S.J.B

A. M. D. G.

BULLETIN

of the

American Association of Jesuit Scientists

(Eastern Section)

For Private Circulation

Published at

LOYOLA COLLEGE

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EASTERN STATES DIVISION

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THE CONCEPT OF SPACE IN SUAREZ AND EINSTEIN

James W. Ring, S.J.

Space and time, notions that are in common use and familiar to average persons, prove themselves very elusive when subjected to analysis. St. Augustine said that he knew what time was until someone asked him about it and then his ignorance manifested itself. Space is very much the same as time in this respect. In fact there are over one hundred recorded opinions on space,—all different. This being the case, it is interesting to find a marked similarity in the concepts of Suarez and Einstein, two men whose view points on the physical world would seem to be so radically different.

This paper makes no pretensions of an elaborate and intensive survey of the doctrines of both these men. It merely attempts to present a comparative study of the concepts of space in Einstein and Suarez, prescinding entirely from the further epistomological questions implied in modern scientific theories.

The traditional Scholastic doctrine as enunciated by Suarez is, that space is a figment of the mind with a foundation in fact. Or to put it in the usual Scholastic fashion, space is an "ens rationis cum fundamento in re". Space as such does not exist, but is conceived as if it were something real. It is not a pure creation of the mind, a mere subjective form of thought; it has a basis and foundation in the fact that material bodies have a property or quality called extension, in virtue of which, as we say, they occupy space. Imaginary space is that which is conceived as being merely a capacity of receiving bodies. Real space, on the other hand, is that part of imaginary space which is actually occupied by a body. This latter space is called real by extrinsic denomination, that is, by reference to the real body which here and now occupies it. Hence no reality formally corresponds to space as such. But let us see how the concept of space itself is derived.

Space is accepted as meaning just what it vulgarly conveys to the average person; this much we have at the very beginning of our inquiry. It is evident that space is distinct from various bodies which are present to our senses. Before us we have a three inch cube; we see it and feel it. One end is a certain distance from the other end. We derive the concept of extension. Now we move the cube and what have we done? We have created a vacuity of a sort. Concerning ourselves only with the twenty-seven cubic inches of this cube we have created a circumscribed emptiness of twenty-seven cubic inches. Likewise, the cube in its new position occupies a new space, so to speak, to the extent of twenty-seven cubic inches. Suarez says, "We confess that this space, according as it is distinguished from bodies, is not a created thing because it is not a reality, but it is rather a certain vacuity." (cf. Suarez M.D. Ll, Sec. 1, N. 23). We conceive this vacuity or emptiness as that which is capable of receiving extended bodies. The emptiness which was unoccupied before we moved the cube, now, as it were, contains the cube. The circumscribed emptiness therefore is a particular space. Since it is not a reality it must be a creation of the mind. However, this particular space is not a pure figment of the mind, it is rather an emptiness conceived as something real because of the extension of the cube which occupies it. "It seems to me that space is a figment of the mind, not however, a pure figment such as impossible beings, but with a fundamental drawn from the very bodies which, because of their extension are suitable for constituting real spaces." (cf. Suarez M.D., Ll Sec., 1 N. 24)

By a similar process we derive from other extended bodies the notion of vacuity and by prescinding from the particular dimensions of these bodies we arrive at the concept of a void capable of receiving any and all extended bodies. Hence we have a universal idea of space. By the privation, therefore, of extension we derive our concept of space as that capacity for receiving bodies. Suarez sums up by saying, "That space, according as it is distinguished from bodies containing space and contained by space, is, in reality, nothing, because it is neither a substance nor an accident, nor it is something created and temporal, but it is something eternal. And although it is understood as a capacity for receiving material bodies, it is not however in itself a real, passive capacity. Of itself it implies a non-contradiction; but in the extended bodies there is understood a certain capacity for occupying such space." (Suarez M.D., Ll Sec. 1, n. 12) So much for the Suarezian concept.

Einstein derives his concept of space by a similar process. It is evident that space is not a reality which can be apprehended directly by the senses. If it were, it would necessarily be something concrete and determined. Einstein is fully aware of this for he says "Now as regards the concept of space, this seems to presuppose the concept of a solid object." (cf. "The World As I See It," pg. 84) A solid object has three dimensions and it's concept is formed by sensations of touch and sight. This concept of a solid is absolutely free and independent of space, nor does it in any way presuppose space. But the intellect is not satisfied with the mere knowledge that a solid object exists, it desire to know where this body is and what relation it bears to other solids. This leads to the formation of concepts which correspond to spatial relations. Let us illustrate.

Two solid cubes of equal size touch one another. We say that they bear a relation of contact or adjacency. Now we separate these two cubes without changing the cubes in themselves and a distance intervenes. The solids thereby bear a relation of distance to each other. This spatial relation, according to Einstein, is as real as the bodies themselves. We admit the real relation. The interval between the cubes may be filled by a third cube. Thus we can insert between cubes A and B, a cube C. In fact we can fill this interval with succesive cubes D, E and F. In this case the cubes C, E, D and F are said to have an 'equal value' for the filling of this interval, and likewise they have an 'equal value' for the filling of other intervals. Because of this fact Einstein says, "The interval is thus shown to be independent of the selection of any special body to fill it; the same is true of spatial relations. (cf. "The World As I See It" p 85)

From the particular interval between the cubes we derive a more extended concept or a universal concept of any interval between solid bodies. This is for Einstein the threshold of space. "In my opinion this *concept of the interval*, detached as it is from the selection of any special body to occupy it, is the starting point of the whole concept of space." (cf. "The World As I See It" p 85) From the concept of any interval between two bodies which can be filled, we derive the notion of something which can receive bodies—space. Of itself it is nothing but a privation of solid bodies, but since this space is so intimately connected with real bodies in its concept, it appears as something real.

Einstein's whole process follows this order—solid body; spatial relations of solid bodies; interval; space. Suarez, on the other hand, has this order of sequence in arriving at his concept of space—extension (three dimensions); capacity of a body for occupying imaginary emptiness or vacuity,—space.

Einstein begins with solids; Suarez goes a step farther by beginning with extension abstracted from material bodies. Einstein speaks of an interval created by separating two bodies; Suarez speaks of a void created by the removal of a body. The interval in Einstein's process, since it is independent of any special body which has a value for filling it, now becomes any interval, which in turn becomes that which any bodies can fill; or, in short, space. The vacuity of Suarez is likewise extended from a particular concept to a universal concept, so that the vacuity now becomes a capacity for receiving bodies. Note that Einstein says that bodies have a 'value' for filling space, while Suarez says that bodies are capable—'apta sunt'—of constituting real space. In both explanations space is ultimately conceived as a reality, not because of itself, but because of the reality of the bodies which occupy it.

Einstein: *The World As I See It.*
Suarez: *Disputationes Metaphysicae. Disp. LI.*

NOTICE

Due to unforseen circumstances, we were unable to publish the two articles: "Statistical Laws from the Physical View-Point", and "The Uncertainty Principle." We will publish these articles in the forthcoming issue of the *Bulletin*.

THE EDITOR.

BIOLOGY

PHOTOSYNTHESIS: THE NATURE AND CHEMISTRY OF CHLOROPHYLL

REV. HAROLD L. FREATMAN, S.J.

The fundamental fact in the nutrition of all living things is the capacity of green plants to make certain complex compounds, that is, carbohydrates out of the CO_2 from the air, H_2O from the roots, chlorophyll in the leaves by the aid of sunlight and a proper temperature. This is called Photosynthesis. Of the raw materials necessary for Photosynthesis here will be discussed Chlorophyll. Hereafter in this paper we shall refer to chlorophyll as "Ch".

Ch is not a single substance. In general it is a yellow-green pigment. Several pigments can be separated more or less completely, of which two are abundant and constant in all the higher plants, the one bluish green, the other pale yellow. The former is called chlorophyllin, the latter carotin. The blueish-green is usually called ch, the yellowish green xanthophyll, etiolin and carotin. Etiolin appears in plants grown in the dark or kept for a time in the dark. Such plants are said to be etiolated. Extracts from leaves contain ch-a-blue green, and ch-b-yellow green in the proportion of 72% ch to 28% ch-b. Present also are carotin, deep yellow or orange, and xanthophyll light yellow or lemon colored (both of which may be associated with Ch in chloroplasts or in chromoplasts). In every green leaf are two crystallizable nitrogen-free pigments; one is identical with carotin of carrots, oxide of carotin ($C_{40}H_{56}O_2$), and its companion xanthophyll ($C_{40}H_{56}O$). A third caritinoid, fucoxanthin is found in green algae, which being present the amount of the other carotinoids is reduced. This differs from the first two by pronounced basic properties of its oxygen atoms and by the formation of a characteristic blue hydrochloride. From experiments on 200 different cryptogams and phanerogams ch is identical in all plants investigated. Ch-a predominates over ch-b, by a ratio of three to one. In phaeophyceae ch-b is present in very small quantities. The ratio of carotin to xanthophyll is 0.6 to 1.

The chemical composition of ch is not so clearly known. It is very easily alterable. Certainly it is very complex, containing C, H, O, N; magnesium also is present. The presence of certain compounds (nitrates) seem to favor ch formation, which some substances including Na Cl, when present in sufficient quantities impede ch formation. The latter fact may explain the pale-green color of some plants growing in salt-marshes. Ch is in some way related to carotinoids and to protein, and certainly is not soluble in the lipoid phase. Ch as obtained by evaporation of its alcoholic solution is a green resin-like powder insoluble in water. Ch-a can be fractionally separated from ch-b by two solvents, methyl alcohol and petroleum ether, ch-a consisting of a blue-green which forms in solution olive-green pheophytin, and yellow-green ch-b whose magnesium-free derivative is red-brown in neutral solutions. Relations between ch-a and ch-b is hazy, because numerous compounds are inclined to form hydrates appearing at times with water, at times without water, frequently being combined with a half molecule. Both ch-a and ch-b agree not only in Mg content and phytol content, but also are similar in composition of basic nucleus. The difference between them is probably in a molecule of O, two H atoms of ch-a being replaced by an oxygenation in ch-b.

Iron does not seem to be an integral part of ch, although considered essential to its formation. It is important to give green color to plants, as we know by adding or leaving out ferric sulphate or ferric chloride from a solution growing corn. Godnev claims that iron brings about the formation of an intermediate compound of the Mg salt type of alpha pyrrole carbonic acid.

The important characteristic of ch is the capacity to absorb light energy. If the greenish extract from a leaf is placed in the path of a beam of light the spectrum appears broken, being interrupted by a number of dark bands; some of these absorption bands are located toward the red-end of the spectrum and some toward the violet-end, and are caused by the absorption of certain rays of light by the ch. There are also two or three bands located toward the violet-end caused by the absorption of light by carotin and xanthophyll. What light-energy is absorbed from these particular portions of the spectrum by either pigments is the energy used in photosynthesis. Light is a very important factor in ch formation. Ch may be formed in presence of visible light of many wave lengths. Ch is formed only in the presence of living matter and only within a relatively narrow range of temperature. Maximum pigment production was obtained at nine to thirteen hours of daily illumination (Knut Sjöburg). Ch can absorb waves of certain length, all falling within the range of our vision. Ch likewise is fluorescent. Kautsky, Hirsch, Davidshöfer showed that ch-influorescence is inhibited largely by O_2. Willstätter assumes that their conclusion that O_2 uses up, as the only molecule in the assimilation-system, the light-energy from the ch, as only partly correct. Possibly the ch itself reacting with O_2 uses up the energy. On the basis of Stoll's work it is believed that H-atoms of ch do not act as a pair, but transfer separately from ch to CO_2 and back from H_2O to ch. All the rays toward the violet-end of the spectrum are made to conform to those near the red in refrangibility. The spectrum of an alcoholic solution of ch has been shown to be essentially the same as that of the ch-granule itself. When a strong solution in alcohol is held between the eye and the light the color is vivid green, but if examined by bright reflected light it appears deep blood-red. The significance of influorescence is still unexplained.

Chloroplasts only directly illuminated receive the energy. The light is absorbed and changed by the chloroplasts. Forty to seventy percent of sunlight is absorbed; ninety-five percent of diffused light. A leaf absorbs in its ch twenty to thirty percent, but only 0.5 to 3% is used in photosynthesis, and stored as potential energy in the carbohydrates made; the rest heats the leaf sometimes ten to fifteen degrees above that of the air. Formation of ch is affected more by variations in light-intensity than by differences in wave-length. In the presence of light ch is constantly being destroyed and reformed. In darkness it is destroyed and not reformed.

In the making of carbohydrates artificially, a complicated process, we can arrive at some explanation of the process through von Baeyer; Carbonic acid is by some means perhaps reduced to formic acid, and later to the simplest carbohydrate, formaldehyde and a molecule of oxyden is set free as a by-product. Free formaldehyde is a by-product. Free formaldehyde is a powerful poison even in dilute solution (1:20,000), but promptly it is condensed into some hexose sugar, thus preventing accumulation to a harmful extent. Glucose probably represents the first stable carbohydrate formed in most plants; in some cases cane sugar, saccharose.

CO_2 plus H_2O equals H_2CO_3 (carbonic acid).

Giving off one part of O it becomes formic acid (CH_2O_2).

By a similar decomposition CH_2O_2 becomes formaldehyde (CH_2O).

Two parts of O pass from the cells through the stomata as a gas. In the presence of certain alkalies and acids formaldehyde increases the number of elements which compose it. Thus six times CH_2O equal $C_6H_{12}O_6$ (grape sugar). This theory is based on the fact that in nature carbon dioxide and water unite to form carbonic acid, and decomposition may take place as above. This is but one theory as to the formation of the carbohydrates in leaves, others may be found in most chemistry texts.

Bertholet and Gaudechon say that carbon dioxide in the presence of hydrogen or water, when exposed to ultra-violet light yield formaldehyde. Baly says that under the stimulus of light of short wave length CO_2 is dissolved in water, and can be readily converted into formaldehyde without ch. Usher and Priestly held that ch in the presence of light produced a double decomposition between CO_2 and H_2O, yielding formaldehyde and hydrogen peroxide. H. Clements claims that glucose and fructose are the first fruits of photosynthesis. Brown and Morris say that the first product is cane sugar. Starch is formed indirectly, katabolically. Photosynthesis is a feeding process associated with anabolism, others say. We are profoundly ignorant of the actual mechanism of the process. Willstätter and Stoll in 1918 asserted that assimilation of CO_2 and its conversion into formaldehyde takes place in the first instant by the addition of CO_2 and H_2O to the atom of magnesium present in ch-molecule from which it is detached in the form of Oxygen and formaldehyde. Certain of the decomposition products of ch bear a close relationship to those of hemoglobin. Verdeil claimed that the coloring matter of blood bore some relationship to that of leaves. F. Hoppe Seyler strengthened this hypothesis. The iron-content was assumed as late as work of E. Schunk, E. Fremy, A. Gautier, etc. This connection seemed to be in their molecular structure. Under heat, it was converted into a purple-red pigment "dichromatic acid", unstable. There is a color change caused by HCl as a result of decomposition. Hoppe-Seyler's derivative reminded him of hematoporphyrin, which is obtained from hemin by concentrated sulphuric acid. Hence he called it phylloporphyrin. Color change is due not to the formation of a salt, but to the elimination of a complexly-bound metal. Porphyrins from ch and hemin are similar, but not identical. Much has been done to trace in this way the common origin of plants and animals.

The ch green carboxylic acids, the chlorophyllins, formed by alkaline hydrolysis of alcoholic leaf extracts are very unstable, but could be separated in a somewhat pure state from their mixture with the other products of saponification. With alkalies chlorophylls which are dicarboxylic esters of phytol and methyl alcohol are hydrolyzed. If the phytol is eliminated the monomethyl ester which remains is termed chlorophyllide. On further hydrolysis chlorophyllide yields green-colored salts of acids, the chlorophyllins, which contain three carboxyl groups, one being present probably as a lactam group. Each chlorophyllin is further decomposed by alkalies at different temperatures. Magnesium compounds are shown to be present complexly bound, but not capable of electrolytic dissociation, as in magnesium salts, but peculiarly united and in stable relation, in which the ionic reactions of the metal are lacking. By heating at 240 degrees Mg was known to be present by decomposition, and there resulted the so-called phyllins which contain, three, two or finally one carboxyl groups. All receive their name from their color—glauco, rhodo, cyano, erythro, rubi, pyro, phyllopphyllin (blue, red, etc.). By systematic decomposition we get a carboxyl-free parent etiophyllin. ($C_{31}H_{34}N_4Mg$). All phyllins contain one atom of the Mg to four of Nitrogen—containing groups of the molecule for binding—they are with primary and secondary valences. Under the influence of acids all phyllins lose Mg and are transformed into polybasic and monobasic carboxylic acids, which show basic and acid properties. Since all these form a natural group with phylloporphyrin, they are called porphyrins, each with the prefix of the corresponding phyllin. Acids change their color to olive, and fluorescence becomes weaker. The Magnesium-free derivative of ch is pheophytin, and is easily obtainable by treating carefully a solution of crude ch and oxalic acid. The meal of dry nettle leaves is a good source. Pheophytin has no ash, is free from colorless and yellow impurities, is waxy without acid properties, and weakly basic.

Phytol appears as a component of ch, and is one-third of its molecule. It is a colorless oil. Plants with chlorophyl that were poor in phytol proved excellent material for isolation of the ch in the form of beautiful crystals as those discovered in 1881 by the Russian Botanist, Borodin. Ch in green plants is accompanied by an esterase enzyme, chlorophyllase, active in alcoholic media. Pheophytin is used for experiment, as it is the most suitable form of ch. It is pure ch, but not a homogeneous compound. Its cleavage products are phytochlorin "e" and phytorhodin "g". Ch contains 4.5% ash, which is pure Mg. ch and pheophytin saponified by boiling for a short time with methyl alcoholic potash yield the normal mixture of phytochlorin "e" and phytorhodin "g", besides a third of the weight of the molecule is liberated as phytol.

Ch is distinguished from ordinary Mg Compounds in consequence of the additionally complex linking of the metal by a greater stability of the Mg toward water. CO_2 perhaps is attracted by the affinity of the Mg compounds and its reduction is brought about by the ch-a component in the process which used up the absorbed light energy. Ch-a is oxidized to ch-b in this process, and this again is transformed into ch-a by the splitting off of O. A state of equilibrium appears between the two components. Possibly this is done directly (giving up of O by ch-b) or that yellow pigments, carotin and xanthphyll take part in the transformation back to ch-a. Perhaps the caritinoids are functionally related, as they constantly accompany the green pigments. Perhaps they regulate the ratio of ch components; carotin withdraws O from ch-b and O is free from the xanthophyll that is thus formed by the action of an enzyme.

In conclusion, although Ch and Hemin have been traced to the same etioporphyrin like a parent-substance, yet there is no close constitutional relationship, as in the one there is Mg, in the other Fe; in the one ester formation with phytol, in the other a combination with globin. There are further nuclear differences of the pigment itself, which disappear only upon far-reaching decomposition. Ch is constant in composition.

A SERVICEABLE INSECT TRACHEA SLIDE.

REV. JOSEPH ASSMUTH, S.J.

Probably you have experienced the same trouble as we here in Fordham: to get a really good slide to illustrate the structural details of insect tracheae. Here is a way out of this difficulty. You certainly know the Cicadas. They are of frequent enough occurrence nearly everywhere, if not our common eastern species *Magicicada (Tibicina) septendecim* L., popularly called "seventeen year locust", then perhaps *Tibicen dorsata* Say ("thirteen year locust", in the Mississippi valley and thereabouts), or any other of the close to a hundred different species known to occur in various parts of the United States. But what is needed for our purpose is not the Cicada imago. To dissect out of it a tracheal stem with all its branchings yet without a bit of other tissue adhering, would be just as difficult as to get a clean preparation of the required kind from any other insect, be this a Hymenopteron, a Coleopteron, or whatever else. What we want is the empty shell of a Cicada pupa after eclosion of the imago.

Where are such exuviae to be found? On tree trunks, usually 3 to 6 or 8 feet above ground. When you hear the male Cicadas singing high up in the trees during the hot summer days, then is the season to be on the lookout for exuviae. The most promising hours for a successful search are from 6 to 8 in the morning; examine carefully the various trees in the garden going round and round them, and you are pretty sure to locate somewhere an empty pupa shell clinging to a trunk. Later in the day the wind usually blows them off, and it is very hard to spot them on the ground.

Inside the shell you see a number of white threadlike structures protruding from the brown side walls. These are the chitinous inner linings of the tracheae pulled out from the body of the just emerged imago. If the exuviae are already quite dry, the tracheae are very brittle and liable to be broken and spoiled at the slightest touch. To avoid this loss put the whole shell for a couple of hours in warm water (about 60-70° centigrade). After this it is easy enough to remove the tracheae from the cast skin without injuring them. The following details ought to be observed: 1) The tracheae once immersed in liquid should as far as possible always remain so. Don't take them out longer than required to transfer them (expeditiously) from one liquid to another; else you may get air bubbles in the tubes, and they would mar the final slide. 2) A tracheal stem arising from any spiracle is usually glued together with its ramifications; so to get a good exhibit of the main trunk with all its side branches it is necessary to disentangle them. Pin the cast skin (under water) in a small dissecting dish and then, using two dissecting needles, gently pull the branches apart.

Now remove the trachea from the exuviae—cutting as closely as possible to the spiracle—and put it into 70 p.c. alcohol. After one or two changes transfer it to 95 p.c., change again once or twice, and finally enclose it in Euparal. Euparal has this great advantage over Canada Balasm—apart from not necessitating a complete dehydration of the object—that it only moderately clears the preparation and thus makes the structural details (taenidia etc.) stand out much more distinctly. Put a good sized drop of Euparal on a common slide, place the trachea on it and (remember: quick action) lightly press it down so that it is well sunk into the mounting medium; with the help of teasing needles (dipped into ether so that the Euparal does not stick to them) neatly spread the tracheal branches apart, and finish with adding a cover slip. The latter must, of course, be raised a little (place a few chips of a broken cover glass under it), else it will crush the object when the Euparal gets dry.

In case staining of the chitin is desired, fill a test tube or vial about half full of water and drop a few tablets of potassium hydroxide (KOH) into it. When they are dissolved place the trachea—cut off from the exuviae, and the branches disentagled—into this solution and leave it there for a couple of days. Pour the Hydroxide off and wash the object thoroughly in several changes of water so that no trace of Hydroxide remains. Prepare a saturated watery solution of acid Fuchsin (Fuchsin S) and place the trachea in it. Leave it there for some days as there is no danger of overstaining. Rinse the object in water, dehydrate in 70 and 95% alcohol, enclose in Euparal as stated above.

In either case—plain or stained—you will have a fine slide of insect trachea showing clearly all the structural details: the main stem, its gradually tapering branchings and re-branchings, the spiral taenidia, and if you have luck you may even get a taenidial thread pulled out from inside a tracheal tube.

The whole process looks rather formidable because it has been here set forth in lengthy detail; but it is, indeed, very simple, does not require any special skill, and yet is sure of giving very good results.

OBSERVATIONS ON THE RELATION BETWEEN SALIVARY GLAND CHROMOSOMES AND MULTIPLE CHROMOSOME COMPLEXES

Rev. Charles A. Berger, S.J.
Department of Zoology, Johns Hopkins University, and Department of Biology, Woodstock College, Maryland.

In 1917 Holt[1] described multiple chromosome complexes found in the pupal intestine of the mosquito *Culex pipiens* during metamorphosis. The diploid chromosome number is 6; the numbers most frequently found in mutiple complexes were 12, 24 and 48.

Bogojawlensky[2] in a study of cell size in *Anopheles maculipennis* found that the large cells of the larval mid-gut had nuclei and chromosomes of the salivary gland type "Balbianischer spiremähnlicher Typus," differing however from the classical type discovered by Balbiania in *Chironomus* in the following points: 1. The chromosomes consist of granules of chromatin attached in a linear series without achromatic connecting threads. 2. There is only one nucleolar body present.

Bauer[3] cites the findings of the above two investigators as furnishing a visible demonstration of the compound nature of the salivary gland chromosomes. His argument supposes that the cells giving rise to multiple complexes are of the same type as those described by Bogojawlensky and that in mitosis the huge "compound" chromosomes separte into their component units resulting in multiple complexes.

The observations of Holt and Bogojawlensky have been repeated on *Culex pipiens* with the following results:

1. The large cells of the larval mid-gut have chromosomes which are similar to salivary gland chromosomes in that they consist of a thick chromatic cord, visible in the resting nucleus. They are made up of serially attached chromatin granules varying in di,ameter.

2. No evidence of cell division in these large mid-gut cells was obtained at any time. Their number is supplemented during larval life by the growth of very regenerative cells which are apparently present from the time of hatching. From the second day of larval life to the time of pupation individual large cells are found being shed into the lumen of the gut where they disintegrate without division. They are replaced by regenerative cells. At pupation the remains of the larval mid-gut is shed and hundreds of cells in all stages of disintegration are found, but again with no evidence of cell division. The new mid-gut is formed by the rapid multiplication of the small regenerative or imaginal cells which show 6 metaphase and 12 anaphase chromosomes in their division figures.

3. In the most anterior part of the intestine, the ileum, numerous multiple chromosome complexes (24-48 chromosomes) were found in dividing epithelial cells between the 12th and 18th hours of pupal life. Throughout the larval period and the first hours of pupal life the nuclei of these epithelial cells of the ileum are typical resting nuclei, very finely granular in appearance and in no way resembling the salivary gland type of nucleus.

In brief the evidence indicates that cells having the salivary gland type of chromosomes do not divide, while the cells giving rise to multiple complexes do not have nuclei and chromosomes of the salivary gland type.

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1 *Jour. Morph.*, 29, 607-627 (1917).
2 *Zeits. Zelf. Mik. Anat.*, 22, 47-53 (1934).
3 *Ibid.*, 23, 280-313 (1935).
4 In *Sciara* the large epithelial cells of the larval mid-gut have chromosomes possessing the salivary gland chromosome characteristics.

CHEMISTRY

A LABORATORY COURSE IN ORGANIC CHEMISTRY

REV. ARTHUR J. HOHMAN, S.J.

The purpose of presenting this outline of a laboratory course in Organic Chemistry is to stimulate criticism with regard to content and method. The course is designed to give a comprehensive application of the principles learned in the lecture course. Conant's Chemistry of Organic Compounds is used as a text, and Laboratory Experiments in Organic Chemistry, by Adams and Johnson, for the laboratory work.

In most instances a few additional references and notes are supplied with each experiment, to complete the theory. A very few modifications in technique are supplied. In only one instance was it thought advisable to design an entirely new set up for the experiment, without however changing the experiment itself. In many instances it was found quite practicable to reduce the amounts of materials proportionally for a given experiment. No experiments were introduced from other sources.

As conducted at present the course consists of two periods per week, each period consisting of two hours. After each such period an additional hour is available to the student, making a total of six clock hours per week. The periods follow each other on successive days. This makes it possible for the student to leave more complicated apparatus set up over night.

The student is supposed to have thoroughly prepared his tables of physical constants, when such are needed, before coming to the laboratory. He is also required to look over the theoretical matter involved before presenting his chart for approval. A few leading questions are proposed to him at this time. All apparatus must be completely assembled and approved by the Instructor before the student is allowed to proceed to the actual work.

During the work he is expected to dovetail experiments intelligently so as to avoid excessive loss of time while waiting for mixtures to stand or be refluxed. Usually one or two simpler experiments follow a more elaborate one so that this dovetailing becomes easy.

The key material for each experiment is supplied to the students in individual bottles. A yield of at least 75% of the minimum specified by the authors is demanded, if the experiments is to be accepted for a passing grade.

When the student has completed the experimental work he is subjected to a thorough quiz on the work and the general properties of the class of compounds dealt with in the experiment. This quiz lasts for 15 or 20 minutes.

The experiments chosen are supposed to occupy the student a total of 120 hours. The authors assign 77 hours, exclusive of the time consumed in refluxing, etc. It is the opinion of the writer that this is not sufficient time for a beginner. Time is needed to teach the student a satisfactory technique. The need for such instruction persists to a greater or less degree throughout the course. This naturally slows down the work of the student, but it is considered time well spent. The quiz also uses up a part of the laboratory time, especially if the student has not prepared well for it. In very many cases it will be found that he has to be sent away to look up some matter that he has overlooked or not understood. It has been thought better to allow a certain amount of time to be devoted to this than to give the student a low grade or fail to pass him. In the latter case he learns nothing from the quiz, and possibly never learns how to prepare properly for a quiz.

No. 1: Determination of the Melting Point. Melting Points are determined for Urea, Cinammic Acid, and for three different mixtures of the two, and the melting points of the five materials plotted. The influence of impurities on the melting point are considered from the standpoint of solid solutions.

Note: Prepared capillary tubes are supplied. They need only be sealed off at one end for use. The technique acquired when the student prepares his capillaries himself does not seem to be proportionate to the time consumed.

No. 2: Purification of Acetanilide by Crystallization. This illustrates the manner in which different types of impurities may be removed, including those that are removed by adsorption on charcoal.

Note: Acetanilide is chosen since water may be used instead of a more costly solvent. The purified acetanilide is used in a later experiment.

No. 3: Determination of the Boiling Point by distillation. This illustrates the influence of a volatile impurity on a solvent.

Note: At this point all thermometers are calibrated.

No. 4: Fractional Distillation. This illustrates the general principles underlying simple fractionation and the operation of the fractionating column.

Note: Extraction by immiscible solvents, steam distillation, salting out, and drying, are stressed in the experiments where they are first met.

No. 5: Qualitative detection of the elements, C, H, O, N, S, and halogens in various organic compounds. Several different tests are applied for each element and the limitations of the methods learned.

No. 6: Preparation of Ethyl Iodide. Illustrates esterification by means of Phosphorus Halide. Drying is here met for the first time.

Note: The lecture course takes up alcohols, alkyl halides, hydrocarbons in the order named.

No. 7: Reactions of the Saturated Hydrocarbons. This illustrates the inactivity of the paraffins, substitution by halogens, catalytic action of light, and the presence of unsaturated hydrocarbons in ordinary gasoline, as a result of "cracking".

No. 8: Preparation of Amylene. This exemplifies the indirect dehydration of a secondary alcohol, pentanol-2 by means of H_2SO_4.

No. 9: Preparation of Butyl Acetate. This treats of direct esterification, hydrolysis, saponification and the salting out effect.

No. 10: Reactions of Formaldehyde. This is a qualitative study of the reactions of formaldehyde including the Cannizzaro reaction.

No. 11: Preparation of Acetaldehyde from Paraldehyde. This illustrates polymerization, depolymerization and some of the principle reactions of the aldehyde.

No. 12: Carbonyl Group Reactions. This exemplifies the main reactions of the carbonyl group in aldehydes and ketones, including the formation of bisulphite compounds, reduction of Fehling's solution, hydrazone formation, formation and hydrolysis of oximes.

No. 13: Preparation of Iodoform. This illustrates the haloform reaction and the conditions necessary. Commercial Clorox is used as hypochlorite solution.

Note: The preparation of alcohol by fermentation is omitted as being of too elementary character. The preparation of ether is also dispensed with because of the danger involved.

No. 14: Preparation of Acetamide. The experiment exemplifies the preparation of a typical amide by the dehydration of the ammonium salt, and the hydrolysis of the amide, and its saponification.

No. 15: Fats and Fatty Oils. This includes the preparation of soap, the precipitation of metallic soaps, and the comparison of the degree of saturation of certain oils, as well as the drying of unsaturated oils.

Optional: Preparation of Methyl Cyanide. This is to exemplify the formation of a nitrile by the dehydration of an amide.

Note: This completes the work assigned for the first semester. The performance of the optional experiment is left to the judgement of the Instructor.

No. 16: Sugars. This is a study of the principle reactions of the monoses and bioses. It includes the formation and microscopic examination of osazones, and the preparation and purification of the beta-glucose pentaacetate.

No. 17: Starch. Starch is extracted from the potato and the percentage roughly determined. The delicacy of the Iodine test is determined. Starch is hydrolysed both by means of an acid, and by pytalin.

No. 18: Cellulose. The hydrolysis is exemplified and parchmentization illustrated. Trinitrates and triacetates are prepared and their properties studied.

No. 19: Preparation of Bromobenzene and Dibromobenzene. This illustrates direct bromination and the use of Anhydrous Aluminum Chloride as a catalyst. The principles of steam distillation are stressed here.

No. 20: Preparation of Nitrobenzene. The experiment illustrates direct nitration.

No. 21: Preparation of Aniline. Reduction by means an acid reducing agent is illustrated. Extraction with immiscible solvents is studied in this experiment.

Note: The student uses his own sample of nitrobenzene in the preparation of aniline.

No. 22: Reactions of Primaary, secondary and tertiary Amines. The preparation of acetamides, sulphonamides, and quarternary ammonium compounds is exemplified. The derivatives are purified and their melting points determined. These reactions are then applied to the identification of an unknown amide according to its character as primary, secondary, or tertiary.

Note: The student uses his own sample of aniline as a primary amine in this experiment.

No. 23: Preparation of Sulphanilic Acid. The experiment illustrates direct sulphonation. It also indicates the influence of the amino and sulphonate groups on each other in the same molecule.

No. 24: Preparation of p-Bromaniline. Acetanilide is brominated and subsequently hydrolysed. This exemplifies the protective action of the acetyl radical on the amino group.

No. 25: Preparation of o-Chlorotoluene. This experiment applies diazotization and decomposition of the diazonium salt in Sandmeyer's reaction.

No. 26: Fluorescein and Eosin. The experiment exemplifies the condensation of phthallic anhydride and the subsequent bromination of the fluorescein. The development of a soluble compound and the quinoid structure together with dyeing properties is also studied. The auxocromic effect of bromination is illustrated.

No. 27: Preparation of p-Nitrobenzoic Acid. This experiment exemplifies the oxidation of a side chain by means of chromic acid mixture. It also illustrates the use of a high boiling bath in the determination of the Melting Point.

Optional: Preparation of Benzoic Acid and Benzyl Alcohol. This experiment is a detailed application of the Cannizzaro Reaction to an aromatic aldehyde.

It is felt that the list of experiments given above affords a fairly comprehensive application of the principles and facts learned in a course of organic chemistry lectures given to beginners in the subject. The manner in which the laboratory is conducted lifts the laboratory work out of the plane of mere mechanical manipulation and makes of it an intellectual process. The quizzes are a great aid to the student in correlating the knowledge acquired in the lectures and in turn teach the student how to study, thus helping him to derive more from the lecture course. So far the method has produced excellent results here. It would be interesting to hear what others might suggest in the way of improvement.

WINE ANALYSIS. UNIVERSITY OF SAN FRANCISCO

CARROLL M. O'SULLIVAN, S.J.

The recently organized courses in wine chemistry at the University of San Francisco are attracting attention. The patronage is very satisfactory.

New apparatus designed for the precise analysis of fruit products, according to recently developed methods which have not been introduced into winery laboratories, is giving full satisfaction—time is saved and accuracy is improved.

Determination of pH values of altar wines, made in Los Gatos and elsewhere, have uncovered interesting facts. A thorough study of all such wines on the market will be made and reported in due time.

The winery built at the Novitiate at Los Gatos after fire destroyed the plant erected in the nineties, is excellent for such investigations. Large refrigerating and pasteurizing units and similar equipment permit full scale tests of ideas developed in the neat laboratory.

The registration for the second term brings up the enrollment of students, following courses in chemistry, to one-fifth of the entire student body. More of the men are listed with chemistry majors than are registered for pre-medical and pre-dental courses. Formerly the latter groups were predominantly large in lower division classes.

The gas laboratory is conducting very interesting analyses of tobacco smoke in conjunction with a medical group investigating clinical problems connected with the enslaving effect of cigarettes and the hazards to life among female smokers. The investigation was suggested by uniformly finding carbon monoxide in the blood of clever students who injured themselves rather stupidly in the laboratories. Following this lead, tests are under way to determine what relation may exist between the failure of perception and general alertness and carbon monoxide intoxication resulting from indulgence in smoking during considerable time.

It will interest readers, harassed by the restrictions of the times and constantly reminded of the depression, to relate one successful adaptation that kept within the limits of economy without sacrificing utility and precision. For the examination of large volumes of smoke it was necessary to have containers very different from those in the stock room. Our machine shop is in charge of an ingenious mechanic equal to any demand. From the goods carried for hotel kitchens by large supply houses, he built a useful and attractive apparatus which held the fumes perfectly and now when not used for analysis, gives better service to students of physical chemistry than equipment far more costly. A portable thermostat, heating unit and controls are practically all that is required for the transformation.

BOOK REVIEW.

NEW PRACTICAL CHEMISTRY. By Newton Henry Black and James Bryant Conant. New York, The Macmillan Company, 1936. VII + 631 pp. 14 × 20 cm. $1.80.

The answer to the High School Chemistry teacher's prayer has finally arrived. Black and Conant's "Practical Chemistry" has long been regarded as the best text dealing with High School Chemistry, but of recent years a revised up-to-date edition has been greatly desired. And that is just precisely what was published last month.

It might be well to state at the outset that "New Practical Chemistry", as the text is called, is essentially the same as the old text. The same pleasing typographical features, bold paragraph headings; explanations of experiments and diagrams in small print; important definitions and laws in italics are again in evidence. The order of chapters is the same with a slight variation. One of these variations is the one change in the entire book with which I find fault. In the old text the authors introduced the consideration of the Periodic Law with two chapters on sodium and potassium compounds and the halogen family. In the new text the Periodic Law is treated first followed by chapters on the halogen family and sodium and potassium compounds. I believe that most teachers of High School Chemistry found the method used in the old text better. However, that may be merely a question of opinion since the success of any system depends to a great extent on the teacher.

Some of the new features of the book greatly outweigh any disadvantage which may appear at first sight. Part of the first chapter is devoted to a brief history of chemistry which is very worth while. The fourteenth chapter gives an explanation of the atomic structure of matter in a manner understandable to high school students.

Another feature is the sets of review questions at the end of each four or five chapters covering the matter in those chapters, and at the end of the eighteenth and thirty-sixth chapters reviewing all that has gone before.

These are the main features of the book and I think they are sufficient to warrant the adoption of the text in our high schools.

JAMES J. PALLACE, S.J.

PHYSICS

THE POSITRON.—IT'S CREATION AND ANNIHILATION

PART II.

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

Once Anderson's discovery of the positron became public, a realization of the processes outlined in the previous issue brought many workers into the field of gamma radiation and absorption. Anderson himself working with Neddermyer (10) made a study of positron production using a gamma ray source from radio thorium and by collimating the rays with the aid of holes bored through lead blocks an intense beam of gamma rays was secured which was then allowed to fall on lead plates placed in a cloud chamber. With a magnetic field of 430 gauss these workers were able to measure the energies of 22 pairs of positives and negatives formed by the action of the gamma rays on lead. Thirteen positrons appeared alone. Blackett and Occhialini bombarded beryllium with alpha particles from polonium and found that the bombardment gave rise to gamma rays and neutrons. By allowing this combination of energy carriers to fall on lead (as well as other materials) they found that positrons were given off from the lead (11). These they ascribed to the action of the neutrons but shortly afterwards Mons. and Mme. Joliot announced that by placing absorbing screens in the path of the same mixture of neutrons and gamma rays they were able to filter out the gamma rays and the consequent reduction of positron production indicated that their formation was due to the photons rather than to the uncharged particles which were able to penetrate the screens and yet produced no positives. (12). Continuing this work with Chadwick, Blackett and Occhialini (13) secured a gamma ray source from the active deposit of thorium and produced positron tracks in such abundance that quantitative conclusions could be drawn from their results without hesitation.

The advantage of using the particular source of gamma rays employed by Chadwick, Blackett and Occhialini to bombard lead in order to produce positrons, arises from the fact that these rays coming from the transformation of ThC" to lead are known to possess high energy. 70% of the high energy quanta are due to a line of 2.62 million electron volts; the remaining 30% being of lower energy.

Now if these gamma rays are converted into pairs of positive and negative electrons, as proposed from the creation theory, then the maximum kinetic energy obtainable for a pair thus formed will be $E = h\nu - 2mc^2$, where the second term represents the energy equivalent of the masses thus produced. Since the energy equivalent of an electronic mass is 5.11×10^5 electron volts we have:
$2.62 \times 10^6 - 1.02 \times 10^6 = 1.60 \times 10^6$ electron volts as the maximum energy of the formed positron-electron pair. Assuming that occasionally the positron received all the residual energy it puts an upper limit on the value that should be found for the energy of the positive which will permit the theory of formation under consideration to maintain its validity. In Anderson's work **all but one** of the measurements on the energies of positrons formed from gamma ray bombardment fell between the values 10^6 and 1.6×10^6 electron volts, and that one of 1.8×10^6 e-volts might easily have been due to cosmic radiation. Chadwick, Blackett and Occhialini give a plot of their results and taking into account the necessary corrections they find 1.58×10^6 electron volts as the maximum energy value for positrons,—but 2.49×10^6 for electrons.

This high energy value for negatives is of course due to free recoil electrons existing in the lead and energized from true photoelectric or Compton effect or both, and is not due to the "pair formed" electrons.

Not only were the mass energy relations thus nicely balanced as a result of this experiment but a precise means of calculating the positron mass was secured.

Since the production of an electron pair requires an expenditure of energy $(m_1 + m_2)c^2$ we can conclude that $E_{max} = h\nu - (m_1 + m_2)c^2$. Using the value found for the maximum energy of the positron: 1.58 million electron volts and taking $h\nu$ as the energy of the gamma radiation from Th C" equal to 2.62 million electron volts and substituting these values together with that of the mass of the negative electron in the above formula we come out with the mass of the positron as $m_2 = (1.04 \pm .14)m_1$, where m_1 is the mass of the electron.

A table prepared by Blackett (14) from the data of Curie and Joliot, Grinberg as well as from that of the Cambridge workers themselves shows the number of positive electrons ejected in a forward direction from different elements by various radiations; the numbers being expressed as a fraction of the observed number of negative electrons. The table is reproduced below and Blackett warns the reader that the effect of different experimental arrangements may introduce considerable discrepancies in the compared results.

PERCENTAGE OF POSITIVES PRODUCED BY GAMMA RAY ABSORPTION

SOURCE	ENERGY OF GAMMA RAY	ABSORBER		
		U	Pb	Al
Ra	1. to 2.2 $\times 10^6$ electron volts		3%	
Th C"	2.62×10^6 " "		10%	Very small
Po plus Be	5 to 6 $\times 10^6$ " "	40%+40%	5%	

The study of gamma radiation which is the result of artificially produced nuclear transformations gives us further insight into the process of creation of positrons. "Artificial" may be used in this connection in two senses. Radioactive transformations such as that of Th C" into lead are called natural. A transmutation produced by allowing a high speed particle or ray, from a natural disintegration process, to fall on another element thereby disintegrating it, might be called artificial transmutation by natural means. Whereas the direct production of high speed particles by means of laboratory generated accelerating fields which are used for the bombardment and disintegration of nuclei truly deserves the name of artificially produced transmutation.

The Joliots, working in the field of artificial transmutation produced by natural means, secured the transmutation of aluminum by bombardment of that element with the alpha rays from Polonium, and found that in addition to the emission of protons there were electrons of both signs accompanying the process. The negatives were of 0.9×10^6 e-volts, and were attributed to the internal conversion of the gamma rays of Polonium. The positives which were found to have the higher energy of 3×10^6 e-volts could not be attributed to such a cause since no gamma radiation of sufficient hardness is known to be associated with the excitation of aluminum and in addition the corresponding negative of at least occasional energy of the same order is not found.

The interpretation put forward is, that after the capture of the bombarding alpha particles the nucleus sometimes emits instead of a proton, a neutron and a positive electron; the nucleus in either case resulting from the change being $^{30}_{14}$Si.

It must be remarked however that the theoretical treatments of positron production have nothing to say about such a process and such a method of formation can not be fitted into the picture drawn by Dirac or Oppenheimer.

The most remarkable part of the process is the fact that the emission of the positrons is not simultaneous with the bombardment, but is produced after several minutes of irradiation, and continues for some time after the cessation of the irradiation. (15) This **induced** radioactivity has been studied for many elements. Mg was found to emit both positrons and negatrons;—Boron only positrons.

The Joliots in their paper predicted that if carbon were bombarded with deuterons the same radioactive product should result as from the bombardment of boron with alpha particles. Crane and Lauritsen (16) succeeded in verifying this prediction. In their test the ions used for bombardment were produced in a modified X-ray tube where a potential difference of 0.9×10^6 volts accelerated H^2 particles and these deuterons endowed with energies of the same order of magnitude (in electron volts) were allowed to fall on a target of carbon for about 15 minutes in quantities equivalent to a current of 10 microamperes. The target was then mounted in an ionization chamber in which both particles and gamma ray activity could be detected. A second ionization chamber was placed adjacent to the first but was so shielded that only gamma rays (or neutrons, if any) could get into it. A plot of the intensity of activity against time for both gamma rays and positrons (1st. chamber) and also for the gamma rays alone (2nd. chamber), shows the same half period of 10.3 minutes and the conclusion drawn was that the same radioactive process is responsible for both positrons and gamma rays and that the gamma rays themselves have their origin in the annihilation of the positrons in conjunction with the electrons.

To check the correctness of the last conclusion a simple but most ingenious method was devised. A piece of carbon, recently bombarded in the manner just described was placed active side **up** directly above one of the ionization chambers. Assuming that the positrons appear in all directions, half of them will go **down** into the carbon and be annihilated there. The other half will go **up** and annihilation will take place in free air. The former half will therefore produce their supposed annihilation gamma radiation within comfortable range of the ionization chamber on which the carbon rests, while the latter half commit suicide at a considerable distance from the detecting instrument. Having determined the intensity of ionization under the above conditions, the carbon was then covered with a piece of aluminum, and it was found that although this aluminum covered only the **upper** but **active** side of the carbon the intensity of ionization in the chamber was doubled by this addition. Why? Because the half of the positrons which previously escaped upwards to be annihilated far from the chamber were now stopped by the aluminum barrier and were annihilated therein, thus producing their swan song gamma rays within easy range of the detector and thus doubling the effective ionization due to gamma radiation.

Equally clever is the work of Thibaud (17) which leads to a similar conclusion.

This investigator employed an original method, devised by himself and called the "Trochoid method", for the purpose of measuring the specific charge on the positron and also for the study of the absorption of these particles. For the details of the specific charge measurement, the reader is referred to the original papers. What we are interested in now is absorption phenomena. By locating a source of positrons (salt of Rd. Th. in lead 3 mm. thick) in the edge of a gap between the pole pieces of an electromagnet, in a position where there is considerable radial gradient,—these particles are made to spiral in a trochoidal path, and although they may be emitted by the source in various directions they are brought to a focus in a region diametrically opposite to the position of their source in the peripheral part of the electromagnet gap. Thibaud claims from 100 to 1000 times greater yield of particles for this method over any scheme employing magnetic deflection methods.

In the determination of the mass absorption coefficient of platinum by using photographic registration, data was obtained which enabled Thibaud to plot the logarithm of transmitted intensity (measured from the photographic density) against mass per unit area of the absorbing screen. This he did for both electrons and positrons and the curves for both (when the platinum screen was used) show a straight portion which is followed by an upward concave trend approaching a nearly horizontal asymptote.

This is interpreted as an approach to a condition in which the effect produced on the film by photons excited by the electrons is becoming comparable with that produced by the few electrons which are not absorbed.

The contribution of the photons from X-ray scattering due to electrons is only 1/7500 of the total effect, but that due to the positrons is 1/180 of the total and fifty times greater than that produced by the negatives, so that at a thickness of platinum where only 1% of the positrons get through there is still found an intense and penetrating radiation. When the mass absorption coefficient for these photons is calculated it is found to be of the order of $0.2 \frac{\text{gms}}{\text{cm}^2}$; suggesting photons of energy of half a million electron volts. Evaluating the photographic effectiveness of these rays in terms of X-ray photons of similar energies Thibaud concluded that the positrons produced 50 times as many photons as the electrons. Since in the case of platinum there are about 0.04 photons per electron produced it follows that approximately two photons per positron are produced. The remarkable combination of experimental skill and logical reasoning has thus led to two conclusions which fit in nicely with the theory that the photons arise from a fusion of positrons and electrons, the process producing two photons which share the energy derived from the rest mass of the two oppositely charged electrons.

Thibaud further concludes that the processes of creation and annihilation of pairs differ in this respect: in creation a single photon may produce the two electrons plus and minus, whereas in annihilation the two electrons must give rise to two photons,—at least when the process takes place in free space. Thus the creation of positrons seems to require the "support" of a nucleus to take up a certain amount of the momentum which would not otherwise be conserved. Thibaud also describes the gamma ray photons of $.507 \times 10^6$ volts proceeding from RaC and Th C" and observed by him in 1925 to the conversion of "natural" positive electrons emitted by the radioactive substance itself and converted into radiation before they escape.

The experiments of Williams (18) give an additional confirmation to the theory of the origin of scattered gamma radiation from positron annihilation.

Employing a 0.8 cm. lead filter to cut out the low energy Compton scattering and yet leave the softer of the components attributed to annihilation processes, the above named investigator measured this type of scattered radiation with successively thinner and thinner scattering foils of lead. He thus reduced the thickness of the scatterer down to dimensions which were **less than the average range of positrons in lead.**

Under such a condition many of the positrons formed should be able to escape from the lead before annihilation, so that as measurements were made on decreasing thicknesses of lead the scattered radiation should decrease much more rapidly than at a rate proportional to the first power of the thickness,—if the creation-annihilation theory be correct. Williams found that at a thickness of 0.002 cm. of lead the value of the intensity of the components of radiation in question was only 30% of the value corresponding to its linear variation with the thickness. He concluded that at least 70% of the radiation is therefore due to annihilation.

Returning again to a consideration of experiments of the type performed by Gray and Tarrant we noted that in addition to the half million volt gamma radiation reradiated from lead bombarded by 2.62 million volt gamma rays, there also appeared a radiation of higher than half million volts. This component or band of radiation gave considerable difficulty and could not be explained satisfactorily by the direct conversion of gamma rays to electron pairs, and of positrons and electrons **at rest** to gamma rays of equivalent mass-converted energy. This dispute as to the amount, energy and cause of this anomalous radiation has apparently been cleared up by E. O. Lawrence and his co-workers at the University of California. For with the advantage of their cyclotron for producing high velocity bombarding particles they have been able to determine that there is no definite line or band of converted radiation higher than a half million volts, but that the effects which led other workers to conclude to such radiation is merely a statistical distribution of gamma photons formed by the combination of pairs of electrons and positrons, **one of which was in motion at the time of conversion.**

Thus the photons formed will have the mass-equivalent energy **and in addition** the kinetic energy of either positron or electron, and their total energies will be above that of the normal radiation formed from pairs at rest. This explanation was proposed at the series of lectures given by Lawrence at Harvard University in January 1936 and was at that time unpublished.

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THE GENERAL PHYSICS COURSES AT GEORGETOWN

(Presented at a meeting of the College Teachers of Physics of the District of Columbia. February 17, 1936.)

By way of introduction, let me say that we agree thoroughly with Dr. Brown's statement of the general objectives of college physics, and endorse his position heartily. Our general aim at Georgetown, however, leads us to make several additions to Dr. Brown's list, or rather, to place added emphasis on points already listed by Dr. Brown. We attempt to correlate our courses in physics not only with the other physical sciences and mathematics, but with philosophy as well—and philosophy we regard as a science essentially as rigorous as mathematics, and of wider scope and greater complexity. The philosophy of external reality rests on the physical sciences as the means for obtaining precise knowledge of the world of physical things. The philosophy of knowledge rests on an understanding of the methods by which knowledge is actually obtained, and in the end evaluates the different methods. As the physical sciences, and particularly physics itself, have been so fruitful a source of knowledge, they form an indispensable introduction to the philosophy of knowledge. In our view, philosophy is not independent of the physical sciences, nor are the physical sciences complete or independent in themselves.

It follows that we oppose, and prevent, immature and undue specialization; and that our candidates for degrees are held to rather rigid programs, all of which include courses in physics and philosophy.

To fit into our general scheme, our elementary physics courses are designed to give the student the more obvious conclusions of physics, an ability to think in terms of physical principles, and, particularly, as precise a knowledge as possible of the scope, nature, and actual methods of the science. This knowledge, we find, can be obtained only by intelligent labor in the laboratory, in deriving formulae, and in solving problems. The precision of measurement and observation, and its implications, occupy a place—and a practical place—in our most elementary course, for we attempt to teach physics rather than applied mathematics. For this reason, also, all our elementary courses begin with optics, rather than mechanics—to emphasize at the outset the approximate character of physical methods and conclusions, and the essentially experimental nature of the science.

The title of this paper, "The General Physics Course at Georgetown" is misleading, for we have at present two quite different elementary courses, and next year shall offer a third. We do this because our beginners fall into three very different groups:

1. Candidates for the degree of Science.

2. Candidates for other degrees who have had little or no mathematical preparation, and many of whom are, to say the least, luke-warm in their interest in physics.

3. Candidates for the Arts Degree who have had considerable mathematics in college, are interested in physics, and are in general more capable than the previous group.

For the second and third groups we offer one-year courses of three lectures, one quiz, and one laboratory period a week. The course for the second group is the most elementary we have. We try to arouse interest with numerous and spectacular demonstrations during the lectures and in the museum. A good deal of the work is necessarily on a qualitative basis, but the students are still held to derivations requiring no more than algebra, geometry, and simple trigonometry; and in the laboratory quantitative results, generally with estimates of precision, are insisted upon. Much of the spade work is done in the quizzes, when the class is divided into sections of about twenty men. The laboratory sections are of about the same size. In the laboratory the students are left to their own devices as far as possible. We use our own manual. The section on each experiment contains a fairly full account of the underlying theory, and the details of instrumental manipulation. Too detailed instructions for the actual performance of the experiment are avoided. Most of the students soon learn to read up on the experiment ahead of time, and to proceed carefully and cautiously. Some even learn to read intelligently. Little is done with modern physics, because we are doubtful of the worth of presenting "simplified" expositions of problems that seem, just now at least essentially complicated. The course is not particularly popular.

The third group has just appeared. We now have a small number of candidates for the Arts degree who elect courses in their first two years covering both volumes of Griffin's "Mathematical Analysis" and are ready for physics in the third year. Their course, as we plan it, will follow much the same lines as the more elementary course, but will take advantage of the excellent preparation, and greater interest and ability of the group.

For the first group, candidates for the science degree, the minimum requirement is one two-year course taken in the first two years. This course is designed to combine the more usual elementary and intermediate courses; the students go from it directly into the upper division courses. High School Physics is not required; the various divisions of the course start from the beginning, but on as broad and general a scope as possible. In the beginning of the course demonstrations are frequent, but after the fundamental concepts of mechanics are developed, the demonstrations are deliberately reduced to a minimum. Demonstrations are, of course, necessary in other parts of the work, but not primarily for their entertainment value. Purely qualitative discussion is eliminated as far as possible; the aim is to provide a thorough quantitative foundation for advanced work in the physical sciences, and the difficulty of rigorous methods is faced as soon as possible.

The course, for the first year, runs parallel with a mathematics course covering the first volume of Griffin's "Mathematical Analysis", arranged in such a way that the student is able to make use of the fundamental notions of the differential and integral calculus from the beginning of his serious work in mechanics. Not all of the students continue in mathematics beyond the first year, so that additional mathematics—notably the elements of partial differentiation—must be given in the second year as part of the physics course.

Whenever it is possible, the attempt is made to eliminate the counterfeit science of special and often invalid solutions, and to bring the students to the general principles and methods that made the development of the science possible, and that are indispensable in practical work of any complexity. Needless to say, there are very definite limits here—the Principle of Least Action can hardly be brought into the first course in mechanics. The Principle of Conservation of Energy, however, and the Laws of Motion can be insisted upon. The second year begins with thermodynamics, and here the student can be brought face to face with a method of complete generality. It is possible, in thermodynamics, to reach the Clausius-Clapeyron Equation, in electricity to stress the reversible cell, and eventually to develop the Gibbs-Helmholtz Equation for the reversible cell, and to discuss heats of formation of compounds.

Wherever it seems useful, different methods are applied to the same problems. Both vector and scalar methods are usually developed in mechanics. Numerical problems of varying complexity are used extensively, but a serious attempt is made to bring out the fact that the derivation of any equation is the general solution of a whole class of problems.

Little is done with modern physics, but the classical concepts are developed with the modern field in view, so that the student will at least have nothing to unlearn in his later work.

Texts in this course have been a problem. Frank's "Introduction to Mechanics and Heat" now seems satisfactory in the first year. For the second year we still use one of the elementary texts extensively supplemented in the lectures, but plan to try next year a fairly advanced text in electricity, and rely on the lectures and supplementary reading for the rest of the course.

F. I. B.

ENTROPY

REV. J. JOSEPH LYNCH, S.J.

The purpose of this paper is to try to get a simple and satisfying definition of a term that has always puzzled the writer. Most texts on general Physics carefully avoid using the term. Ganot, Saunders, Spinney, Kimball, Caswell, Duncan and Starling, Knowlton, Foley, Moore, Smith, Hector, Millikan and Gale, Edwards, Randal, Williams and Colby, Sheldon Kent, etc., and Edser (General Physics) omit the term altogether, partly perhaps because it really belongs in Thermodynamics, but partly no doubt because it is difficult to define in general physical terms. However, Miller, Watson, Duff, Franklin and McNutt and Daniell are among the few who attempt a definition in their texts on General Physics.

Historically, Clausius (1822-1888) is credited with the first use of the term in 1865. He took it from the Greek (transformation) and intended *en*tropy to be a parallel word with *en*ergy, the former meaning transformation contents and the latter work contents. Applied to the universe, he defined it as a measure of the unavailability of its thermal energy for conversion into mechanical work. His statement ran, "The entropy of the universe tends to a maximum".

The first use of the word in English is credited to Ttait (1831-1901) in 1868. With his typical chauvinism however, he deliberately used it in a sense which was the exact opposite of that introduced by Clausius. Tait defined entropy as a measure of the availability of thermal energy and worded his statement, "The entropy of the universe tends to zero." Clerk Maxwell, a pupil of Tait, at first followed Tait in his use of the word, as he (Maxwell) says, erroneously. In 1875 however, Clerk Maxwell inserted a note in his text on heat reverting to the original meaning of entropy as defined by Clausius. Since that date the meaning of the word in the sense intended by Clausius has been universal.

We might start by giving some definitions of entropy used by classical authors.

Planck: "Entropy is a definite property of the state of a body expressed by the equations:

$$\begin{cases} dS=\dfrac{du+pdv}{T} \\ S=C_v \log T+R \log V+\text{constant} \end{cases}"$$

or: "Entropy is the thermodynamic probability of the state of a body."

Glazebrook: "The entropy of a substance is a function of its state which is most conveniently defined by reference to the heat taken in or given out while the state of the substance undergoes change in a reversible manner. The heat taken in or given out divided by the absolute temperature of the substance measures the change of entropy, i.e.; $S\phi=Sw$

Poynting: "If a substance at temperature θ receives heat Q it is said to receive entropy Q/θ. If the gain or loss of heat affects the temperature, the amount of entropy gained or lost is $\int dQ/T$."

Wulf, Watson, Duff, Miller and Franklin and McNutt give the usual definition, Q/T. Franklin and McNutt effectively introduce the Humpty Dumpty rhyme to bring out the idea of thermodynamic degeneration.

Looking at entropy from the mathematical standpoint we see an excellent reason for the introduction of the term. If we consider a gas to which an infinitesimal quantity of heat dQ is added, the first law of thermodynamics tells us that;

$dQ=du+pdv$ where: u=internal energy
p=pressure
v=volume

There is, however, no function Q of u and v of which dQ is the differential. We need an integrating factor to make dQ a perfect differential. Such an integrating factor is $1/T$ as the following shows:

From the definition of specific heat;

$$dQ=C_v dT+pdv \quad (C_v=\text{specific heat at constant volume})$$

Substituting for p from, $pv=RT$, we get,

$$dQ=C_v dT+RT\ dv/v$$

Dividing by T,

$$\frac{dQ}{T}=\frac{C_v dT}{T}+\frac{Rdv}{v}$$

Therefore: $\int\frac{dQ}{T}=C_v \log T+R \log v+\text{const.}$

Therefor dQ/T is a perfect differential $=dS$ ($S=$entropy)

Thus mathematics gives us a reason for the introduction of the term entropy but does not give us a definition.

The classical definitions of entropy so far given while good are not quite satisfying. Let us take the case of change of entropy due to diffusion. Suppose we have a gram molecule of each of two gases, say Hydrogen and Oxygen. Suppose moreover that they are at the same temperature and pressure. If we bring the gases together so that now the two gases together have the same volume that each alone had formerly, using Gibb's law for the entropy of a gas mixture, we find that the entropy of the mixture is the sum of the former entropies of the separate gases. If however we merely allow the gases to diffuse one into the other so that the volume of the mixture is the sum of the original volumes of the gases, applying Gibb's law again we find that the entropy of the mixture is some three calories per gram more than the sum of the original entropies of the separate gases. Without going into the paradox that tells us that if the two gases are the same, or isotopes of the same substance, there is no increase in entropy, let us see how the above definitions of entropy apply to this increase in entropy due to diffusion. With the exception of Planck's, these definitions introduce the terms, heat received or heat lost, or rise or fall in temperature, and are not satisfying since in diffusion whatever change there is in temperature, or quantity of heat can only be reasoned to,—it does not appear explicitly.

If we compare the diffusion of two such gases with the "diffusion" of two quantities of water at different temperatures, we note in both cases a rise in entropy. If we then ask ourselves what change can be said to have taken place in the two cases—what positive quantity has been increased in the two cases—the simplest answer is,—the unavailable energy. In both cases a certain amount of available energy has been lost and in both cases it can be measured as so many calories.

We obtain a better picture of the loss of available energy in diffusion by comparing it with the impact of two spheres. If the spheres have different masses, after impact the momentum will be the sum of the former momenta, but the kinetic energy will be less than the sum of the former kinetic energies—some has been made unavailable by impact. If the spheres have the same mass and velocity, then after impact, as in the case of the diffusion of a gas into more of the same gas, there is no loss in available energy.

All things considered, if we wish a simple and satisfying definition for a General Physics course, it seems best not to define entropy itself but to define a change in entropy as a change in the unavailable energy. Planck's Thermodynamic Probability (first suggested by Boltzmann) would require too much preliminary explanation in a general course.

VIBRATION GALVANOMETER

Edmund B. McNulty, S.J.

Our laboratory has been interested for a very long time in accurate and simple A.C. bridges. The first thing to obtain was a good source of A.C. power and then a detector. At first a microphone hummer was thought of as a source of supply but later this was discarded in favor of a vaccum tube oscillator and amplifier, on account of the high power output. Next came the question of obtaining some sort of a detector. We did not care to use phones on account of laboratory difficulties, so we cast about for some other null indicator. The simple rectifier and meter first presented itself but, although this was good for ordinary purposes, we found that in very accurate measurements many errors were introduced.

In certain A.C. bridges, unbalanced circuits gave rise to spurious oscillations and also it was very difficult completely to eliminate in the main oscillator the harmonics of the fundamental frequency, so the meter rectifier combination instead of giving the tone null point, gave only the average of the fundamental and secondary oscillations. This was particularly noticed in dealing with A.C. bridges to measure the conductance of electrolytes.

The next thing that suggested itself was the use of a vaccum tube null detector as described by R. D. Huntorn in "Review of Scientific Instruments" Oct. 1935. Using this as the fundamental circuit we attempted to introduce a filter and thus detect only the fundamental frequency of the oscillator. After a great deal of experimenting we found that, although we could fairly well eliminate the secondary frequencies, still another difficulty presented itself. Namely that the oscillator and null detector were both operated on the A.C. line. The reactance between these two instruments, of course rendered accurate results impossible. While debating with ourselves whether to battery operate the detector and thus eliminate capacity effects from outside, we picked up a vibrational galvanometer in the laboratory which was the simple type developed by P. G. Agnew in A. I. E. E. Vol. 39 Part I. After very carefully adjusting the vibrating wire, we finally made it resonate to the frequency of the oscillator. We applied this to various bridge circuits and found that it gave very excellent results. However on trying again the next day we found that it was necessary to re-adjust the vibrational galvanometer and this was a very tedious task, for if the reed is off resonance a few cycles the sensitivity drops to a very marked degree. From this we concluded that the vibrating galvanometer was the accurate but not the practical detector.

After some study on the subject we thought of the following method. We inserted a small variable condenser of .00035 mf. in parallel with the tank circuit on the oscillator. Although this did not change the frequency very much we found that it did change it enough to cover the range of the variation of the oscillator and the variation of the vibrating wire. This was indeed a simple method of adjusting the oscillator to the frequency of the vibrating galvanometer and throughout a variety of measurements the vibrator and the oscillator could be easily controlled so that the galvanometer was always operating under optimum conditions.

After reviewing the different methods we have tried, we concluded that this form of the vibrational galvanometer and oscillator combination was the most economical, simple, accurate, and sensitive means that we could adopt for laboratory use.

SCIENCE AND THE LIBERAL ARTS

THE COLLEGE OF LIBERAL ARTS AND THE LABORATORY SCIENCES

REV. PAUL L. CARROLL, S.J.

I conceive a University as a dynamic unified living organism whose structure may be as intricate as interwoven muscle, bone and nerve, yet whose function is as smoothly coordinated as the graceful movements of a gliding skater. I conceive the College of Liberal Arts as the pulsating heart of this great organism. Four channels of life-sustaining blood radiate from this heart as so many throbbing arteries terminating in capillaries that supply every contiguous college or school. The streams that flow in these channels are laden with soul-nourishing religion, with mind-seasoning philosophy, with tongue-enervating language, with cosmic-revealing science. One stream alone I now trace to its source and examine its multiple fountain-head. Just as the heart of every great organism is subject to its phases of systole and diastole so the heart of the University, the College of Liberal Arts, with the result that a wavelike motion of crest and trough is produced. Today Science seems to be riding high on the crest. In this paper the word science is restricted to the Chemistry, Biology and Physics commonly taught in the Catholic College of Liberal Arts.

England's Belloc wrote: "There never was such a time as ours for the use of magical words divorced from reason and used as talismans. There is 'Democracy', there is 'Progress', there is 'Recent research has established', and there is 'All Authorities are agreed'; but I think the worst of all is the word 'Scientific'. It is used with finality, as though, once used, all discussion ended. A thing having been established 'Scientifically', there is no more questioning it . . . The word 'Science', properly used, means organized knowledge. . . . The moment any of us sees the word 'Scientific' let him beware; it is the sign-post, like one of those big colored marks they put up on roads to warn the motorist that he is in danger of running over fools who may attempt to run across the road in front of him. It ought not to be so. Science is a noble word, for it originates in that pursuit of truth which is the second noblest of men's activities." Thank you, Mr. Belloc.

A certain John Gould Fletcher said in an address given at the Southwestern Conference on Higher Education held at Norman, Oklahoma: "The belief that the world was about to be ruled by science, and that science would mechanically usher in a new age of unlimited progress, was the classical and cherished belief of our grandparents, the Victorians. And it still rules the world today, despite the fact that the ablest scientific men of our generation have taken refuge in some mystical over-belief, or have concluded that science, in itself, offers no final key to the problems that afflict mankind. The belief in progress still rules the western world today, however, this belief that by making things scientific we can get somewhere." A mere verbal fanfare, Mr. Fletcher, for those who will be duly impressed, or for those who are taking refuge in the psychiatrists' pigeon-hole for the feeble-minded, or for those who are dangling at the periphery of our whirling educational sphere.

I do not intend to go into a tail spin of scientific technicalities nor make a nose dive into a mirage; no, it would defeat my purpose to clothe my statements in an unintelligible jargon or to paint for you a scene of imaginary scientific grandeur. The science of chemistry, biology or physics means two things to me; first, an accurate knowledge of the facts tabulated under these subjects in all of their many ramifications, and secondly, the thoughtful use of these facts. The various courses in these sciences offered in the College are designed to furnish the facts, but it is up to the teacher to coordinate the facts so as to provoke thought on the part of the student who must make use of the facts for theoretical and practical purposes. Such is education in the sciences. The thought-stimulating Dimnet writes: "The more a man thinks the better adapted he becomes to thinking and education is nothing if it is not the methodical creation of the habit of thinking."

There does not seem to be agreement among educators themselves regarding the purpose, scope and aim of this painful process we call education in the broadest sense of the word, to say nothing of education in the sciences. Abraham Flexner roundly declares that most college students amongst us are "not being educated at all", and that even of those who attend the best accredited institutions of learning "There is no certainty that they have been properly prepared or that they are pursuing a course that deserves to be called a liberal education". Dr. Flexner to the contrary notwithstanding we do hold that we are giving a liberal education in our Colleges and I hold moreover that the sciences contribute their share. The College of Liberal Arts is not a pre-professional ante-room for any Medical or Dental School. A rather prominent Catholic writer has this to say about education: "I think that one can safely say that education in America today is somewhat of a risk. With its growing complexity, its short-sighted utilitarian aims, and its stalwart stupidity, it succeeds in obliterating a youth's intuition without teaching him to think. It gilds him over with superficialities, makes him vaguely sensitive to caste, bloats him with a particularly empty vanity, and sends him out with a shining eye and a hollow head to join the long parade of the unemployed". I think we might justly remind this writer of the words of St. Augustine: "Learn to distinguish the charlatanism of words from the realities of things."

Let us now look at some of the purposes of our scientific courses. First, it is the aim of the College to offer a fundamental knowledge of the sciences for those who wish to sprinkle it in between their linguistic, historical or philosophical courses. Secondly, there is the more intense training in the sciences for the advanced students, particularly the majors, but always of course in conjunction with their other branches. Thirdly, there is special attention to be given to a small group of students who hope to be the teachers of the future either in the general science courses of our grade and high schools or as adjutants in hygienic programs. Fourthly, there is the preparation of those who will some day replace us. This or that exceptional student may show definite signs of scientific interest and ability even in his College days. A teacher should give such a student every encouragement, both by example and precept, to continue his studies in the field of his choice. Fifthly, there are certain colleges and schools which I previously described as contiguous to the College of Liberal Arts, namely, College of Journalism, School of Speech, College of Business Administration, etc. True it is that a modicum of scientific knowledge will be appreciated by the future business man, by the writer, the debater, the reporter and the public speaker. Provision for this scientific information is made by the close interrelationship between the various schools and colleges which I have already indicated.

Now I would like to show how we can attribute to the sciences the power of "methodical creation of the habit of thinking". The sciences must justify their place in the curriculum by proving their worth to the present educational system. The sciences of biology, physics and chemistry actually do have some method in their madness. While the science curriculum is pretty accurately predetermined by centralized standardizing agencies, still there is a certain amount of latitude left to the individual schools. The following discussion will be applicable, I trust, to most of our Catholic Colleges of Liberal Arts.

We can divide our science classes into didactic and recitative periods. In the didactic I would put the lecture and the laboratory, while the quiz belongs to the recitative. There is, however, another type of class which is becoming more and more popular and I do not refer to the seminar. I speak of the period in which there is a happy blending of instruction, laboratory work and quizzing. I could give an eloquent defense of this method of teaching a science, but let it suffice to say that its worth is best attested by the success attending it. Let us consider the lecture period first. During this class the student hears about scientific facts, laws and theories concerning, in the case of biology, living things; in the case of physics, the phenomena apparent in the universe; in the case of chemistry, the elements and compounds both organic and inorganic. True it is that the bare facts may be read from a textbook, hence the real value of a lecture resides in the method of presentation and the proper coordination of any series of facts or laws or theories. We do not want our students to say: "He is a grand lecturer", but we do want them to say: "He is a thoughtful lecturer; we can follow his train of thought". Naturally when looking for examples to illustrate my point I will go to the science with which I am most familiar. Hence I will give you several instances in which biology has a very intimate bearing on the thinking of the college student and especially the Catholic student in the Catholic College. First, there is the meaning and implications of the origin of life; secondly, there is that accurate information concerning sex and the production of a new individual, the physiological evils of sterilization and birth control; thirdly, there are those burning questions of heredity, genetics and evolution. I need not pause here to make applications already forming in your minds.

Let us go on to the laboratory period. It is during long hours spent in laboratory work that the student can verify, even if only in an elementary way, the facts presented in the lecture. He can dissect out bone, muscle and nerve; he can prove for himself that H_2S gas has a peculiar odor; he can substantiate the fact that the period of a pendulum is constant when the arc is extremely small. In a word, a carefully arranged group of experiments exercise his powers of observation, increase his ability to use previous information, develop a sense of responsibility and finally provide a discipline for his five senses as well as his mind. When students first come to the laboratory they remind me of the caterpillars in Fabre's backyard that went round and round, each one close after the other, without ever getting anywhere in particular.

The quiz which should follow the lecture and laboratory periods provides an opportunity for the student to show just how much thinking he has been doing. The mere memorizing of facts, or a fancy drawing, or an orderly protocol may help him get a passing grade, but more than this is required, for if we do not find during the written or oral quiz evidence of thought on the part of the student we must confess that our science is not living up to the ideals that have been set for it and which the college has a right to expect.

I do not consider any class period unimportant whether it be lecture, laboratory or quiz, but I do place above all else the responsibility resting on each teacher for every student entrusted to his care. There is no moment of any class period when this grave responsibility can be shirked, although the variation in type of student and the burdensome character of science teaching may at times reduce one's patience and physical strength to the breaking point. We can never drown our cares as the fox would drown fleas. The fox, as you all know, is a very wise animal, in fact entirely too wise to be pestered long by a hoard of fleas. So one day he went down to the creek and very slowly backed into the water. The fleas began to scamper headward as the fox gradually immersed himself. Finally only the tip of his nose remained out of the water and on it had gathered every shivering flea. The fox quickly ducked his head and swam away leaving all the fleas to their sad fate.

Just as volumes could be written about the relation of the teacher to the student, so much could be said about the students sent to us. By way of contrast I am going to give you a pen picture of a model student found in an essay read by the Blessed Edmund Campion at Douay about the year 1570. "In the course of a few years, with the help of good teachers in the common schools, he mastered all the difficulties of grammar and the rudiments of knowledge. He knew Latin well, he knew some Greek; he was eloquent and ready in his own mother's tongue in which he could turn a rhyme. He knew how to paint, to play the lyre, to sing by note; he wrote in a clear flowing hand; he was constant in the practice of his style. Moreover, so bravely and perseveringly did he keep up these opening studies that, by the time he had reached manhood and was entering on philosophy and other sciences, he had already given no mean proof of his ability."

I am sorely tempted to say something about another kind of responsibility and I think I will drag this temptation out into the light and conquer it by yielding to it. You have heard, perhaps ad nauseum, of scientific equipment, museum specimens and library facilities. You have heard too that the science courses are costly to operate. You may have heard that certain colleges have a grand array of scientific equipment and a well filled library which has caught the eye of prospective students. You have undoubtedly heard that competition among the colleges is keen, and finally you may have vaguely been aware of minimum requirements of standardizing agencies. Now it is perfectly futile to get excited about the cost of scientific equipment as we have no control over this industry and it is sinful for us to envy other more fortunate colleges, but we must interest ourselves in maintaining the integrity of our student body and meeting minimum requirements. I agree with Miles Connolly who wrote ten years ago that we have no sympathy with the Catholic parent or student who tries to justify his presence at a non-Catholic college on the ground of superior equipment. Our colleges should conduct their science courses within their means and hence any large expenditures requiring a lump sum of thousands of dollars is out of the question. However, I do maintain that certain equipment should be purchased at regular intervals in order that the usefulness of the sciences to the general scheme of education in our colleges be not impaired. I believe that a certain sum taken from the various laboratory fees should be set aside each semester for the purchase of new equipment, books and periodicals. I fear that efficient instruction in the science courses of many of our colleges is impaired by the want of the tools with which the scientist works. Walk into the library of any of our colleges and try to find the most common current scientific periodicals. Go through the corridors of any of our school buildings in search of a very ordinary print of the likeness of a great scientist. I once dug up some nice etchings of Mendel and Pasteur and I hope to see them hung before my first sabbatical leave. Instead of lines of inexpensive wall-cases filled with specimens gathered from year to year at little or no cost, the student gazes at blank walls when he is confined to the building on account of inclement weather. I know of one school that has a very expensive piece of scientific equipment, a hot-house whose usefulness for teaching purposes may be expressed by this little definition I either read or overheard, "A hot-house is a place where green freshmen are ripened."

I am not really throwing bricks at the science equipment of our Catholic Colleges of Liberal Arts because I live in a glass house. My point is simply this: If the sciences have a definite place in the College and we are agreed that they have, then the accessories that go to make the sciences possible cannot be wanting. The need of equipment for both teacher and student should be the measure of quantity and quality. The use and protection of our present equipment might prove sufficient matter for a science teacher's examination of conscience.

In conclusion I wish to say that since educators admit that at least a cultural knowledge of science is one of the marks of an educated man, we on our part should strive with increasing effort to assure our Catholic Colleges of Liberal Arts that no one of these marks which should be found in her graduates will be missing.

SEISMOLOGY

RECENT PROGRESS IN SEISMOLOGY

REV. J. JOSEPH LYNCH, S.J.

When a baby first learns to walk, it likes to look back from time to time to see how far it has travelled. Seismology is still taking baby steps and in this article, I propose to look back and see how far we have traveled seismologically in the last few years.

In the matter of instrumental development, the most recent progress has been the perfection of a new instrument especially adapted to the detection of local earthquakes. These local earthquakes are known to have an extremely short period. In contrast with the last short period instrument developed some ten years ago, the Wood-Anderson torsion pendulum with a mass of seven-tenths of a gram, the new Benioff instrument has a mass of one hundred kiligrams and the extremely short period of one half a second. The instrument is somewhat similar to the older Galitzin instruments and, like them, uses galvanometric registration, but its magnification is enormous. An idea of the sensitivity of the instrument can be had when we say that a ground action of one two-millionth of a pinhead is easily discerned on the galvanometer. The magnification for extremely short period waves is of the order of a hundred thousand. Since its invention, hundreds of local quakes are recorded annually that would otherwise pass unnoticed. But though so admirably adapted to the recording of local quakes, its use is by no means confined to local disturbances. It has the added feature that it can be coupled to a long and short period galvanometer simultaneously, making it a two in one instrument for the recording of both local and distant quakes. The acquisition of this new detective to its staff makes seismology a veritable Scotland Yard.

It will be hard for an earthquake to escape detection now. Turning from the instrument to the records it produces, one type of record that has long puzzled seismologists is the record of micro-seisms. These micro-seisms are small vibrations with a period of a few seconds and a ground amplitude of about one-three hundredth of a pinhead that continue periodically for several days at a time. They occur whenever we have a severe windstorm or whenever we have a sudden cold spell, and they are slight up and down motions of the ground extending down some depth and felt simultaneously over wide continental areas. Extensive investigations have been carried on to determine the cause of these baby quakes and to date, there are three explanations offered. One explanation is that they are caused by the beating of the surf against rocky coasts. A second explanation is that the ocean imparts a vibratory motion to its bed which, in turn, imparts it to the entire continent. A third explanation is that they are vibrations caused directly in the continent by barometric changes above it. The majority of seismologists seem inclined to favor the latter.

Another question which the seismograph record is expected to answer is: "What is the nature of the core of the earth, is it solid or liquid?" One of the waves started by an earthquake is what is known as a shear wave which can only travel through a solid. Does this sheer wave travel through the core of the earth? If it does, the earth is a solid. If it does not, the earth is a liquid. To date there is much dispute as to whether or not this shear wave has been proven to have passed through the core. Seismologists have looked for it on their records but it is not easy to recognize, since it always occurs, if it occurs at all, in the midst of a group of other reflected and refracted waves, many of which are stronger than itself. The seismologists' task in identifying this wave is like that of an ardent radio fan trying to tune in to his favorite distant station when it is sandwiched between two more powerful local stations of about the same wave length. Seismologists in Japan, in America and elsewhere, claim to have positively identified this core shear wave on their records, but there are still some authorities who doubt their findings. The consensus would seem to be that the shear wave does pass through the core and, hence, that the core is solid. However, the decision to date is not quite unanimous.

Perhaps the most interesting topic discussed by seismologists recently, is the depth below the surface at which an earthquake occurs. It was previously thought that earthquakes occurred comparatively near the surface within a depth of about ten miles. In recent years, it has become apparent that earthquakes occur at much greater depths than this. We have reason to believe that they can occur at a depth of five hundred miles. What leads us to believe this? The first thing that led seismologists to suspect so great a depth for the origin of an occasional quake was their inability to locate some quakes. With plenty of perfectly good records obtained from well equipped stations occasionally, it was impossible to locate the quake in a position which would satisfy the distance demanded by the records of the various stations. As an extreme case—a well equipped station was occasionally found to place a quake as much as four or five hundred miles away from the true location. This error I refer to was one of estimated distance—not of direction. (There is often an uncertainty of direction but rarely one of distance.)

Now the tables by which the distance of a quake is read off from the time difference between the arrival of the thunder and lightning waves (longitudinal and transverse waves) of a record were computed on the supposition that the quake occurred near the surface. The tables would be in considerable error if the quake occurred five hundred miles down. It was suggested that these occasional errors of distance on the part of reliable stations were due to errors in the tables—or rather, due to the fact that the tables could not be used for such unusual depths of focus. For some such rebellious quakes, new figures were computed for various depths of focus, and it was found that the supposition of a suitable depth of focus enabled the readings of the various stations to be brought into agreement and the quake to be definitely located.

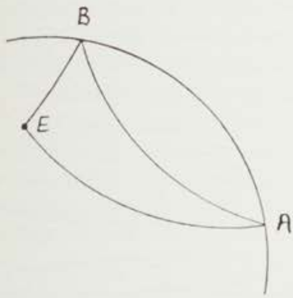

Figure 1.

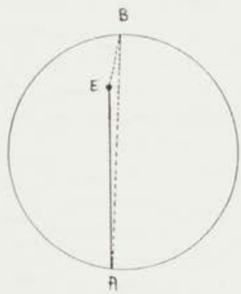

Figure 2.

Let us suppose now that a quake occurs at an unusual depth below the surface, at E in Figure 1. One wave should travel directly from the quake to the observatory at A. Another wave starting out with the first from E should travel up to the surface at B and from B down to A. It would arrive at A a little later than the first. Such a pair of waves were looked for in rebellious quakes, suspected of being at deep focus—and were found.

Suppose now as in Figure 2, the observatory were at the end of a diameter passing through the quake, then the time difference between the arrival of the two waves at A—the wave traveling directly from E and the wave going first from E to B and then from B to A—the time difference between these two waves is simply the time an earthquake wave takes to travel twice the distance from E to B, and hence, the distance EB is known since we know how fast an earthquake wave travels in the crust. EB is the depth of the quake below the surface or the depth of focus. The wave traveling directly from E is called the P wave or push wave. The wave traveling from E to the surface and then to the station is called the pP wave to distinguish it from the former. Tables have now been computed for the depth of focus corresponding to all possible time intervals between these two waves—the P wave and the pP wave—so that the seismologist is now able to determine not only the distance of the quake but also its depth of focus. In this way it has been found that many quakes have their origin at a depth of five hundred miles or so.

This discovery has brought up a further difficulty. An earthquake has usually been considered a fracture in the earth's crust. Is it possible for a fracture to occur at such a depth? The depth of the crystalline crust in which fractures might take place has been variously estimated from ten to thirty or forty miles below which is supposed region of flow. A depth of five hundred miles would seem, therefore, to be in a region where fractures do not occur. Two possible viewpoints arise then for these deep seated quakes. 1. They are caused by fractures—but fractures occur at much greater depths than was formerly thought possible. 2. They are not caused by fractures at all but by some other cause. What is the other cause? A suggested cause is taken from thermodynamics. Quite recently it has been found that at enormous pressure and only moderately high temperature, a change of state occurs in some substances with explosive violence. In the light of these experiments it has been suggested that a deep focus earthquake is the explosion resulting from such a change of state under the enormous pressure that exists hundreds of miles below the earth's surface. The matter has not been sufficiently discussed as yet to enable one to give the consensus of opinion. In recent writings, both the fracture and the thermodynamical origin of earthquakes have been advocated. The weight of evidence from seismology seems to favor the fracture origin of earthquakes. Briefly, this evidence is: 1. In some deep focus quakes, the bulk of the energy is in the shear wave—not the compressional or explosive waves which one would expect were the earthquake an explosion. 2. At the same location or epicentre we have both deep and shallow focus earthquakes occurring (at different times, of course). Since the shallow focus quakes are caused by fracture, it seems reasonable to attribute those of deeper focus from the same epicenter to the same cause. 3. Deep focus earthquakes so far have not been found off the beaten track of earthquakes—they only occur in definite earthquake regions. They would seem, therefore, to be brought about by the causes of earthquakes in general. If the thermodymanics explanationtion were correct, one would expect an occasional thermodymanic explosion somewhere off the beaten track of earthquakes. Yet in a period of twenty years or so, no deep focus quake has occurred very far from the equator or outside the Pacific Basin, but perhaps after all, we now know far less than we did of the origin of earthquakes because we now know so much more.

MANILA METEOROLOGICAL OBSERVATORY

THE MANILA OBSERVATORY AND ADMIRAL DEWEY

REV. WILLIAM C. REPETTI, S.J.

Since the American Jesuits came to the Philippines, or possibly before, a tradition has grown up in the States that Father Algue sent a typhoon warning to Admiral Dewey and thereby saved his fleet. This is one of the interesting traditions that labors under the defect of not being founded on truth.

The story implies, if it does not actually relate, that the warning was sent while a state of war still existed in the Philippines between the Spaniards and Americans, i. e., between May 1st and August 13th, 1898. Any typhoon message before or after this period would have been a matter of routine and not deserving of any special tradition.

The most conclusive argument against warning being sent to Dewey by Father Algue is the fact that there was no typhoon near Manila during that period. An examination of the meterological records of the Observatory shows that from May 1st to August 13th the highest wind velocity in Manila was 30 miles per hour. This would not have been dangerous to ships anchored in the bay.

Aside from the instrumental records, the Observatory diary reveals that on May 7th the captain of the port sent orders to the Observatory that typhoon signals were not to be hoisted while the American fleet was in the bay. He added that in case of typhoons the reports should be sent to him so that he could warn neutral ships.

It should also be recalled that Father Algue was, first of all, a loyal Spanish citizen at the time. In addition to this, he was something more than a mere citizen; he was the Director of an institution which was being subsidized by the Spanish government for public service. Any information which he might communicate to the Americans would render him guilty of the grave charge of "giving aid to the enemy". We can not imagine that Father Algue would be false to his trust.

As a matter of fact the American fleet was not exposed to more danger than the neutral ships. They received all necessary weather reports through the captain of the port or their respective consuls. The foreign ships had been warned by Dewey against free movement about the bay and it may be recalled that hositility with the Germans on this point was narrowly averted. An article in the National Geographic Magazine, Vo. 10, No. 2, by Major A. Falkner von Sonnenburg of the German Army, describes the situation in the middle of June. The American fleet was anchored near Cavite. He continues, "In front, just before the city of Manila, was a great squadron of neutral ships. There were three German, two French, two British, and one Japanese men-of-war, while between them were anchored chartered steamers full of refugees of the respective nationalities which Admiral Dewey's humanitarian warfare and broad-mindedness had allowed to be brought out of the beseiged town, the only condition being that the Spanish vessels had to fly the flag of the respective countries which were responsible for their return to the American authorities after the surrender of the town". The Americans were in circumstances which required them to be very much on the alert. If a typhoon had threatened Manila at the time the Americans would have at once detected unwonted activity and would have ascertained the reason for any movement of the neutral ships. This would have been sufficient warning without Father Algue being involved. On August 22nd, 1898, the regular weather reports to the captain of the port were resumed under the American regime.

This explanation should be sufficient to lay the tradition in a peaceful grave.

Father Algue did not meet Dewey personally until November 28th. An interview was arranged for him on the "Olympia" by Dr. Becker, an American geologist, and Father Algue's motive was to ask Dewey to exert his authority for the safety of the Jesuit missionaries in Mindanao.

NEWS ITEMS

Fordham University, Seismology Department.

On Friday, March 20, Father J. Joseph Lynch read a paper before the members of the American Physical Society, Metropolitan Section, at the meeting at Columbia University. The title of Fr. Lynch's paper was "Modern Seismology and Some of Its Problems." The discussion took up old and new theories on deep-focus quakes, structure of the earth's core, causes of deep-focus quakes, with an evaluation of the theories proposed.

Mr. Kevin O'Brien gave a lecture on Seismology before the Associated Members of The American Institute at the Institute Meeting Room, New York City.

Seminars, experimental work, and study of the literature of Seismology are being carried on, with eight members in the group.

The Earthquake Demonstrator which was exhibited at the St. Louis meeting of the A. A. A. S. last December has been installed in the Geophysics Laboratory, and is still causing considerable interest and comment. A more elaborate and perfected set-up of the machine is being planned.

The re-cemented and water-proofed Seismic vault has been completed and all the machines are being set up for operation. A new dehumidifier has been installed, a product of the Curtis Refrigerating Machine Co. The air in the vault is dehumidified and recirculated completely in one hour. Very good results have been obtained so far.

Fordham University, Chemistry Department

Rev. Francis W. Power, S.J., Professor of Chemistry has recently presented the following papers: "Function of Science in Education." Radio talk; March 18. — "Science and Religion." A lecture to the members of the Collins Chemistry Society at St. Peter's College, Jersey City, New Jersey. — He also read a paper at the meeting of the New York Section of the Microchemical Society, New York University, Washington Square College, on April 2. Father Power will also present a paper at the May Meeting of the North Eastern Section of the American Chemical Society.

New Method for Obtaining Vitamin B.

After five years of research, Fordham University chemists have worked out a process which eliminates more than half the steps in the older process and does away with the use of the expensive chemicals involved in isolating pure Vitamin B.

This substance (the antineuritic vitamin) is now in such wide use by biochemists and physicians, that a simpler and cheaper method of preparing it should arouse considerable scientific and commercial interest.

The main feature of the Fordham process is the use of Permutit, a sand-like substance widely used as a water-softener. Rice polishings are used as the starting material; these are extracted, and the extract is allowed to trickle down through the Permutit. The latter picks the vitamin out of the extract. The vitamin-rich Permutit is then treated with another solution to remove the vitamin which can then be isolated without the use of costly materials such as the salts of gold and platinum which have been used in the older processes.

There is only one ounce of pure vitamin in about a ton and a half of rice polishings, so it is easily seen how necessary it is to get a simple and inexpensive method for extracting such minute quantities. The Fordham process has also been tried on the extracts from yeast and from wheat-germ, both of which are comparatively rich in Vitamin B, and has given results on these sources as well.

The Fordham Permutit process has been worked out under the exclusive auspices of the University by Prof. Leopold R. Cerecedo, with the assistance of Mr. Douglas J. Hennessy, Mr. John J. Thornton and Mr. Frank J. Kaszuba.

The W. P. A. project has been inaugurated in the Chemistry department here involving our use of 11 persons. Of this number, 8 are chemists, 2 are classified as translators and one as a typist. The title of this project is "Biochemical Studies of Metabolic Processes".

A few of the chemists work on separate problems and the remainder assist in problems that are already in progress. The government allots $450.00 to be spent for supplies and equipment.

This number of workers was limited only by the laboratory space available here. To date the project has been satisfactory.

Loyola College, Baltimore, Maryland, Chemistry Department

On May 14, Rev. Richard B. Schmitt, Professor of Chemistry, lectured at Johns Hopkins University to the faculty and students of the Chemistry Department. The subject: "Recent Advances in Micro Analysis." This is the second lecture within the year.

Dr. Robert W. Wood, F.R.S., LL.D., Chairman of the Department of Physics and President of the American Physical Society, lectured to the members of the Loyola Chemists' Club on the subject: "Some Remarkable Properties of High Explosives." A capacity audience crowded the Chemistry lecture-hall to hear the distinguished lecturer.

The final meeting of the Chemists' Club was held on Tuesday, April 28, to hear Dr. Frank Owen Rice, of Johns Hopkins University, lecture on the subject: "The Chemistry of the Aliphatic Radicals."

Canisius College, Physics Department

Three new photometer benches with photo cell equipment have been installed in the Canisius College physics laboratories. The widespread application of the new photo cells to the measurement of light intensity has quite displaced in industry the classical methods of the Bunsen and the Lummer-Brodhum photometers, now quite obsolescent except for their historical interest. The new photometer benches at Canisius will supplement rather than displace the older equipment, and several new experiments have been elaborated for exemplifying the inverse square law, for calibrating the photo cell for photometry, and for determining the candle power of colored sources.

SEISMOLOGY

The investigation and measurement of seismographic tilt, previously reported at the 1934 Pittsburgh meeting of the American Association for the Advancement of Science, and at the Ottawa meeting of the Seismological Society of America, Eastern Section, has been continued. Two further reports are in preparation, one for the coming Washington meeting of the American Geophysical Union, and one for the Edinburgh meeting of the International Union of Geodesy and Geophysics.

On Thursday March 26th, the New York State Society of Professional Engineers, Buffalo Chapter, convened in the auditorium of Canisius College for an address, "Earthquakes and Seismographs", by the Rev. John P. Delaney, S.J., Professor of Physics and Director of the Seismological Observatory.

Boston College, Department of Physics

Physics and chemistry were prescribed courses for the Bachelor of Arts degree until this year. At present, all students not in the Bachelor of Science courses of physics and chemistry or in the Pre-Medical course, were obliged to elect one of the three sciences for the

Junior year. One hundred and fifty-five students elected physics, forty-five students elected chemistry, and thirty-two elected biology. In the new course: BACHELOR OF ARTS WITH HONORS, the students have no mathematics and only one science with two lectures a week, for one year. The courses in philosophy were reduced to six hours a week, and the students of the Junior and Senior classes in the Bachelor of Arts course, take a concentration course in the languages.

Riverview College Observatory, Sydney, Australia

The Astronomical Observatory of Riverview College recently published an excellent bulletin recording the research done on: Photographic Observations of Variable Stars. The following articles were published by Rev. D. O'Connell, S.J.: "A New Cepheid Variable in Puppis." "A New Cepheid Variable in Centaurus." "A New Algol Variable in Centaurus." "Two New Eclipsing Variables in Sagittarius." "Note on VX Puppis." "The Long Period Variable AL Centauri."

Rev. William O'Leary, S.J., presents these articles: "Four New Variables in Puppis." "The Algol Variable SW Puppis."

Aberdeen, Hongkong, Astronomical Observatory

A new telescope recently arrived at Hongkong, to be set up at the Regional Seminary, Aberdeen. The Jesuits from the Irish Province came to Hongkong about nine years ago, and have done excellent work in the field of education in the Colony. They are now establishing an Astronomical Observatory and it will soon be equipped with all the necessary instruments for prescribed observations.

The telescope now at the Regional Seminary was purchased by the Irish Jesuits from Markree Observatory, County Sligo, Ireland. It is of the refractor type and is mounted equatorially. The mounting is the original and probably made by T. Grubb of Dublin in 1832, and erected for E. J. Cooper, Esq., at Markree in 1834. The object-glass was made in 1831 by Cauchoix and purchased in Paris; this is one of three made at the time. The other two formed the objectives of the "Northumberland" Equatorial at Cambridge, and the "South" Equatorial at Greenwich. The objective is thirteen inches in diameter and twenty-four feet focal length. The instrument at the moment is not equipped for minute astrophysical and photographic work, but it is hoped that when the initial stages of establishing the Observatory are over and regular observations have begun, this important section of modern astronomical research will not be overlooked.

BULLETIN OF THE AMERICAN ASSOCIATION OF JESUIT SCIENTISTS

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FIFTHTEENTH ANNUAL MEETING

of the

AMERICAN ASSOCIATION

of

JESUIT SCIENTISTS

August, 1936