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BULLETIN

of the

**American Association of
Jesuit Scientists**

Eastern States Division

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OF THE
THIRTIETH ANNUAL MEETING

August 28, 29 and 30, 1955

FORDHAM UNIVERSITY

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Bulletin of the American Association of Jesuit Scientists

EASTERN STATES DIVISION

VOL. XXXIII

OCT.-JAN. 1955-56

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NOTICE TO AUTHORS

Manuscripts are to be submitted to associate editors of the appropriate section and *may* be submitted directly to the editor in chief. Clear manuscript, preferably typed, with wide margin to the left, with double spacing between lines, is desirable. Please try to follow the typographical style of the most recent issue of the BULLETIN. Line drawings should be submitted on Bristol board, or similar material, and done in India ink. Figure number should be written on this in pencil. Titles for drawings, with figure numbers, should be typed on a separate sheet. Please try to minimize footnotes. Appended references and bibliographies, clearly so marked, should be done in the style of the A.A.A.S. publication, *Science*.

Program

Thirtieth Annual Meeting of the

AMERICAN ASSOCIATION OF JESUIT SCIENTISTS EASTERN STATES DIVISION

FORDHAM UNIVERSITY

August 28, 29 and 30, 1955

FIRST GENERAL MEETING

Sunday, August 28, 1955 at 7:30 P.M. in Freeman Hall

Address of Welcome

Rev. Laurence J. McGinley, S.J.
President of Fordham University

Business Meeting

PRESIDENTIAL ADDRESS: Radiation Chemistry

Rev. George J. Hilsdorf, S.J.

MEETINGS OF THE SECTIONS

CHEMISTRY SECTION

Chemical Effects of Neutron Irradiation of

Alkyl Iodides

George J. Hilsdorf, S.J.

Data on Stability of Standard Solutions

Albert F. McGuinn, S.J.

Ozonolysis of Phenanthrene

William Schmidt, S.J.

Studies of the Interaction between Stable

Molecules and Atoms

Robert Cloney, S.J.

A Magnetic Susceptibility Balance for

Student Use

Paul McCarthy, S.J.

MATHEMATICS SECTION

Methods in Advanced Calculus

John F. Caulfield, S.J.

The Transformation of the Definite Integral

under the Composition of Functions

Charles J. Lewis, S.J.

Note on Differentials

Stanley J. Bezuska, S.J.

Making Solid Geometry Three Dimensional Plane Geometry, the Scholastic Approach Neil P. McLaughlin, S.J.
Joseph A. Persich, S.J.

BIOLOGY SECTION

Historical Background of Certain Philosophical and Biological Problems Anthony J. MacCormack, S.J.
The Origin of Life Joseph P. Lynch, S.J.
Differences Between Animal and Plant Life John W. Flavin, S.J.
The Gene and the Atomic Bomb Michael P. Walsh, S.J.
The Counseling and Guidance of the Pre-professional Student George F. Lawlor, S.J.

PHYSICS SECTION

Symposium—Subsidized Physics Research Projects in Catholic Colleges

The Approach to Subsidized Research J. Franklin Ewing, S.J.
Subsidized Research at Boston College William G. Guindon, S.J.
Subsidized Research at Catholic University James C. Carter, S.J.
The Georgetown Eclipse Expedition of June 30, 1954 Francis J. Heyden, S.J.
The Gama-Ray Spectrometer John J. Kinnier, S.J.
Quadratic Stark Effect in Xenon Matthew P. Thekaekara, S.J.
The Geometrical Postulates of Quantum Mechanics Frank R. Haig, S.J.
Semiconductor Rectification James J. Ruddick, S.J.
Scintillation Counters Francis X. Roser, S.J.
Field Electron Microscope Francis X. Roser, S.J.
Shifts of Arc Lines in Magnetic Field at Various Pressures Richard A. Miller, S.J.

SECRETARY'S REPORT

FIRST GENERAL MEETING

The thirtieth annual meeting of the American Association of Jesuit Scientists (ESD) was called to order by Father George Hilsdorf, the president, at 7:30 p.m. on August 28, 1955. The meeting was held in Room 105 of Freeman Hall, Fordham University, New York City.

In the absence of Fr. George L. Drury, the secretary of the Association, Rev. John Kinnier was appointed as acting secretary.

Fr. Hilsdorf introduced Rev. Laurence J. McGinley, president of Fordham University who cordially welcomed the members of the Association in behalf of his community.

The minutes of the previous meetings held at Holy Cross Col-

lege, Worcester, Mass., were approved as printed in the BULLETIN. Fr. Hilsdorf appointed the following committees: Committee on Resolutions, Fr. Thomas Smith, chairman, Fr. Francis Heyden and Fr. Joseph Mulligan; Committee on Nominations, Fr. John Flavin, chairman, Fr. Joseph Persich and Fr. Arthur Coniff.

An announcement was made by the president concerning the decision of the executive committee to establish an office of Assistant Editor of the BULLETIN. Appointment to the office will be announced later. It was also announced that new sectional chairmen would be elected this year in the chemistry and biology sections.

Father Hilsdorf delivered the presidential address on the subject: Radiation of Chemistry. Following this address, there being no further business, Fr. Hilsdorf adjourned the meeting at 8.30 p.m.

FINAL GENERAL SESSION

The final general session of the convention was called to order by Fr. Hilsdorf at 9.30 a.m. Tuesday, August 30th. Fr. Hilsdorf took the occasion to express the sympathy of the members in attendance to Fr. Joseph Mulligan whose Mother died suddenly.

Fr. John McCarthy, editor of the BULLETIN spoke briefly, inviting the members to contribute to the bulletin. Especially desirable for publication would be preliminary research papers on problems now under investigation.

Fr. John O'Connor, the treasurer of the Association, gave the financial report, showing at this time a balance of \$1500.00 on hand.

The secretaries of the various sections electing new chairmen reported the results. Fr. Joseph Duke was elected chairman of the chemistry section and Fr. Rocco Belmonte, chairman of the biology section.

The report of the resolutions committee was presented by Fr. Flavin:

1. Be it resolved that the American Association of Jesuit Scientists (ESD) express its sincere gratitude to the Reverend Father Rector, Father Provost and the community of Fordham University for their cordial reception and gracious hospitality shown the Association during its meetings.
2. Be it resolved that the Association express its heartfelt thanks to Rev. George J. Hilsdorf, president, and to the other officers of the Association for their thoughtful generosity that made the meeting a success.
3. Be it resolved that this Association express its continuing appreciation of the work of Fr. John McCarthy, editor-in-chief of the BULLETIN.

4. Whereas this Association has, on the deaths of Fr. Thomas Love and Fr. Paul McNally, lost most loyal members and colleagues, be it resolved that the Association express its most profound regrets at this loss.
5. Be it resolved that the Secretary of the Association be instructed to send a copy of these resolutions to Rev. Fr. Rector and Fr. Provost of Fordham University and a copy of the resolutions on Fr. Love and Fr. McNally to their nearest relatives and to the Reverend Father Provincial of the Maryland Province.

This report was accepted with the unanimous approval of the members present.

The report of the nominations committee was called for by Fr. Hilsdorf. Fr. Smith reported the following nomination: for the office of President of the Association, Fr. John P. Delaney of the Maryland Province. After the nominations were closed, Fr. Delaney was unanimously elected to succeed Fr. Hilsdorf. The new president spoke briefly, thanking the members for this honor and indicating that the 1956 meeting will probably be held at Georgetown University, pending final arrangements and approval by superiors.

There being no further business, the meeting adjourned with a prayer at 10:15 a.m.

Respectfully submitted,

JOHN J. KINNIER, S.J.

Acting Secretary

Presidential Address

RADIATION CHEMISTRY

GEORGE J. HILSDORF, S.J.

INTRODUCTION

Radiation chemistry is *not* radiochemistry. It is not Radiology, or Radio-physics, or Radio-biology. We will take the next twenty minutes telling you what it *is*. Our purpose is to introduce the

members of this group to a field of specialization which has successfully appropriated the name Radiation Chemistry.

If you want to know the effects of high energy radiations on the tails of white mice the literature is readily available. Physicists have a very detailed knowledge of the surprisingly large number of kinds of such radiations and their sources. Everyone knows that there is nothing very new about the chemistry of the radioelements. But even the chemists, so trustingly using radioisotopes for tracing purposes, are not all aware that their energetic emanations may be producing reactions that may, or may not, interfere with the tracer reactions under study. The radiation chemist is concerned exactly with this problem, the study of the chemical changes produced as a result of high energy radiations. He asks the question: "what happens to molecules in the path of a gamma ray, or x-ray, or high velocity electrons, protons, neutrons, deuterons, helium nuclei, or recoiling atomic nuclei?". The number of answers so far is pitifully small and our scientific knowledge and understanding very imperfect. And yet, because these rays can polymerize molecules, change the properties of plastics, and even create new ones, because they can change the course of reactions and sterilize potatoes and frankfurters to say nothing of drugs, industry has gone all out in obtaining sources and building hot labs, and we can expect an era of peaceful subatomic bombardments. It is another example of industry going empirical and alchemical. The art can be used and industry is far from an intellectual snob.

PHOTOCHEMICAL ANALOGUE

To understand the chemical effects of high energy radiations it will help to recall what happens when *light* falls on molecules. This is the ordinary photochemical effect. As we know, before a molecule can react with another molecule upon collision, *one* of them at least, must be excited. That is to say, only those molecules containing an abnormal amount of energy can effect chemical change and only a few molecules obtain this energy from collision if the activation energy is normal and the temperature is low. Most chemical reactions require less than 100 large calories, or 4.3 electron volts per mole, for thermal activation. Now, molecules can be excited or activated by other means than a fortuitous number and kind of collisions. A photon of light of a particular energy content will be absorbed by a molecule attuned to that quantum of energy and the molecule will rotate or vibrate in an excited state. Several things may now happen. It may pass on this energy upon collision to other molecules as kinetic energy which will result in heat; it may vibrate

itself apart, or it may drop to a lower energy level by emitting a photon as fluorescence. Phosphorescence is the same phenomenon if there is a time lag. The important thing is, that by choosing light of proper wave length, one type of molecule in a system can be excited and, the light being absorbed quantum-wise, the number of primary chemical effects produced is equal to the number of quanta absorbed.

We would expect that radiations of the order of millions of electron volts, as compared to the 4.3 electrons volts needed for activation, would produce chemical effects quite different from those produced in photochemistry and follow laws very much more complex. High energy radiation is *not* absorbed in one unit, one quantum, but fritters away its energy along its path ionizing and exciting molecules of *all* types. X-rays and gamma rays eject electrons from matter with which they interact and it is the interaction of these electrons with the material in which they are produced which is responsible for the overwhelming portion of the chemical effects produced. The single molecule affected by the X or gamma ray in the first place makes an undetectable contribution to the total chemical change. Therefore, we are here concerned with the passage through matter of charged and uncharged particles of high velocity and the resultant chemical effects, if any. Charged particles interact for the most part with the electronic cloud, uncharged particles exclusively with the nucleus in a kinetic energy transfer process.

PASSAGE OF CHARGED PARTICLES THROUGH MATTER

An electron from a Van der Graaff generator with a typical maximal energy of 6 m.e.v. would penetrate a medium of density 1 about 3cm. Interaction with the molecules in its path is directly related to the charge on the electron and inversely to the velocity and distance of closest approach. That is, the slower the particle the longer it will be in the vicinity of the molecule and the more chance for energy transfer. This energy is transferred by displacing the electrons in the electronic cloud of the molecule. If it is sufficient, the electron is no longer associated with the parent molecule and a positive and somewhere else a negative ion-molecule is produced. A displacement of smaller magnitude results in excitation. All the subatomic charged particles act in the same way. Differences are due to their different velocities. A proton of equal energy to the electron above, for example, would be 43 times slower and consequently the density of ionization and excitation along its path is much greater. The average distance between successive ionized molecules may be 5 to 10 molecules for the proton but 100 to 500 along an electron

track. At the end of its path, of course, when its velocity is very much reduced, the electron will have about the same ionizing potentiality as heavy particles and as we would expect, low velocity electrons do not differ sensibly from more energetic heavy particles in producing chemical effects.

PASSAGE OF UNCHARGED PARTICLES THROUGH MATTER

The ultimate effect of neutron bombardment is also ionization and excitation, but the manner of production is quite different. As a result of a neutron impact with a nucleus, let us say a hydrogen nucleus in a water or hydrocarbon molecule, the proton will be displaced, either leaving its electron behind, with subsequent ionization, or possibly simply in another orbit-excitation. The nucleus thus ejected may have energies of the order of hundreds of thousands of electron volts and can in its turn eject other atoms from their normal positions in a sort of avalanche effect. Thus, one neutron may be responsible for the displacement of a large number of atoms. In the case of water, the protons ejected by initial neutron impacts are responsible for practically all the observable chemical effects obtained by neutron irradiation.

FISSION AND ATOM RECOILS

Very heavy charged particles, such as fission and atom recoils in radioactive processes, also produce ionization and excitation and consequently chemical effects. One very interesting application of this effect is the Szilard-Chalmers technique for isolating isotopes with high specific activity. For example, the manganese in solutions of potassium permanganate captures slow neutrons to become radioactive Mn^{56} with the emission of a gamma ray. The recoil from this gives the atom sufficient kinetic energy to break all its bonds. Dense ionization along its track leaves the radioactive atom in a different chemical state from its non-radioactive parent and the isotope Mn^{56} is filtered out as the insoluble manganese dioxide using ordinary filter paper.

CHEMICAL EFFECTS OF IRRADIATION OF PURE WATER

Since all living cells are between 85% and 92% water and since most biological suspensions are in a water medium, the chemical effects of high energy radiation on pure water should be of interest to the biologists. The ultimate products are hydrogen, oxygen and hydrogen peroxide. The oxygen is most probably due to the decomposition of the peroxide. Interesting as is the presence of these chemicals in the suspension medium, the intermediates formed in the

process are more important. As a result of the passage of a high energy electron, for example, positive water ions are formed by the displacement of electrons and these are surrounded by a negative water ion sheath. Water ions are in extremely unstable states and if their distance apart is greater than a certain magnitude these ions will react with water molecules to produce free hydrogen atoms, free hydroxyl radicals, hydronium ions and hydroxyl ions. These are strong reagents. The free hydrogen atom is an extremely strong reducing agent; the hydroxyl radical is an excellent oxidizing agent; and the hydronium and hydroxyl ions would be responsible for extreme local pH conditions of 0 and about 13.

It should not surprise us to learn, then, that it is commonly held that the lethal and other effects of radiation upon cells and biological suspensions of viruses, bacteriophage, chromosomes, etc., are really a poisoning of the entities by strong oxidants and reducing agents and extremes of pH rather than the result of their being the target of the radiations themselves. A hit in the water suspended biological entity itself is not necessarily effective. This "poisoning theory" as opposed to "target theory" is fairly well established. Over a wide range of concentrations the quantity of solute changed by a given dose of radiation is independent of the concentration and proportional only to the radiation dose.

Obviously then, the presence of a more easily oxidizable substance would be expected to shield from radiation damage a biological entity which is itself sensitive to oxidation. This has been found to be the case. One solute can effectively shield another from radiation even though both *alone* are sensitive. Sulfur containing compounds such as cysteine have already been demonstrated to increase many fold the lethal dosage of radiation in certain enzyme studies. This is an extremely interesting and fruitful hypothesis in the search for an internal medicine against radiation sickness. It is also no wonder that radiation sterilization of potatoes and frankfurters and other foods, while successful in killing bacteria, has not yet attained commercial success. Among other things, many of the proteins are sulfur containing compounds sensitive to oxidation and reduction. Neither the oxidized nor the reduced form of sulfur is very appetizing.

INDUSTRIAL APPLICATIONS

This month, however, August 1955, witnessed the first exploitation of radiation as a bactericide in the manufacture of drugs. The Upjohn Company, making use of a two million volt electron accelerator, began production-line sterilization of one of its products,

an eye ointment. A pencil-size beam is swept back and forth over traveling trays of the packaged drug. This method of sterilization has many obvious advantages, and, undoubtedly, intensive research is going on and will go on to extend its application. More real scientific knowledge of the process gained from carefully controlled experiments with simple molecules would speed success and eliminate costly, empirical, searches. But this is basic research, and it is only lately that industry has learned that it is approaching the stage where it can no longer count on a deep backlog of scientific knowledge. It was wishful thinking that the universities could keep far ahead.

It is in the field of plastics, rubbers, and chemical fibres that the immediate industrial future of radiation induced reactions seems most assured. The properties of styrene and methyl-methacrylate polymers are significantly changed when irradiated. While yet in low yield, new polymers, never before made, polyperfluoro-propylene, butadiene, and acrylonitrile, have been successfully made by irradiation techniques. Polyacetylene and ethylene have also been made with the same technique, the latter at 200°C and atmospheric pressure. Present methods require higher temperatures and extremely high pressures. Acrylamide has actually been polymerized in the solid state.

The predominant effect of radiation on polymers is cross-linking, which is due to the breaking of the carbon hydrogen bonds with subsequent formation of carbon bonds between molecular chains. Since the mechanism of polymerization is different a whole new range of polymers and plastics is forseen. It is envisioned that reactor-byproducts could serve for six months as high energy radiators and for about thirty years as a constant long-lived source for this purpose.

Probably the most interesting effect detected in research work in radiation chemistry is the phenomenon called "discomposition" in solids. Fast neutrons are capable of permanently displacing relatively light atoms from their lattice positions in crystals. The result is a change in properties. For example, graphite, exposed to intense neutron radiation, changes its heat conductivity, elasticity and electrical resistance. The radiation produced holes in the lattice become electron traps and these trapped electrons can be released when the solid is warmed or illuminated, as manifested in bleaching, thermoluminescence, conductivity or photoelectric emission. Since 75% of natural rocks show thermoluminescence because of the irradiation they received during geological time from traces of radioactive material present, it has been suggested that the property could be used in the correlation of strata, rough estimation of the age of rocks, and the detection of uranium in rocks.

Very dim patterns are beginning to emerge from the limited studies of the chemical effects of radiations on organic compounds. It is already pretty clear that radiation certainly does not break bonds indiscriminately as appeared at one time but acts as a reasonably selective agent.

CONCLUSION

In this "year one of the peacetime atom" as it has been called at Geneva, and in view of the accompanying publicity, we should remember the words of one of the conference's participants. "I think we must be near the peak of the decibel curve. The curve of technological progress is, as usual, rising more slowly". But judging from the number of industrial companies having and applying for irradiation sources, Van der Graaff accelerators, cobalt sixty, X-ray machines, and even cooperative management of reactors for research purposes, we can expect a rapid growth at least in qualitative data of the chemical effects of radiation. Industrial application of photochemistry have been disappointingly meagre. Perhaps a brighter industrial future is in store for radiation chemistry.

Chemistry

DATA ON STABILITY OF STANDARD SOLUTIONS

(Abstract)

ALBERT F. MCGUINN, S.J.

The changes in normality of 0.2 N solutions of HCl and NaOH in a one year interval were reported. Storage of NaOH solutions in polyethylene bottles preserves them intact. In glass, the normality of NaOH solutions increases when exposed to laboratory air through a soda lime tube. The HCl solution exposed to the air, without any protective tube, also increased in normality. In both cases, the change in normality was significant for any exact quantitative analysis, but would be insignificant for reuse of the solutions as 0.2 N for other purposes.

STUDIES OF THE INTERACTION BETWEEN STABLE MOLECULES AND ATOMS

(Abstract)

ROBERT D. CLONEY, S.J.

This paper was a report on some theoretical work in Chemical Kinetics recently conducted at the Catholic University of America. The molecular orbital method of calculation has been applied to the interaction between simple closed-shell species. The molecular orbitals are used to construct correlation diagrams from which mechanisms are predicted and reasonably accurate activation energies are calculated. This method yields good qualitative insight into the activation process and accurately predicts the relative activation energies for the interaction between two closed-shell molecules, a molecule and a radical, and two radicals.

A MAGNETIC SUSCEPTIBILITY BALANCE FOR STUDENT USE

(Abstract)

PAUL J. MCCARTHY, S.J.

A magnetic susceptibility balance similar to that of Schuler¹ can be easily assembled with little expense if an analytical balance and a magnet of several thousand gauss are available. Such a balance is useful for measuring paramagnetic susceptibilities and magnetic moments. The latter can be measured with an accuracy and a precision of about 2%. Diamagnetism can be readily detected, but can be measured with less accuracy due to the smaller magnitude of the effect.

1. R. Schuler, *J. Chem. Education* **27**, 591 (1950).

Mathematics

MODELS TO MAKE SOLID GEOMETRY THREE DIMENSIONAL

(Abstract)

NEIL P. McLAUGHLIN, S.J.

For many years, I have been told, teachers of solid geometry have been looking for an easy method of building models of the theorems. The practical value of such models as a teaching aid has never been questioned. But how to make them? Many of my listeners at the recent Jesuit Science Convention at Fordham University

thought that the method I am about to outline answered that question of "how" in a striking manner.

The method is to use a department store item that goes by the name of *Tinkertoy*. This toy is made up of a number of one-quarter inch dowels of different lengths e.g. 8"; 5"; 3"; 2"; 1". Connecting pieces also come along with each set. These are mainly of two types. One type is cylindrical in shape and $1\frac{3}{8}$ " long. It has a hole at each end for the insertion of the dowel sticks. The other is button shaped, $1\frac{3}{8}$ " in diameter and $\frac{5}{8}$ " thick. This has eight holes around the side circumference set at 45° angles to one another, and another hole drilled completely through the center of the top and bottom.

By means of two sets of *Tinkertoy*, costing last year \$3.00 each, I was able to build a model for eleven different theorems. Nine of these were from the section of Solid Geometry which dealt with lines and planes. One was from the section on cones, and one was from the section on spheres. In addition to the *Tinkertoy*, I used large pieces of cardboard for the planes, scotch tape to connect the sticks at irregular angles, and a bit of stiff aluminum wire to form curved lines.

The main features which make *Tinkertoy* models such a valuable aid are these. The models made Solid Geometry very easy to teach. They stimulated great student interest in a fairly difficult subject. The initial cost was low. Longer sticks could easily be added to the set by obtaining strips of $\frac{1}{4}$ " dowel from a lumber yard. And lastly, the construction of the models was so easy, modification and dismantling was so simple, that it was a joy to use them. Many times I started with just a vague idea and kept fitting and adjusting and modifying until I had exactly what I wanted.

If some of my readers think this may be of help to their teaching, please take a look at a *Tinkertoy* set. I assure you that in one look you will be able to see much more of the innate usefulness than my words have been able to describe.

TRANSFORMATION OF THE INTEGRAL OF A FUNCTION OF ONE REAL VARIABLE UNDER A COMPOSITION OF FUNCTIONS

(Abstract)

C. J. LEWIS, S.J.

If f is a differentiable function on a domain of real numbers, then it is permissible to write

$$\Delta f = A\Delta X + a(\Delta X)$$

where A is a real number, the value of f' at the point x of the domain, where ΔX is a finite increment at the point, and where $a(\Delta X) \rightarrow 0$ as $\Delta X \rightarrow 0$, and is continuous there. Should the teacher of the calculus wish to prepare his students for the reading of physics manuals by

introducing the differential of f , then let the differential f at the point x be defined

$$df = f'(X) \Delta X$$

The differential is what is called the linear part of the first expression. That is, the contribution to Δf of $a(\Delta X)$ (sometimes referred to as "terms of higher order" when there is a Taylor series expansion of f at x) is disregarded. df is, of course, linear in ΔX at the point x . This banal fact occasioned the historical misnomer of calling $f'(x)$ a differential coefficient. The teacher should emphasize the fact that if f is a differentiable function of one variable (Weierstrass variable), then df is a function of two variables, the variable x at which f' is evaluated, and the independent variable ΔX . More generally, if f is a differentiable function on a domain of n variables, then df is a function of $2n$ variables. The teacher must also emphasize the meaninglessness of talk about the differential of the independent variable. Some texts still bother to "prove" (and often without the introduction of the identity function) that $\Delta X = dx$, and then write

$$dy = df = f'(x) dx.$$

If dy is a differential, surely dx is *not*. dx is, here, a finite increment, a real number. And dy is a function, indeed a function of two independent variables.

The above matters should be insisted upon, with clarity and vehemence. For later, when the teacher writes the expression for a primitive of f (also called an indefinite integral)

$$F(t) = \int_a^t f(x) dx$$

or the definite integral of f with lower limit a and upper limit b ,

$$F(b) - F(a) = \int_a^b f(x) dx$$

then equal insistence must be placed upon the fact that dx is, here, an *incomplete symbol*. It is neither a finite increment, nor a differential, nor — to use a word that should not even be mentioned — an "infinitesimal." History has visited the calculus with confusing and ambiguous symbolisms and notations. They have led to confusion of ideas. A teacher must either resign himself to the ambiguity of symbols and insist on the distinction between ideas, or he can join forces with Karl Menger (see his *Calculus, A Modern Approach*, surely the most original and brilliant contribution to the library of calculus texts in several decades) in his advocacy of reform.

For many a student, the storm's eye of confusion is reached when there is a composition of functions $h = f \cdot g$ properly defined, and either of the above integral expressions is to be transformed. The procedure is often called "change of variables" with little insistence placed upon the conditions for the validity of the change. For example, one writes

$$\int_{g(c)}^{g(d)} f(x) dx = \int_c^d [f(g(s))] g'(s) ds$$

In this case, what was formerly regarded as the independent variable, x , on the domain of definition of f , is regarded now as a function of s , variable on the domain of g : $x = g(s)$. The student is told that

$$dx = g'(s)ds$$

and indeed the differential dx may now be referred to (if x is a differentiable function on the domain of g) without utter nonsense. But the dx on the left side of the expression immediately above is surely not the dx of the expression second above. The latter is an incomplete symbol; the former is a function of two variables. And more surely, the proof of the validity of the transformation formula does not lie in the fact that one can write $dx = g'(s)ds$.

The valid proof of the transformation of the integral is/terms of function and primitive of function. The mathematician can and should emphasize primitives and their role in the theory of the calculus. The emphasis is just a consistent counterpart of the well-known observation that mathematicians prefer derivatives where physicists prefer differentials.

Biology

THE ORIGIN OF LIFE

(Abstract)

JOSEPH P. LYNCH, S.J.

The Russian biochemist A. I. *Oparin* has been for some thirty years a student of the Problem of the Origin of Life. He has worked out a theory of Chemical Evolution which he thinks preceded the Evolution of Species.

In summary his Theory is as follows:

The Earth became a planet when a cosmic catastrophe resulted in a vast mass of gases flung off from the Sun.

All elements were in this mass. The Carbon was in two-atom molecules even at the Sun's surface. Later cooling made the molecules larger.

The Carbon fell through the Earth's gases to the heavy metals at the core as Carbon Rain or Carbon Snow, one might say.

Carbides were formed particularly with Iron.

Then the igneous rock crust of the Earth formed, dividing the molten core from the Steam Atmosphere. Tides due to gravitation of Sun and Moon sloshed around the molten material within crust and the insufficiently rigid crust cracked in many places. Carbides came

out with other materials. In the Superheated Steam the Carbides reacted with Ammonia which by that period had appeared on surface.

There was originally no oxygen gas nor nitrogen gas in the Earth's atmosphere.

Reactions and interactions occurred with the iron and other carbides and the ammonia and the oxygen and hydrogen of the steamy water. Thus Hydrocarbons were formed. They went into colloidal solution wherever there was liquid water. Result was a thin hot soup.

With further reactions these colloidal solutions formed semi-liquid gels with membranous walls.

Then natural Selection began with competition for growth and survival.

Those successful eventually became very complicated, balanced and intricately organized tiny masses, developing gradually the newly appeared capacity for self-maintenance, growth and eventually reproduction.

Thus appeared the primary organisms, the antecedents and generators of what eventually became the viruses, genes, bacteria, protozoa and ultimately our current flora and fauna.

Oparin thinks that at some remotely future date organisms will be successfully synthesized in the laboratory. But first our knowledge must be vastly increased, particularly in the fields of Proteins, Protoplasmic Organization and Enzymes.

Oparin's ideas on Chemical Evolution are well received in scientific circles. An interesting three and one-half page summary and comment is also included in the "TEXTBOOK OF EVOLUTION" by Professor DODSON of Notre Dame University.

Oparin's book "THE ORIGIN OF LIFE" is available in its second English edition (1953) from Dover Publications, New York, at \$1.70 paperbound and in boards for a dollar or so more.

THE ATOM BOMB AND GENES

(Abstract)

MICHAEL P. WALSH, S.J.

Much has been written recently on the effects atomic radiations might have on future generations. There are two extreme viewpoints proposed by some individuals but not supported by geneticists. There are those who claim no harmful genetic effects will result from fallout or from the Hiroshima explosions. Others tend to exaggerate the dangers of atomic energy by referring to the monsters that will result. From studies made so far on Hiroshima victims nothing conclusive can be stated. Geneticists know that radiations induce for the most part harmful mutations in mice and fruitflies and that doses of radiation accumulate in the testes and ovaries and hence there is no threshold value below which radiations are ineffective on these organs.

No startling abnormalities have been observed in the first generation of Hiroshima survivors. Very likely mutations due to atomic explosions or fall-out from test explosions will be lost to sight as they are absorbed among the many mutations that occur naturally in each generation. Many mutants will not survive or reproduce themselves in future generations. The number of mutations that have been caused by test explosions through fall-out in the 10,000's which is a very insignificant figure for a population of 160 million.

However with future expansion of the use of atomic energy in medicine and industry, layers of mutations could be superimposed on each generation and ultimately produce a noticeable effect on some subsequent generation. There are a few moral, social and political implications that can be settled only by carefully controlled studies on the dangers of radiation to genes in humans.

Physics

THE APPROACH TO SPONSORED RESEARCH

(Abstract)

J. FRANKLIN EWING, S.J.

Usual meaning in which I use word "Research" very broad, includes any scholarly, creative activity. Thus, investigation of better methods of teaching a subject, included. Here, word used in somewhat narrower sense; specifically, those projects for which monetary support can be obtained. Usually means research yielding new knowledge in field (but such things as teaching methods not excluded).

For the past two years the Group Discussion of Deans, at the Conference on Cooperative Research, held here at Fordham, estimates that only some 10-15% of faculty now ready or fit for formal sponsored research. Percentage should be higher among a group of physicists.

Difficulties against sponsored research: lack of time, lack of equipment, lack of student help; distaste for being tied down to a narrow project-field; paper-work involved.

Advantages:

- (1) Stimulation of teacher, enrichment of his professional life.
- (2) Stimulation of students, whether employed in project or not.
- (3) Prestige of institution.

- (4) Attraction of better students, particularly graduate.
- (5) Rare equipment may be bought, beyond normal budget of institution.
- (6) Possible enrichment of faculty (in two senses) by salaries involved.

Proposals for grants. Method of making proposals summed up in accompanying brochure, "How to Make Proposals for Grants-in-Aid." This brochure written for Fordham situation, but general principles the same all over. Note however, if there is no one man appointed to administer research grants, you should check budget with Treasurer's office, and your proposal should be signed by an official of the institution (usually the President). Grants are not made, with rare exceptions, to individuals, but to institutions.

Sources of funds. Four classes:

- Government (National Science Foundation Particularly)
- Armed Forces (Office of Naval Research the best)
- Foundations (Rich Associates, or JFE)
- Business (your contacts)

Suggest cooperation in this matter; possibly news about possibilities and projects to be circulated by Secretary?

- Reference to new book on Foundations:
American Foundations and Their Fields.
Wilmer Shields Rich. 7th Edition.

American Foundation Information Service, New York, 1955.
\$30.00.

SUBSIDIZED RESEARCH AT CATHOLIC UNIVERSITY (Abstract)

MR. JAMES C. CARTER, S.J.

This talk might be entitled: "In Which What Has Gone Before Is Confirmed by Some Examples." The preceding papers have adequately covered the general aspects of subsidized research. This will be a report based on interviews with various people engaged in sponsored research at Catholic University. It will cover in some detail the problems being investigated, the size of the grants, the type of personnel being employed, and the manner in which several of the contracts were obtained.

In brief, the contracts may be outlined as follows:

<i>Agency</i>	<i>Principal Investigator</i>	<i>Problem</i>
Office of Naval Research	Dr. Henderson	Ultrasonics in gases
	Dr. Griffing	Molecular Orbitals

Office of Ordnance Research	Dr. Litovitz	Ultrasonics in liquids
Air Force	Dr. Byrne	Spectra of certain polyatomic molecules
	Dr. Pulvari	Electronic memory devices
Naval Bureau of Ordnance	Staff	Confidential
Atomic Energy Commission	Dr. Rice	Free Radicals

This list is not complete. It stresses those projects of interest to the physicist.

SPONSORED RESEARCH AT BOSTON COLLEGE

(Abstract)

WILLIAM G. GUINDON, S.J.

1. Purposes of Research
 - a. Search for knowledge — fundamental aim of University
 - b. Intellectual life and growth of professional staff
 - c. Elevation of lectures and of thesis research
 - d. Stimulation of student interest and activity
 - e. Physical growth of University
 - f. Improvement of reputation of University
 - g. Attraction of top-flight staff and students
2. Need for Sponsorship: Financial Aid to University
 - a. Provision of apparatus, supplies, and time (salaries) for staff research, and for thesis projects
 - b. Expansion of University's facilities, apparatus, etc.
 - c. Provision of higher caliber graduate students by means of assistantships
3. General Observations
 - a. Projects must be of interest to staff, within their capabilities and experience
 - b. Government vs. Industrial vs. Foundation grants and contracts
 - c. University's part in sponsored research (preparation, support, etc.)
4. Some Experiences at Boston College
 - a. OOR Project: Ultrasonic Absorption in Liquids
 - b. Research Corporation Project: —C=N— stretching Vibration
 - c. American Academy Project: Gamma-Gamma Angular Correlation

- d. Projects in other Departments: Biology, Chemistry, Mathematics, C
5. Practical Reflections
 - a. Evaluation of research facilities (staff, technicians, apparatus, shops, space, supplies)
 - b. University contribution (staff time (salaries), apparatus, supplies, secretarial and technical aid)
 - c. Financial problems (salaries, overhead, supplies, accounting)
 - d. Other problems (renewals, reports, performance)

THE FIELD-EMISSION MICROSCOPE

(Abstract)

FRANCIS X. ROSER, S.J.

When a strong electric field is created at the surface of a metal, the potential well existing there, on account of the image force, is lowered in height (Schottky effect) and shaped into a form of thin barrier which measures only a few Å in thickness at the Fermi level of the conduction electrons in the metal.

Since the energies corresponding to that level endow these electrons with de Broglie wave lengths of the same order, the quantum mechanical effect of their tunneling through the barrier (Nordheim's theory of cold or field-emission) affords a possibility of obtaining extremely high emission densities which (differently from Richardson's formula of thermo-ionic emission) are independent of temperature. High field strengths (10^7 to 10^8 V/cm) and enormous current densities (10^4 to 10^6 Amp/cm²) can be obtained, practically, on surfaces of an extremely reduced radius of curvature.

Electron microscopy arose when it was recognized that electrons, like all matter, have wave properties and that they can be treated in close analogy to light waves in optical microscopy. In the field-emission projection microscope, cold emission offers a new possibility to do it (E. W. Mueller: *Z. Pb.* 126, 642, 1949; *Z. f. Naturf.* 5a, 473, 1950; *Z. Pb.* 131, 136, 1952).

On applying several kV between the tip of an ultra-thin tungsten wire ($r = 0.1$ micron) and a concentric fluorescent screen ($R = 5$ cm) coated on the inside of an highly evacuated bulb, electrons given off by cold emission are accelerated in straight paths along the field lines from tip to screen. In this way, geometrical amplification, equal to the ration R/r , is achieved and increased further (5 to 10 times) owing to the particular (spread out) configuration of the field at the surface of small objects adsorbed on the tip. Amplification factors of several millions can be reached.

Due to the fact that the emission density varies so enormously with field-strength and radius, according to the formula of Nordheim-Fowler, features of the crystallographic structure of the tip, as well

as molecules and atoms adsorbed on it, become distinctly visible in form of bright spots on the fluorescent screen (field-electron microscope).

Objects of such extremely small dimensions would never be detected with the conventional (transmission-type) electron microscope owing to their transparency to fast electrons. In addition, the resolution of such microscopes cannot be increased for various reasons of construction properties (electrostatic and magnetic focusing, apertures, etc.) very far beyond 40 Å. The resolving power of field-emission microscopes, on the contrary, is solely limited by diffraction and tangential velocities of the electrons emitted from the tip which spread out the image points into small circles bound to, eventually, overlap. A resolving power of 10 to 15 Å has been obtained.

By reversing the field, all atoms adsorbed on the tip become highly polarized and are torn off the surface, at properly increased field strengths of the order of $3 \cdot 10^8$ V/cm, in form of ions (field desorption). Due to the shorter de Broglie wave lengths of these ions and to their considerably lower tangential velocities, much higher resolution (2.9 Å in the case of H-ions) can be achieved (field-ion microscope). Cooling the device with liquid air and thus diminishing thermal agitation further, an ultimate resolving power of 1.7 Å has been reached.

THE GEOMETRICAL POSTULATES OF QUANTUM MECHANICS

(Abstract)

FRANK R. HAIG, S.J.

The rules of correspondence between the physical situation in quantum mechanics and the mathematics needed to describe it are not as simple as in a classical dynamical problem. An attempt is made to present these rules in respect to state vectors, Hermitian operators and their eigenvalues.

SEMICONDUCTOR RECTIFICATION

(Abstract)

J. J. RUDDICK, S.J.

Semiconductor rectification occurs in two types of device, the metal-semiconductor contact and the p-n junction. The former is explained in terms of the injection of minority current carriers from the metal contact into the base semiconductor. The rectification occurring at p-n junctions depends on the development of a potential barrier between the two sections of the single crystal. It is likely that this latter process is actually the more fundamental for it has been shown that point-contact rectification does not occur on uncontaminated surfaces of germanium.

GAMMA RAY SPECTROMETER

(Abstract)

JOHN J. KINNIER, S.J.

The construction of an instrument for determining gamma ray energies and intensities, sometimes called a gamma ray spectrometer, followed shortly upon the development of modern scintillation counters. Radiation incident upon a phosphor, such as thallium activated sodium iodide or anthracene, transfers the whole or part of its energy to the individual molecules within the phosphor by three processes, the photoelectric effect, the Compton effect and pair production. The energy thus absorbed in the phosphor through luminescent conversion appears in the emission of photons which being absorbed at the cathode of the photomultiplier tube give rise to a voltage pulse at its anode. Analysis of the pulse height distribution and the location of triads of peaks due to the photoelectric effect, Compton effect and pair production processes leads to a determination of the incident gamma ray energies once a calibration of the scintillator has been established.

RECENT ADVANCES IN THE DETECTION OF HIGH ENERGY PARTICLES

(Abstract)

FRANCIS X. ROSER, S.J.

While thick photographic emulsions reveal the tracks of high energy ionizing particles in the form of sensitized solid grains (thus permitting an exact determination of their momenta, charges, and masses), they are greatly limited in usefulness when a time determination of events or a coincidence measurement is required. In the various forms of cloud chambers this limitation is overcome by means of coincidence circuits, triggering the expansion mechanism of these chambers. Other limitations, however, (as long recycling processes, low stopping power, kinetic and thermal distortion of tracks, high background) have to be taken in exchange, as inherent in the very nature of cloud chamber operation.

Along the line of successive evolution from gas filled cloud chambers (C.T.R. Wilson 1911) to the liquid filled bubble chamber (D. A. Glasser 1952) and the luminescent chamber (E. K. Zavoiskii et al. 1955), these shortcomings have been eliminated to a great extent. As the amount of mechanical work necessary for operation has been gradually reduced by passing from cloud to bubble chambers and entirely substituted by electronics in the luminescent chamber, the recycling periods became increasingly faster and the sensitive time, if needed, could be made substantially shorter. Absence of track distortion and of background thus resulted. Even the high stopping power of the emulsions, only precariously achieved in high compres-

sion cloud chambers, could be brought back again in the bubble and luminescent chamber with the added advantage of negligible Coulomb scattering, of uniform substances and (in the case of liquid hydrogen bubble chambers) of a pure proton target at disposal.

Varia

RESEARCH IN THE CHEMISTRY DEPARTMENT

B. A. FIEKERS, S.J.

We are often asked to describe research activity in the Department of Chemistry at the College of the Holy Cross. So this notice should serve as a basic and general reply.

Research in physical chemistry deals largely with the process of crystallization of solids from solution or from the melt. It includes the study both of nucleation and of growth. Surface phenomenon, reaction rates, thermodynamic considerations, analytic and synthetic devices, all of which may be incidental to this program, are necessarily included. For example, the study of the crystallization of sugar from syrup by sonic and ultrasonic methods has, with the cooperation of the Physics Department, been carried on in this department over the last ten years. Dr. Andrew VanHook, an eminent leader in the field of crystallization theory and practice, directs this program.

Another topic in physical chemistry, directed by the Reverend Joseph A. Martus, S.J., deals with the determination of stability constants of chelate structures. His work, and that of co-workers, in the past has dealt mainly with the chelates formed by common transition metals and amino, thio and hydroxy organic acids.

Research in organic chemistry is manifold, including both synthesis and analysis. Favored syntheses include Diels-Alder-Diene adducts from solutions and the production of ligands for chelation. Analytic work is devoted to the estimation of mono and di-saccharides by a modified Somogyi method. Dr. Olier L. Baril directs research in organic chemistry.

Many of these projects have enjoyed the support of the Sugar Research Foundation, the United States Department of Agriculture, the Ordnance Department of the United States Army and the Bersworth Company.

Candidates for the Master of Science degree in Chemistry carry on this research with their directors. Normally their candidacy is of one year's duration and at least one full day per week is spent in research.

The author carries on shorter research projects, notably the characterization of acid derivatives for qualitative organic analysis and the development of basic techniques for undergraduate training. All staff members assist in directing shorter undergraduate research theses. On occasion funds have been made available for summer work in substantial support of the complete program. Departmental publications exceed eighty in number. Lists of these are available on request.

A "MAGNA CHARTA" FOR THE CHEMIST*

BERNARD A. FIEKERS, S.J.

What the Bill of Rights is to the common man, *Das Kapital* to the Communist, and the *Ratio Studiorum* to the Jesuit teacher, that the Periodic Table of the Chemical Elements is to the Chemist. For, it is the principle and foundation in which all known developments in his science are synopsized, from which new ones are prophesied, and to which revolutionary ideas are ultimately referred. It is the chemist's alphabet, his *alpha* and *omega*, his chemical testament, his table of sums and products, of differences and quotients, his very Constitutions and all of the amendments.

The recent construction of such a periodic chart of the chemical elements on wall tile in the larger lecture room of the Chemistry Department is a monument to the organized teaching of chemistry at the College of the Holy Cross for well over half a century. Its eight by eighteen foot dimensions encompass the beautiful realization of the dream of the beautiful realization of the dream of the Jesuit chemistry professor, such as no doubt would win the approval of Fathers Sullivan, Langguth, Strohaber, Ahern, Coyle and Wessling, were they alive to see and use it. May it survive for centennials!

What could be the world's largest production of this kind is mounted over the blackboard of the two-storied wall at the front of room 19 in O'Kane Hall. With a great deal of color to it and well lighted, it fits gracefully into its surroundings. It lends functional beauty to impress the mid-twentieth-century student of chemistry with the belief that the atom is here to stay. He is brought face to face with its full symbolism in his daily classes. If he has

* Reprinted from the Holy Cross *Hormone*.

any misgivings about its destructive power in modern times, he can join this belief with his faith in *the sign that conquers*. For, in the open spaces at the upper levels of this chart there stands the Cross itself above the element cobalt, thirty by twenty-two inches, and two and a half inches slender. At the very base of the chart, beneath this cross, the dreaded element plutonium is located, an eventual conquest for *the sign of the Crusader*. In more than one sense is it then a *Magna Charta* to liberate men from fear of the invisible atom.

This chart was finally made possible through the co-operation of many contributors. To the chairman's brother, Edmund J. Fiekers of Duratile of Ohio in Fremont goes credit for generously donating the materials. To the Reverend J. Gerard Mears, S.J., Chairman of the Art Department at the College, credit is due for his patient, enthusiastic and beautiful work of hand-lettering the ten by ten inch plates with the symbols of the elements and the necessary numerical data. The Chairman of the Chemistry Department designed the work and directed its construction, not without benefit of the generous aid of maintenance officials and college workmen. Enthusiastic encouragement from students and staff alike is also acknowledged. To the Reverend Francis A. Hugal, S.J. of the College Faculty credit for photographic work is duly given.

Duratile is a zinc bordered sheet steel material that has been spray-painted and baked to produce tiling material in a variety of exquisite tints and colors. It is attached to a sealed wall surface with mastic. Thus it has a certain degree of flexibility under temperature changes and is not subject to the danger of cracking and crazing commonly encountered with ceramics. It is easily washed and polished. Though it is damaged only with difficulty, individual tiles can be replaced with relative ease. This is an attractive feature in that it reduces worry about changing atomic data, new elements, such as Einsteinium (Z99), Fermium (Z100) and Mendelevium (Z101), as well as renamed elements. With such material, the ancient art of tessellation becomes modern and functional.

The borders of this chart are done in black tile, two and a half inches wide; the black divisions between the elements are mostly of five-eighths inch width. While most of the symbols of the solid elements appear in black lettering on white tile, those of the liquids appear on powder blue, and gases are allotted yellow tile. Symbols for the lanthanide and actinide series, however, are done in deeper maroon on peach colored tile. Roman lettering was used. Unmarked tiles, employed for fill, are generally in white, with color patches to break the monotony of the white, as suggested by tinted

insertions in leaded glass windows. All atomic numbers are painted in red; atomic weights, generally to four significant figures, appear in blue. The technical notation, of a subscript to the left of the symbol, for atomic numbers; and of a superscript to the right, for atomic weights, has been followed throughout. This mural was set up in sections on plywood (five-eighths inch) in the belief that it will eventually have to be moved to new locations. Glass wax was used for producing a polished finish.

The so-called long form of the periodic table was selected as likely to be in vogue for the longest time. Thus the tempting luxury of overloading the symbols with secondary data was everywhere eschewed. Fanciful tiling designs were even rejected in order to emphasize its stern functional demands.

NEWS ITEMS

The Physics Department of St. Joseph's College announces a course in the "Physics of Transistors" to begin in September. The course will consist in one lecture a week from 7:15 to 9:00 P.M. for two terms. The subject of the course is the physics of semiconduction and its application to transistor electronics. The purpose of the course is to aid engineers, physicists and chemists in bridging the gap between the theory and application of semiconductors. Among the topics covered are experimental properties of semiconductors, theory of the solid state, Germanium and Silicon, the point contact transistor, the p-n junction, transistor electronics. The text used is "Electrons and Holes in Semiconductors" by William Shockley, D. Van Nostrand Co. Parts I and II. The course will be given by Dr. C. J. Kriessman of the Physics Department and Remington Rand.

Three seniors of St. Joseph's College were awarded National Science Foundation Fellowships for graduate study at schools of their choice. Of the total of two hundred ninety-six pre-doctoral grants, sixteen were given to students of Catholic colleges and universities. Among the Catholic schools, St. Joseph's was second to Notre Dame which received four. Last year an award was made to a student at St. Joseph's, who is currently studying physics at the University of Pennsylvania. The awards this year went to one chemistry major and two physics majors. All three are graduates of Catholic high schools, two from St. Joseph's Prep. Under the provisions of the grants, they will be provided with first year stipends of fourteen hundred dollars each and the tuition costs at the school at which they elect to pursue their studies. Two other physics majors received honorable mention.