory furniture for all departments was supplied by the E. H. Sheldon Co., of Muskegon, Mich.

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## COLLEGE OF THE HOLY CROSS

A biology building will be started possibly this summer on a plot of ground between Linden Lane and Beaven Hall. Another edifice under contemplation is a Navy building. Present legislation, now pending, would grant a Navy building to all colleges and universities maintaining a Navy ROTC unit. Our government would share with these colleges the expense of erecting such a building. Holy Cross has the largest Navy ROTC unit in the country. *N.E.P.N. 12*, (4) 2 (1949).

Chemistry Department. A small annex in the form of a chemical stockroom is being built near the back O'Kane tower. Its purpose is to provide for now a fireproof room for the storage of chemicals; it has been designed, however, in the form of a three-car garage with inner entrance to the Department, so as to be practicable for other purposes if, and when, chemistry moves from O'Kane. Alterations in the large lecture room nearby are contemplated.

*The Cross and Crucible Chemists' Club* of the College has been recognized as a Chapter of Student Affiliates of the American Chemical Society. The club was reactivated recently. Before World War II it was well known across the country for the publication of its bulletin, the *Hormone,* which was sent to every chemistry department in the land. Activities of the club call for a continuation of the *Hormone* and plans are being laid for a meeting in May for the formal conferring of the Affiliate Charter. Older A.C.S. Affiliates among the twenty-seven Jesuit Colleges and Universities in the country include the following: Boston College, Canisius College, Creighton University, Fordham University, John Carroll University, Loyola (New Orleans) University, St. Joseph's College, St. Louis University, St. Peter's College and the University of Detroit. Individual students may become affiliated with the American Chemical Society at small cost and thus gain many of the benefits of full membership, such as the use of the Employment Clearing House, a subscription to the Society's weekly journal, *Chemical and Engineering News,* along with reduced rate subscriptions to other technical journals. A group of such affiliates may then organize a chapter on the campus. The General Electric *House of Magic* show was put on for the entire study body under the auspices of the *Cross & Crucible* on April 7th, 1949. Kimball Auditorium was filled to capacity.

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## JOHN CARROLL UNIVERSITY, CLEVELAND

Engineering Program. With the completion of the first course in surveying ever given at Carroll during this past summer, over thirty basic engineering students finished their required work for transfer to the third year in the College of Engineering at the University of Detroit. The course at Carroll is not a pre-course, but strictly a basic engineering course such as all engineering schools require for their students during the first two years of enrollment. The new program permits students from this area to complete their first two years of study while living at home. *Chicago Province Chronicle, 13,* 15 (1948).

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## LOYOLA UNIVERSITY OF NEW ORLEANS

The American Chemical Society Student Affiliate Chapter was host to one hundred and three students from affiliate chapters of twelve universities in the South and Southwest in a two day session, January 15th and 16th, 1948. Technical papers from students were given, along with two given by members of the local staffs J. E. Muldry of Loyola on *Frontiers of Chemistry;* and Hans Jonassen of Tulane: on *Graduate Training in Chemistry in the South.* On Saturday afternoon two plant trips were conducted. There was a banquet in the Roosevelt

Hotel on Saturday evening. Social arrangements by Paul F. Bailey, Moderator of the Loyola Chapter, and Charles Jarreau, its chairman, received good publicity. *Chemical & Engineering News*, *27*, 277 (1949).

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## MARQUETTE UNIVERSITY HIGH SCHOOL

Camera Club members under Mr. Studer's direction entered the National Eastman Photography Contest—. A senior placed second in one division. *News-Letter (Miss. Prov.)*, *16*, 126 (1949).

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## ROCKHURST COLLEGE

Office of Naval Research has subsidized the Solar Furnace Research Work conducted by Dr. W. M. Conn. *News-Letter (Prov. Miss.)*, *16*, 124 (1949). *Newsweek*, *33* (5), 46 (1/31/49) describes an earlier undertaking of this work in France and mentions Dr. Conn.

Several college amateur radio operators recently formed the Rockhurst College Amateur Radio Club and have received a station license with call numbers W O P N operating on all amateur frequencies and on both phone and code. QSI cards have been received from all over the world. The college men hope to organize a CW chain of Jesuit stations. *The News-Letter, Missouri Province*, *16*, 116 (1949).

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## ST. CHARLES' COLLEGE

Grand Coteau, Louisiana. Rev. Julius J. May, S.J. and Brother Frank J. Riedinger, S.J. (W5KIR) have sent copies of a circular letter to about one hundred Jesuits at home and in the Missions in an endeavor to organize Jesuit amateur radio operators. The heads of the various physics departments in all provinces were circularized. The BULLETIN will be glad to co-operate by publishing the data .once collected. *Editor.*

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## ST. LOUIS UNIVERSITY

The University received the bulk of an estate estimated in excess of $400,000 in the will of the late Miss Cecia M. Steuver. Her brother, Dr. Francis L. Steuver, who died in 1928, was a graduate of the University. The will stipulates that the money be used for the establishment of chairs of research in diseases of the ear, nose and throat in honor of Dr. Steuver, and of the eye in honor of Miss Steuver. . . . Cancer clinic has been given a grant of $3,000 by the American Cancer Society. *The News-Letter, Missouri Province*, *16*, 120-1 (1949).

## ST. PETER'S COLLEGE

On April 9, members of the Collins Chemical Society attended a regional convention of student affiliate chapters of the American Chemical Society at Upsala College in East Orange. Bus transportation was arranged. A senior student gave a paper on the Surface Tension of Milk. On March 2nd, Dr. John E. Snow of the Heyden Chemical Corporation spoke to the Collins Society on the Chemist in Process Development. *Pauw Wow, 16*, (10), 3 (3/11/49).

Mr. Frederick Jacques (faculty), Moderator of the Collins Chemistry Society A.C.S. Affiliate Chapter, has been elected President of the Alumni Association. Activities of the chemistry club include a trip to the Maxwell House Coffee Plant of the General Foods Corporation, regional meetings with affiliate chapters of other colleges in New Jersey and student demonstrations. *The Pauw Wow, 16* (8), 3 (1949).

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