John A. Tobin, S.J.

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EASTERN STATES DIVISION

Vol. XIX **DECEMBER 1941** **No. 2**

WESTON COLLEGE

WESTON, MASS.

Rev. and Dear Fr. Editor

At frequent intervals some zealous advocate of Scholastic Philosophy puts forth an ardent plea that we "do something about our Philosophy." What that "something" is, does not always appear clear from the appeal. Perhaps the petitioner is not quite certain what ought to be done about so tremendous a thing as philosophy. It is not a simple matter like sweeping a floor or putting oil in a motor car. However, a glance at the past volumes of the BULLETIN will show that the members of the Association have been doing their "something" in the discussions of problems bordering on Science and Philosophy. It is a worthwhile effort. Let me call your attention to another phase of this problem. The students of "Section A", of the Junior class, Fordham College, have undertaken to "popularize and sell" philosophy. They are not professional philosophers—so to speak—but like the Juniors of any Jesuit college. They have the same classical and scientific training as students of Boston or Georgetown or Canisius College. Their method is this: They choose a broad topic and divide it into various aspects. Each student does his "research" on his problem and after mastering it, tries to explain it, not in technical, philosophical terms but in the language of Mr. John Q. Citizen. Have you seen their excellent publication, called the SOPHIST? Our philosophically-minded scientists would be interested in their recent (1941) symposium on "The Nature of Inorganic Bodies." Prosit the SOPHIST and its sponsors.

We are all acquainted with the many attempts to formulate a Philosophy of Science—we might better say a Philosophy for Science. The failure of the Materialism of the past century to solve the problems of the New Physics spelled its doom. Out and out Idealism contradicted the basic realism of scientific practise. The limitations of the "observables and the measurables" have been a latent worry to scientists. While professing to have nothing to do with "ultimates," few scientists can resist the temptation to philosophize about causality, certitude, etc. One can hardly blame them. Man is naturally a philosopher. The human intellect by nature tends more and more to seek an ultimate answer and the mind is not satisfied with solutions of problems if it can still ask that eternal "why." The observables and the measurables are but too apt to arouse the curiosity of man. Hence, men of science will almost naturally yield to some form of philosophy, be it an Idealism as proposed by Jeans, a Kantianism of Einstein or a Scientism sponsored by some Americans. A philosophy for sciences seems inevitable because cosmic problems clamor for solution. Clearly, there is a need of a philosophical complement for the natural sciences.

We all believe, at least theoretically, that Scholasticism can supply that need. Again and again, our educational ancestors have insisted on the treasures of knowledge contained in the works of the Master Scholastics. Perhaps they have remained as hidden treasures. (We do not wish in any way to detract from the measure of praise due to those who have been and are endeavoring to bring these treasures to light. More power to them.) In the present situation we are not calling for a re-editing of St. Thomas or Suarez, critical editions excepted. Nor do we ask for a republishing of theses-manuals handed down from generation to generation. Scholasticism was not built that way. St. Albert and St. Thomas did not simply repeat Aristotle. The "ipse dixit" school was not part of their mentality. Our philosophical contributions should not be a repetition of Albert, Thomas or Suarez. We cannot solve the modern problem of Time by a statement of the Thomastic definition.

A thorough investigation of Scholastic principles and methods, together with an application to current problems would be of tremendous value. Let us remember that the last word has not been said in philosophy. The ultimate constitution of matter is an open field for investigation; the philosopher and the scientist could have a "Roman holiday" on the question of causality; and the relations between science and philosophy is still the subject matter for many volumes. It is admitted even by many non-scholastics that the "Philosophia Perennis" offers the best field for the solution of many perplexing questions. But this philosophy cannot remain stagnant. It must be like an organic being; it must live and grow and be enriched with new knowledge. A truly noble ideal is suggested by Dr. John Zybura: "To penetrate more deeply into the best thought of the great Greeks and medieval Scholastics; to rethink it in the manner outlined, in reference to modern questions in every realm of thought and to present-day problems; with fine discernment to search out the perennially true in the old and the new; thoroughly to assimilate both, with a view to the eventual elaboration by another Aristotle or another Thomas, of a richer and more fruitful, philosophical synthesis of existing knowledge than any yet achieved." (Progressive Scholasticism." Bruni-Zybura. p. xxix)

Sincerely Yours,

JOSEPH P. KELLY, S. J.,

Weston College, Weston, Mass.

NOTICES

There are some copies of the four numbers of volume 18 still available. They will be held for members until December 20th., 1941. After that date, the Editor will not be responsible if requests for these numbers cannot be filled.

The dead line for papers for the March issue will be February 1st., 1942. If you intend to submit a paper for this Issue, please inform the Editor before that date.

The Mailing list of the BULLETIN has been completely revised. If there are still some errors of any kind, the Editor would appreciate such information.

BIOLOGY

THE GUINEA PIG

By

PAUL A. EICHORN, S.J.

During the past year and a half we have been conducting experiments in heredity with Guinea Pigs. When we first entertained the idea of raising them we found it very difficult to obtain any accurate and complete data regarding them. What data we were able to glean from many diverse sources varied from the popular but erroneous opinion that Guinea Pigs are like Topsy: they just seem to take care of themselves and can be fed practically anything, to the equally vague opinion that they require expensive care as experimental animals.

In this short paper we wish to present the results of our work with Guinea Pigs, that is, to outline a brief but adequate summary of their history, housing, maintenance, feeding and diseases as experimental animals.

HISTORY:

In point of time the Guinea Pig is probably the first of the rodents to have been domesticated. It is claimed that before the discovery of America the Ancient Peruvians found it to be a valuable source of food, and the economical practice of raising Guinea Pigs for this end continues to the present day, especially in southern countries. Guinea Pigs exist in the wild state and may be found in the forests of Brazil where they are known by the general name of Preâ. The Guinea Pig with which we are familiar differs from this Preâ in being almost twice its size, a much more tractable animal, possessing a much wider variety of coat characters, a more frequent oestrum period and a more even frontal parietal suture of the skull.[1] The colors of the domesticated animals range from definite solid colors to mixed broken patterns. They may be long- or short-haired, smooth- or rough-coated. Outside of special experiments in heredity or the breeding of show animals, the short-haired varieties are to be preferred, especially from the standpoint of sanitation.

In spite of their high chromosome complex which is 30 (haploid)[2] Guinea Pigs have been used extensively for experiments in heredity. In the first burst of genetic fervor following the discovery in 1900 of Mendel's writings and the independent conclusions of de Vries,

[1]Ubisch and Mello, in The Journal of Heredity, 31:9, (Sept., 1940), p. 394-5.

Correns and von Tschermak, the Guinea Pig was the outstanding animal used to test and illustrate their principles. Its wide variety of distinct coat colors and the several characters of long or whorled hair have all been found to be true Mendelian unit characters.

In the branch of serology the Guinea Pigs are still almost indispensable for the testing of and experimenting with diseases and their cures. Today we find them being used extensively in anaphylaxis tests.

Their practical use in the laboratory, however, is not restricted merely to these two experiments. Although the fruit fly has in great part replaced them in the line of genetics, yet especially for more advanced students, a study of the characters of the Guinea Pig is valuable and may serve as an excellent subject for research work. A list of other experiments that may be performed with them would include the determination of vitamin C reactions, transplanting of the ovaries and of the adrenal glands, and the investigation of abnormal characteristics such as polydactylism, cyclopeanism and the apparently inherited diseases such as tuberculosis.

In individual experiments, such as ones conducted in heredity, it is often more convenient to have individual cages in which one male and one female may be kept together, but under no consideration, however, should more than one male be left with females. Males, especially when mature, will fight savagely, frequently wounding one another badly. When young, males with a few exceptions get along peacefully, but once they have mated they show a strong tendency to fight when returned with other males. Females as a rule get along peaceably with one another and may be kept together. In our own cages we have been forced by lack of space to keep young and maturing males together, and, by weeding out the real trouble makers, to keep fighting down to a minimum. Nevertheless, the separation of males in individual cages is much more to be preferred.

Crowding of the cages is often disastrous, not only because of the fighting which it promotes, but also because the young may be easily smothered by the older animals.

It is also well to avoid any extensive inbreeding if possible, as the mating of animals from the same litter brings about a decline in vigor in all characteristics. This decline is most marked in the frequency and size of the litter, and is greater in the gains after birth than in the birth weight, and also greater in the percentage *raised* of the young born alive than in the percentage *born* alive. The ability to raise large litters also falls off rapidly.[3]

Usually 1 to 3 offspring are produced in the first litter while later 1 to 9 may be born. The size of the litter, that is the number of young, increases steadily and reaches a maximum when the dams are about 18 months old, after which it begins to decrease.

[2]Painter, in Science, 64, (Oct., 1926), p. 336.
[3]Wright, in Bull. 1090, U. S. Dept. of Agric., (Nov. 15, 1922), p. 16.

"The effect of the season of the year on the litter size takes place at the time of conception. There is a slight seasonal variation in litter size, the largest litters being born late in the summer or fall when the feed and temperature conditions about two months before the litter were favorable."[4]

3 to 4 young, however, usually constitute the normal litter. This small number of young is really to be desired, as they are then better formed and more easily cared for by the dam than a larger litter would be.

It is well to remember that, due to the added burden of bearing young, females in pregnancy should be given almost twice the normal amount of food.

Males may be left in the cages with females when the young are born, as they are even less likely than the female herself to harm the young. She will eat them only if they are malformed or too weak to live.

The number of litters produced during a year depends mainly on whether or not the litters succeed one another without delay. Evidence, however, shows that any irregularity in this respect is due rather to the sire than to the dam. Environmental conditions, such as scarcity of succulent greens, sudden changes of temperature in the winter, etc., will also affect immediate mating. In general it may be said that the larger litters are born in the late summer months and the smallest litters in the winter. Females from 1 to 2½ years old tend to produce slightly larger litters than those younger or older, apart from any seasonal complications.

YOUNG:

Of practically all animals the Guinea Pig is the most perfectly developed at birth. Its eyes are open, it is covered with a thick coat of fur and often, within half an hour, it is running about and nibbling at greens if they are present. At birth the weights of the individual animals differ greatly. Those which are destined to reach maturity may weigh anywhere from 40 to 150 grams at birth although about 80 grams is the average. The size of the litter seems to be the governing factor of weight, as single offspring are invariably larger, have longer hair and are more active than the animals from large litters.[5] Young Guinea Pigs grow rapidly and reach their final weight at the end of a year. There is, however, a slight growth after this for a longer time.[6]

Even should the litter be fairly large, that is, about 6 animals, the female is able to care for them, but it exacts a great drain on her, so much so that she may become dangerously thin. In view of this it

[4]Wright, Ibid., p. 29.
[5]Wright, Op. cit., p. 16.
[6]Ibid., p. 10.

seems best to distribute some of the young from a larger litter with another or other females who have a small litter. Usually they will nurse these new protégés, but if any aversion to them is manifested a slight dab of Vicks on the nose of the female will sufficiently impair her sense of smell so that she will be unable to distinguish the odor of these new young from her own.

It is customary to wean the young at about 33 days. In the case of well developed offspring this period may be shortened if it is noticed that they are capable of eating dry food.

The young, it may be observed, may be born dead for a number of reasons, not the least of which is premature births. Frequently animals are unusually large at birth but are found dead due to the difficulties of parturition. In general the percentage of the young born alive depends upon the health of the dam.

CAGES:

The question of housing Guinea Pigs centers about two things; they should be as sanitary and as easily accessible as possible. There are several types of cages on the market, either individual types or expensive steel tier arrangements. Rat cages which are less costly, are too small for even one animal.

For general use the colony system of raising Guinea Pigs has been found to be the most practical. If a large enough pen is provided 25 to 30 animals may be kept together, keeping in mind, however, what has been said above on the distribution of males among females. Smaller hutches prove to be more convenient and sanitary. This latter type of cage measures 4 feet long, 4 feet wide and 3 feet high. It is divided by a floor while a wire partition divides each floor in two giving 4 individual cages. In each division or quarter of the cage, 6 to 10 animals may be kept conveniently. All the wire used in the cages should be of ½ inch mesh. At one end of the cage a shelf 6 inches high and 6 inches wide may be constructed as a shelter for the females and for some of them to sleep on. This, however, is not necessary.

Two types of floors are possible, either of wood or of ½ inch mesh wire. The wood floor is more convenient to build but is soon contaminated by the animals and unless given constant care will become a source of foul odors and parasites. If such a floor is used, sawdust or wood chips serve as excellent absorbent material and help greatly towards the cleanliness of the animals. The use of hay as bedding has proved to be inadvisable as it becomes quickly contaminated; the animals will also eat it in large quantities and may easily be overfed with it. The wire mesh floor is much more desirable. Pans may be bought or made from sheet metal: these are placed underneath the wire to catch the refuse. This type of floor provides a much neater cage and is more easily cleaned than the wooden floor.

Cages for special experiments in which it is desired to keep separate only one or two animals may be easily and economically constructed from old strawberry crates. The compound tier cages as advertised by the Chicago Apparatus Company is ideal, but the expense ($75 for a tier of six cages) is quite forbidding in view of the ease with which one can make his own. In constructing cages from crates, the bottom and every other slat of the crate is removed, the corners reinforced with blocks of wood or strips of iron and the interior covered with ½ inch mesh wire. A long bench is then constructed on which to keep the cages. One that we have found to be convenient measures 15 feet long, 30 inches wide, and has two floors. This takes care of 12 cages with a space of about 6 inches between each cage. Underneath each cage the surface of the bench has been cut away and the hole covered with ½ inch wire, which serves as a floor for the cages. 3 and ½ inches below the surface of the floor another board running the entire length and width of the bench provides a surface on which pans may be kept in order to take care of the refuse from the cages.

It is advisable to paint both the large hutches and the individual cages and bench, as they may then be more easily washed and will dry more rapidly. Care should be taken that none of the paint be where the animals can get at it, as they will eat it while gnawing on the wood. Painted sections inside of the cages which are accessible to the animals should be protected by metal or wire. The eating of the paint by the animals invariably causes death due to lead poisoning.

FEEDING:

Guinea Pigs require about the same diet as rabbits. They should be fed twice daily on a regular schedule to avoid their bolting the food if given only one meal. The evening meal, however, may often be eliminated, especially if the animals are in good condition. After testing many different diets which have been suggested, we have found the following to be about the best.

Dry Feed: The Complete Rabbit Rations put out by several companies prove to be very good.[7] They contain practically every food requirement except vitamin C which is supplied by frequent feedings of vegetables.[8] The Rabbit Pellets put out by these same companies are also very good but are not quite as acceptable as the complete ration. Oatmeal, that is plain rolled oats may also be used as a substitute for these feeds, but it is more expensive and lacks many of the good qualities contained in them.

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[7]Wirthmore Feed Company and Purina Mills are several companies producing this ration.

[8]It is of interest to note that the Guinea Pig is able to synthesize all of the necessary vitamins in its own system with the exception of vitamin C.

Each animal requires about 1 and ½ to 2 pounds of feed a month. As the feed retails for about $2.50 a hundred pounds, the cost a month per animal is about 4 to 5 cents.

Green Feeds: As a supplement to this rabbit ration the following have been found to be among the best. Fresh grass cuttings: care should be taken that they are not too moist as this will often cause diarrhea in the females which frequently results in abortions. Clover, although it is relished by the animals should not be used as feed. Very small quantities, however, do not seem to affect them. Non-poisonous weeds in the Summer and Spring are very good and include such as Dandelions, Plantain and Water Cress.

Lettuce: especially the outer leaves which have a higher vitamin content and are usually waste.

Celery: both the leaves and the stalks.

Carrots: especially good for females during pregnancy and lactation because of the high vitamin A content.

Corn: especially the green husks.

Other greens which are good for them (but which they will eat only if they are forced to) are, parsley, carrot and beet tops, cabbage, brussels sprouts and spinach.

Good quality legume hay should be supplied several times a week. With the Wirthmore feed this may be omitted but the use of it will help keep down the amount of feed. The hay when used may be just thrown into the cage, or, better still, a small rack made of one-inch mesh chicken wire aids in keeping the cage clean and preventing contamination of the hay.

When greens are used there is no need to provide water. When greens are not supplied, water should be on hand at all times. Milk may be given at frequent intervals in place of water.

It is to be noted that during the winter months and the very early spring, green feeds tend to be inferior in quality. This variation from good feed is reflected in low weight gains and in high mortality. The condition of the stock as a whole, apart from feeding conditions, is much better in the early part of the summer and in the fall than during the hot weather of July and August.

MAINTENANCE:

The general rule is at least to tidy up the cages each morning. If the cages have wire floors the trays collecting the refuse should be cleaned out each morning and the whole cage cleaned thoroughly once a week or oftener if necessary.

Cages with wooden floors should also be tidied up each morning, that is, remove any left-over vegetables, and smooth out the saw-dust, adding some if necessary. Once a week they should be thoroughly washed down with a strong solution of ammonia and hot water. Twice a year all the cages should be thoroughly disinfected.

As Guinea Pigs have weak eyes they should be kept out of direct sunlight. However, at least some indirect lighting should be provided. If they are kept in a room without windows, artificial lighting for several hours a day is necessary. This artificial lighting is necessary mainly for their eyesight. Lack of indirect sunlight should be compensated for by some food containing vitamin D (chiefly D3) such as milk.[9]

Care should be taken to eliminate any drafts or sudden changes in temperature as such often result in colds, pneumonia and death of the young. An even temperature of about 70 degrees is the best. Very high temperatures, especially those caused by direct sunlight in the summer, even though the cages are protected will often be followed by severe cases of fits and prostration. In such cases, if the cages cannot be moved to a cooler location, at least the affected animals must be removed directly to cooler cages.

As regards identification of the animals, the notching of the ears has not proved to be very successful a method, as the animals often have their ears torn in minor scraps among themselves, thus rendering the original notches useless. Small numbered ear tags, which may be procured from any biology supply house, are very satisfactory if not placed too near the edge of the ear where they may be easily torn off.

DISEASES:

If a strict regard for sanitation and ventilation is observed the diseases or other minor troubles with the Guinea Pigs are not very numerous. Listed below are a few of the more common ailments and suggestions as to their control.

Colds: These are apparently the chief source of sickness in Guinea Pigs. Sudden changes in temperature or the presence of drafts are the principle causes. The symptoms are usually watery eyes, lack of appetite and often sneezing. Such animals should be isolated at once and the food and water dishes they have used disinfected to prevent further spreading of the cold. The sick animal should be kept warm and fed plenty of liquids and dry foods. Usually within a week or ten days the animal will have recovered sufficiently to be returned with the others.

Pneumonia: Colds, while not too dangerous in themselves may in a weak animal easily develop into pneumonia which is almost always fatal. Animals suffering from pneumonia show signs much akin to those of colds although more pronounced and often accompanied by a difficulty in breathing. Frequently they become completely prostrated. If taken care of in time there is a slight chance of curing them by strict isolation in very warm quarters and feeding with warm liquids.

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[9]The Wirthmore Rabbit Ration contains dried skimmed milk.

Diarrhea: Due mainly to feeding too many greens or moistened greens. It is especially dangerous with females as it often results in abortions and possible loss of the female herself. However, it is usually more noticeable among the young where, in addition to too many greens, a sudden change in the weather or a poor milk supply from the mother may also be the cause. Affected animals should be placed in dry clean cages, and fed only dry food for several days. It is advisable also to give about one eye-dropper of castor oil in order to clean out the animal's system.

Indigestion: Guinea Pigs will invariably eat as long as there is food present. As a result they often suffer from indigestion. Food should be taken from them for at least 12 hours. A small amount of baking soda, about one-half teaspoonful to a pint of drinking water, may be given to them for the next few days.

Epileptic Fits: Fits are most frequent in the hot summer months and are characterized by convulsive running about the cage and against the sides of the cage, ending in complete exhaustion. The animal should be immediately placed in a cool dry cage and given plenty of water. For several weeks after the seizure the animal will appear listless and dull, with little interest in the other animals which may be about him. The instinct to mate in males at such a time is seriously impaired although after about a month they appear normal again in this respect.

USEFUL HINTS:

External Parasites: Are due mainly to unsanitary quarters. Small lice and cockroaches soon overrun an uncared for cage. In such cases the cages should be given a thorough disinfecting and the animals dusted with Pyrethrum powder.

Bleeding Ears: Bleeding ears are common especially among the males which are together, or among the animals with ear tags which are frequently ripped off by the wire of the cage. Though the animals are usually able to care for themselves, yet, where bleeding is profuse, a dusting with Sodium Subsulphate powder will stop the flow.

Records: Doe Breeding Charts which may be procured for the asking from the Wirthmore Feed Company, although primarily intended for rabbits, serve equally as well for keeping an accurate record of individual matings of Guinea Pigs.

Feeding Dishes: For feeding dishes, large circular crockery bowls which are flanged at the bottom, to prevent the tipping of them, have been found to be the best.

In conclusion it is to be remarked that, the purpose of this paper was not in any way intended to be a complete treatise on Guinea Pigs. It is merely a general outline which may serve as a guide for those interested in raising them as experimental animals.

Most of the data included in the body of the article has been derived from our own experience, although many valuable suggestions have been taken from several pamphlets. To these acknowledgement is made and they are offered with several others as more complete treatises for further detailed reference on the Guinea Pig.

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3. Ubisch, Mello. 1940. Genetic Studies on a Cavy Species Cross. Jour. Hered. 9: 389-398.
4. Wright, Sewall. 1922. The Effects of Inbreeding and Crossbreeding on Guinea Pigs. Dept. Agr., Tech. Bull. 1090.
5. Keeler, Clyde E. 1931. The Laboratory Mouse. Its Origin, Heredity, and Culture. Published by the Harvard University Press, Cambridge, Mass.
6. Young, William C. June, 1941. Observations and Experiments on Mating Behavior in Female Mammals. The Quarterly Review of Biology. 2:141-143.
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BOTRYTIS INFESTANS MONTAGNE AND FAMINE

JOSEPH P. LYNCH, S.J.

We have all heard of the Irish Famine. This paper is concerned with its cause.

Just what was the Blight that caused the famine? What was it happened to the crops? Well, it was only the potato crop that was affected; it was practically a total loss. What happened was simply a rotting of the potatoes. In the words of a contemporary—". . . the disease consists in a gradual decay of the leaves and stem, which become a putrid mass, and the tubers are affected by degrees in a similar way. The first obvious sign is the appearance on the edge of the leaf of a black spot which gradually spreads; the gangrene then attacks the haulms, and in a few days the latter are decayed, emitting a peculiar and rather offensive odor. When the attack is severe the tubers also decay."

But why should the loss of the potatoes cause famine? The answer lies in the economic set-up in Ireland. Half of the eight million people in Ireland were poor farmers and cottiers. These people lived on potatoes. How so? Why? The land in Ireland was owned by the proprietors of large estates. These were mostly absentee landlords. To ensure a large revenue and freedom from worry, the lands were let out to middlemen, who in turn subdivided the lands and let them out to other middlemen. These in their turn subdivided and sub-let. The subdividing and sub-letting went on till it got down to the cottiers. The cottiers were farmhands. The average wage for labor on the farms was six pence, i. e. twelve cents a day. A man's wages would not support himself even without a family. The average cottier therefore raised his own food. He had a cabin and a quarter of an acre of land. He could get work about six months of the year. His little plot was rented at the rate of ten to twelve pounds (fifty to sixty dollars a year). The rent for his cabin, a hut without windows or even a chimney, was the same as his quarter acre of land. His wages could not pay his rent. So every cottier kept a pig. He could not buy food; so he raised his own. The only food that would sustain a family and grow in sufficient abundance on a quarter acre of land to do so was the potato. Therefore the quarter acre went into potatoes. Many and many a family tasted nothing but potatoes and pepper water from one month's end to another. The quarter acre, if it happened to be pretty good soil, would produce about five tons of potatoes, which meant a ration of thirty-two pounds a day the year 'round. The average poor Irishman was living on a mass of eight to fourteen pounds of potatoes a day,—that and nothing more for the most part. A typical annual budget was as follows:

	Pounds	Shillings	Pence	
WAGES	3	18	0	($19.50)
Market value of PIG	4	0	0	($20.00)
	—	—	—	———
Total INCOME	7	18	0	($39.50)
RENT of ¼ acre	2	10		($12.50)
cabin	2	10		($12.50)
	—	—	—	———
Total RENT	5	0		($25.00)
BALANCE	2	18		($14.50)

The average cottier had just that,—a grand total of $14.50 a year for himself and his family—to buy food, clothing, medicine, to take care of recreation, church, travel, etc. It is easy now to see he was living on the potatoes from his quarter acre. When those potatoes went, he had—no food.

The Blight, the Murrain, came suddenly. What it was no one knew. "On July 27th", wrote Father Matthew, "I passed from Cork to Dublin, and this doomed plant bloomed in all the luxuriance of an abundant harvest. Returning on August 3rd I beheld with sorrow one wide waste of putrefying vegetation. In many places the wretched people were seated on the fences of their decaying gardens, wringing thir hands and wailing bitterly at the destruction which had left them foodless." This happened twice in a row at first, 1845 and 1846. The winter and spring of 1845-46 and 1846-47 saw starvation for half of the Irish.

This Blight was not peculiar to Ireland. It broke out at the same time in Poland, Germany, Belgium, France, and all over England. But nowhere were people so dependent on the potato as in Ireland. Just what the Blight was, just what caused it, no one knew. A certain fungus was observed as associated with the decaying of the plants. It was first noticed in France in 1845 by Dr. Montagne. He and M. J. Berkeley of England both maintained that the Blight was caused by this fungus, but they could not prove it. Berkeley studied the fungus and found it a species new to science. It resembled in certain respects a mould that he had seen growing on onions and shallots. It seemed to belong to the same order as a fungus associated with a certain silkworm disease of France and Lombardy. It was a minute fungus of the genus Botrytis. In the first issue of the Journal of the Horticultural Society, January 1846, Berkeley described it as:

BOTRYTIS INFESTANS, Mont., coespitibus laxis erectis albis apice plus minus ramosis, ramis passim nodosis erecto-patentibus, sporis lateralibus terminalibusque solitarius ovoideo-ellipticis pro ratione magnis concoloribus subapiculatis, nucleo granuloso . . . ."

The censensus of opinion was against any fungus being the cause of anything. Rather the fungi and molds were considered as results, the results of wetness, weakness, decay. The rot of the potato was generally figured to be due to excess luscious growth followed by a superfluity of water,—or else as due simply to the fact that the whole strain of European potatoes was debilitated by long use without any strengthening from association with native wild American strains. There was no way of combatting the disease except by cutting off the leaves or branches as soon as they were seen to be going. Search was made for newer and better potatoes to withstand the Blight. Various types and even substitutes were tried. But nothing completely filled the bill. Much argument continued about the role of the fungus. Gradually after years of study conviction spread that the fungus was the cause. Intermittently from 1845 right up to the present the Potato Blight has appeared with varying virulence not only in Ireland but pretty much all over the whole world where potatoes are grown.

In 1852 Botrytis Infestans, Mont. had its name changed to Peronospora infestans, Mont. following the recognition by the botanist Caspary that it resembled more closely the genus Peronospora than it did the genus Botrytis, not only in morphology but particularly in the fact that while the Botrytis fungi were facultative, living on decayed leaves or else killing a leaf's tissues and then living in the dead matter, the Peronospora fungi grew only in the living leaf tissue and their spawn died in the leaf as the leaf decayed. The Blight Fungus seemed to be this kind of obligate parasite.

In 1857 Speerschneider in Germany established the fact that spores fallen from the mycelia in the leaves and the haulms germinated on the tubers in the ground. Four years later the famous German botanist Anton de Bary discovered that the "spores" of the Potato Blight fungus were really sporangia, each of which released in water from six to sixteen motile spores, i. e. zoospores. Each zoospore could germinate and produce a new mycelium. Rapid multiplication and quick spread over a potato field in wet weather was no difficulty.

De Bary did much work over a period of years on the Potato Blight fungus, but without finding anything sexual about it or even how it could survive over the winter from one season to the other. In 1875 De Bary decided the fungus should no longer be called Peronospora infestans but should establish a new genus which he called Phytophthora. His reason was chiefly the fact that the Potato Blight fungus produced its spores, or rather sporangia, on the tips of the conidiophores and further growth of the stalks shoved the sporangia down from the tip to develop along the side. The true Peronospora fungi had conidiophores much more branched and the sporangia never slid from the tips. The name of the Potato Blight fungus still remains today Phytophthora infestans.

It was not until 1910 that the wintering spores of the Potato Blight fungus were first seen. In that year Clinton, at the Agricultural Experiment Station of Connecticut found a few of the winter spores in cultures of the fungus that he was raising on agar jelly with oat juice. He saw Phytophthora infestans actually did have a sexual stage, —oogonia and antheridia were produced. The oogonia were 40 microns in diameter on an average. But most of them were imperfect. The antheridia were much smaller and very few. Zygotes or oospores were rare. By 1914 Pethybridge and Murphy in Galway had found that another species of the Phytophthora genus was fertilized in a strange way. The female organ penetrated the male organ. It was very difficult to distinguish the parts of the sex organs in Phytophthora infestans but they obtained evidence it was in this same strange way.

In 1926 Helena de Bruyn in Holland successfully cultured the Potato Blight on sterilized straw of wheat, oats and rye. Not only did the fungus grow but it produced plenty of oospores. Some of these oospores had been produced sexually but others apparently asexually. But not even one could be got to germinate. The next year Murphy in Ireland came closest to finding the winter spores in nature. Murphy discovered his winter spores, oospores, among the external growth of Phytophthora infestans growing from the cut surface of a potato in a pot of sterilized soil. Like the oospores of de Bruyn those of Murphy had been formed partly sexually, party asexually, and likewise could not be got to germinate. Did the Potato Blight survive the winter as resting spores, oospores, in the soil? Did it? Does it? As far as I have been able to find out our knowledge of the fungus in nature still rests just there. Not yet have the winter spores been found in nature, in the potato fields. And the oospores found in culture media have not yet been proved to be a natural propagating link in the life cycle of Phytophthora infestans, they have never been found to germinate.

The Potato Blight is still a very real thing. But its dangers have been much minimized. Many new resistant varieties of the potato have been either found or developed. Copper spraying has since about 1890 been much in use, and where resistance is weak or partial only, still proves highly important and valuable. When to spray and how much was solved in large part only as late as 1926 when van Everdingen of Holland worked out his chart of the weather conditions that precede severe attacks of Potato Blight. In summary these conditions are: No less than four hours of dew during the night, a night temperature of not less than 10 degrees C, with the cloudiness of the following day not less than 0.8 and rain of at least 0.1 mm.

None of this data is later than 1939. What studies have been made since, I do not know. If any one is interested in a bibliography I shall be glad to supply it.

AN INTERESTING ANOMALY IN THE MESENCEPHALIC NUCLEUS OF THE TRIGEMINAL NERVE.

Charles E. Shaffrey, S.J.

Every spinal nerve has two roots, a ventral one which is efferent, i. e. carrying impulses away from the nervous system, and a dorsal one which is afferent, bringing impulses into the central nervous system. The former are motor and the latter are sensory fibers. On the dorsal root there is a ganglion, a collection of cells whose axones become the sensory fibers of the nerve. These ganglion cells are unipolar, having but one process attached to the cell, and this the axone. Close to the cell body the axone divides, giving a T-shaped process, one branch of which passes in the spinal nerve to the periphery, while the other passes into the spinal cord and may terminate in its gray matter or pass on to the gray matter of the brain, ending in the medulla oblongata, pons, cerebellum, midbrain or optic thalamus.

The ganglion on the spinal nerve is outside of the central nervous system, i. e., outside of the spinal cord and brain. Those cranial nerves which are composed of both motor and sensory fibers also have one or more ganglia on their course associated with sensory impulses. These ganglia are made up of unipolar cells just like those found in the spinal ganglia. These cells send one branch of the T-shaped axone to the periphery and the central one to some nucleus of gray matter in the brain. Such nerves are the trigeminal or fifth cranial nerve with its Gasserian or semilunar ganglion, the facial or seventh with its geniculate ganglion, the acoustic or eighth with its two ganglia: the vestibular which is concerned with equilibratory impulses and the spiral ganglion of the cochlea mediating auditory impulses, the glossopharyngeal or ninth with two ganglia and the vagus or pneumogastric, the tenth, also having two. The cells of all of these ganglia are of the unipolar type except those of the acoustic nerve.

Hence these unipolar cells, with their T-shaped axones, are characteristic of these ganglia, and are found outside the central nervous system with one known exception, and this is the interesting anomaly.

These unipolar cells are found in the mesencephalic nucleus of the trigeminal nerve. This nucleus is composed largely of those unipolar cells which are in all respects similar to the afferent neurons of the spinal ganglia and of the ganglia on the cranial nerves. The nucleus lies in the lateral wall of gray matter surrounding the cerebral aqueduct of the midbrain and is continued into the lateral wall of the rostral portion of the fouth ventricle.

Johnson in 1909 showed that the large unipolar cells of the mesencephalic nucleus of the fifth nerve which gives rise to the fibers of the mesencephalic root of that nerve, are probably sensory in function. Willems in 1911 and Allen in 1919 regarded these as sensory fibers to the muscles of mastication. Ranson states that if this interpretation is correct we are presented with an exception to the rule that the afferent fibres of the cerebrospinal nerve take origin from cells located outside the cerebrospinal axis.

The sensory impulses which travel over afferent nerves may be of three different types; they may be exteroceptive, arising in the superficial somatic areas, or interoceptive from the viscera, or proprioceptive which take their origin in the receptors of the sensory end-organs in the skeletal muscles, tendons, ligaments and joints. These last mentioned impulses are produced by pressure on the end-organs in the locations enumerated above, and they report the spatial relations of the several parts of the body. Waking out of a sleep, one is immediately conscious of the position of the members of his body. He knows whether or not his arms are flexed or extended and to what degree; the same of the head, trunk and lower limbs.

It is with these proprioceptive impulses that the mesencephalic nucleus of the fifth cranial nerve is thought to be involved. It is regarded as the proprioceptive nucleus of the trigeminal nerve, mediating impulses from the muscles of mastication, and also from the extrinsic muscles of the eyeball, hence, sending fibers into the oculomotor, trochlear and abducens nerves. The origin and termination of the afferent fibers for the external muscles of the eyeball are unknown, but that the third, fourth and sixth nerves contain such fibers is certain. The fact has been proved by Tozer and Sherrington who found that the sensory fibres of those nerves degenerate along with their neuromuscular and neurotendinous end-organs on section of these nerves.

In man there are also groups of unipolar cells connected with the roots of the oculomotor and trochlear nerves. A few such cells have been found outside the semilunar ganglion proper of the trigeminal nerve which send their axones into the mesencephalic root of that nerve.

While these scattered cells along the course of the nerves are to be found, and resemble very much the cells of the mesencephalic nucleus of the fifth nerve, it is not certain that they are proprioceptive. In 1926 Clark showed that the cells found along the course of the nerves, though they are unipolar and so resemble those of the mesencephalic nucleus to that extent, have in Nissl preparations a quite different arrangement of the Nissl granules.

From the above we may conclude that the mesencephalic nucleus of the fifth nerve is not a true nucleus, but is rather a displaced ganglion, derived from the neural crest in the developing embryo and incorporated into the mesencephalon.

CHEMISTRY

MOLECULAR WEIGHT DETERMINATION BY ISOTHERMIC DISTILLATION

Richard B. Schmitt, S.J.*

This method of determining molecular weights is based upon isothermic distillation of a volatile solvent from a solution of lower molarity to one of higher molarity. In a closed system, this change (caused by surface phenomena) can be measured by following under a low-power microscope, the changes of the meniscuses of the two solutions contained in separate capillaries. By appropriately pairing standard solutions of various but known molarities with a solution of known concentration of a test substance in the same solvent and tabulating the ensuing changes in the volumes of the standard solutions, the molarity of the solution of the test substance is ascertained.

At the Detroit Meeting of the American Chemical Society the preliminary work by G. Barger (1) K. Rast (2) and J. R. Spiess (3) was described. The results we obtained with these fundamental principles were tabulated (4). In all these determinations, the same solvent was used, namely ethyl alcohol, and all capillaries were sealed under reduced pressure, i.e. about 15-20 mm.

Standard Solution: Azobenzene in 95% ethyl alcohol.
(0.06, 0.08, 0.09, 0.11, 0.12 and 0.13 molar)

				Molecular Weight Found			
SUBSTANCES:	c	Mm	Mn	c/m	c/n	Mean	Calcd.
Benzoic acid	12.21	0.11	0.09	111.0	134.5	122.8	122.0
Benzylcinnamate	21.172	0.09	0.08	235.2	264.6	249.9	238.3
p-Benzyl-phynol	19.556	0.11	0.09	177.7	217.2	197.5	184.2
p-hydroxyacetophenone	12.348	0.11	0.09	112.2	137.2	124.7	136.0
o-nitrophenol	13.332	0.11	0.09	121.1	148.1	134.6	139.1
Pyrogallol	11.348	0.11	0.09	103.1	126.1	114.6	126.0
Thymol	17.044	0.12	0.11	142.0	154.8	148.4	132.2
Vanillin	13.728	0.11	0.09	124.7	152.5	138.6	152.1
vic. Xylenol	11.848	0.11	0.09	107.7	131.6	119.6	122.1

*This paper was presented at the National Meeting of the American Chemical Society, Atlantic City, N. J. September 9, 1941.

In our recent research (1941), we obtained satisfactory results at atmospheric pressure and with solvents other than alcohol. The reagents and experimental procedures were the same as noted in the problems as reported (5) The results of two typical examples, using benzene and acetone as solvents, are given below:

Standard Solution: Azobenzene in Benzene.
(0.075, 0.0875, 0.100, 0.1125, and 0.125 molar.)
Unknown: Benzoic Acid in Benzene.
(0.10 molar, 12.205 g/1, 1.22%).
Capillaries filled: December 2, 1940 (P=50 mm). Reduced Pressure.
Capillaries mounted; and first reading: December 2, 1940 (T=23°C.).
First Observation (Second Reading): December 3, 1940 (T=23°C.).

Micrometer Readings

AZOBENZENE								BENZOIC ACID							AZOBENZENE	BENZOIC ACID
Molar	1st			2nd				1st			2nd					
0.075	A	V	22	A	V	29		L	IV	42	L	IV	25		−7	−17
0.087	L	V	24	L	V	26		L	V	8	A	V	10		+2	−18
0.100	L	IV	37	L	IV	34		L	V	7	A	V	9		−3	−16
0.112	A	V	17	A	V	25		A	V	5	A	V	21		−8	−16
0.125	L	V	39	L	V	41		A	V	20	A	V	30		+2	−10

L=Liquid Line A=Air Line.

TABLE I a

Second observation (Third Reading, December 4, 1940, T=21°C.).

Micrometer Readings

AZOBENZENE								BENZOIC ACID							AZOBENZENE	BENZOIC ACID
Molar	2nd			3rd				2nd			3rd					
0.075	A	V	29	A	V	28		L	IV	25	L	IV	24		+1	−1
0.087	L	V	26	L	V	29		A	V	10	A	V	14		+3	−4
0.100	L	IV	34	L	IV	38		A	V	9	A	V	15		+4	−6
0.112	A	V	25	A	V	18		A	V	21	A	V	29		+7	−8
0.125	L	V	41	L	V	45		A	V	30	A	V	37		+4	−7

Micrometer Units Plotted

A=Total Volume change of Standard (sum of Micrometer units.)
B=Total Volume change of Unknown. (sum of Micrometer units.)

Molar	$\frac{B-A}{2}$ Up to 2nd Reading	$\frac{B-A}{2}$ Up to 3rd Reading	$\frac{B-A}{2}$ Up to 4th Reading	$\frac{B-A}{2}$ Up to 5th Reading
0.075	− 5.0	− 6.0	−14.5	−14.5
0.087	−10.0	−13.5	−17.0	−20.0
0.100	− 6.5	−11.5	−17.0	−21.0
0.112	− 4.0	−11.5	−17.5	−22.0
0.125	− 6.0	−11.5	−16.5	−22.5

Molar	Up to 6th Reading	Up to 7th Reading	Up to last Reading
0.075	−17.0	−20.5	−51.0
0.087	−27.5	−33.0	−78.5
0.100	−32.5	−41.0	−108.5
0.112	−35.5	−45.0	−133.5
0.125	−36.5	−46.5	−139.0

Line crosses X—axis at 0.051 concentration at equilibrium.

$$M.\ W. = \frac{\text{Wt. of solute/liter}}{\text{concentration}} = \frac{12.205}{0.051} = 239$$

Theoretical Value for associated Benzoic Acid in Benzene=244.
Definitely a polymeric compound.

$$\%\ \text{Error} = \frac{5}{244} = 2\%$$

Standard Solution: Azobenzene in Acetone.
(0.075, 0.0875, 0.100, 0.1125, and 0.125 molar, 1.36−2.27% solutions).
Unknown: Sulfanilamide in Acetone.
(17.25 mgs in 0.81578 g., 0.09708 molar, 16.72, 1.672%).
Capillaries filled: April 9, 1941 (P atmospheric).
Capillaries mounted: and first reading: April 9, 1941 (T=25°C).
First observation (second reading): April 10th, 1941 (T=25°C).

Micrometer Readings

	AZOBENZENE						SULFANILAMIDE						AZOBENZENE	SULFANILAMIDE
Molar	1st			2nd			1st			2nd				
0.075	L	IV	12	L	IV	7	L	III	28	L	III	30	−5	+2
0.087	L	IV	14	L	IV	5	A	IV	21	A	IV	22	−9	−1
0.100	A	IV	14	A	IV	25	A	IV	0	A	IV	2	−11	−2
0.112	A	IV	12	A	IV	18	L	III	45	L	III	44	−6	−1
0.125	L	III	45	A	III	18	L	IV	22	L	IV	3	−63	−19

TABLE IX b

Third Observation (Fourth Reading, April 15, 1941, T=25°C).
Micrometer Readings

	AZOBENZENE						SULFANILAMIDE						AZOBENZENE	SULFANILAMIDE
Molar	3rd			4th			3rd			4th				
0.075	A	IV	8	A	IV	10	L	III	26	L	III	25	−2	−1
0.087	A	IV	6	A	IV	8	A	IV	30	A	IV	33	−2	−3
0.100	A	IV	39	L	III	45	A	IV	9	A	IV	12	−1	−3
0.112	A	IV	23	A	IV	19	L	III	36	L	III	38	−4	+2
0.125	A	III	23	A	III	25	A	IV	13	A	IV	15	−2	−2

Micrometer Units Plotted

A=Total volume change of Standard (sum of Micrometer units).
B=Total volume change of Unknown (sum of Micrometer units).

$\frac{B-A}{2}$ = Gain or loss in volume of UNKNOWN.

	$\frac{B-A}{2}$
Molar	Up to last Reading
0.075	+12
0.087	+ 5
0.100	+ 5.5
0.112	− 6.5
0.125	− 4.0

Line crosses X−axis at 0.098 concentration at equilibrium.

$$\text{M. W.} = \frac{\text{Wt. solute/liter}}{\text{concentration}} = \frac{16.72}{.098} = 170$$

Theoretical Value for M. W. of Sulfanilamide = 172

$$\%\ \text{Error} = \frac{2}{172} = 1\%$$

Other experimental data, i.e. with vistanex (synthetic rubber) using carbon disulphide in a 2% solution, under atmospheric pressure and using the same procedure as described, definitely showed that the results were in the right direction. Since there is no definite and known standard for this substance of very high molecular weight (approximately 100,000) exact results cannot be given.

Further research will include solvents of high boiling points, the standardization of the apparatus and methods of calculation.

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MATHEMATICS

MATRIX PRODUCTS BY SCHEMATIC ARRANGEMENT

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In the higher branches of mathematics and even in the specialized fields of theoretical physics, the concepts involved in matrices arise as a natural progression of the theory. A period of teaching experience and individual consultation has shown that many of the associated fundamental operations with matrices: namely, addition, subtraction and scalar multiplication are easily applied and remembered. However, even among the advanced students, there is a definite lack of constant familiarity and operational skill when it comes to multiplying square matrices and rectangular matrices (i.e. those of an unequal number of rows and columns). This deficiency can be remedied to some extent, it is hoped, by the following rules and schematic development. The practical mathematician and class teacher whose aims are primarily simplicity and habitual knowledge will perhaps find the method helpful or at least suggestive for even a clearer exposition and understanding of matrix products.

A brief restatement of the classical rules for matrix products and their application to a set of generalized matrices will prove useful as a readily accessible check and contrast to the procedure developed in this article.

Given two square matrices in their generalized form:

$$A=\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1N} \\ a_{21} & a_{22} & \cdots & a_{2N} \\ \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ a_{N1} & a_{N2} & \cdots & a_{NN} \end{bmatrix} \qquad B=\begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1N} \\ b_{21} & b_{22} & \cdots & b_{2N} \\ \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ b_{N1} & b_{N2} & \cdots & b_{NN} \end{bmatrix} \quad \text{---}(1)$$

then the matrix product AB is given by:

$$AB=\begin{bmatrix} \sum a_{1i}\, b_{i1} & \sum a_{1i}\, b_{i2} & \cdots & \sum a_{1i}\, b_{iN} \\ \sum a_{2i}\, b_{i1} & \sum a_{2i}\, b_{i2} & \cdots & \sum a_{2i}\, b_{iN} \\ \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ \sum a_{Ni}\, b_{i1} & \sum a_{Ni}\, b_{i2} & \cdots & \sum a_{Ni}\, b_{iN} \end{bmatrix} \quad \text{---}(2)$$

where the summation index i runs through the values 1, 2, 3, ___ N.

The usual rules and methods for developing this product can be found in any book dealing with higher algebra or a specialized treatise on matrices.[1] Since this general form proves unwieldy for purposes of illustration, we shall use as examples, square matrices with three rows and three columns.

In this specific instance we have:

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}, \quad B = \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix} \text{------} (3)$$

$$AB = \begin{bmatrix} a_{11}b_{11} + a_{12}b_{21} + a_{13}b_{31}, & a_{11}b_{12} + a_{12}b_{22} + a_{13}b_{32}, & a_{11}b_{13} + a_{12}b_{23} + a_{13}b_{33} \\ a_{21}b_{11} + a_{22}b_{21} + a_{23}b_{31}, & a_{21}b_{12} + a_{22}b_{22} + a_{23}b_{32}, & a_{21}b_{13} + a_{22}b_{23} + a_{23}b_{33} \\ a_{31}b_{11} + a_{32}b_{21} + a_{33}b_{31}, & a_{31}b_{12} + a_{32}b_{22} + a_{33}b_{32}, & a_{31}b_{13} + a_{32}b_{23} + a_{33}b_{33} \end{bmatrix} \text{---} (4)$$

In the new development, the schematic arrangement for a matrix product AB (where the factor matrix on the left of the symbol AB is regarded as the operator or multiplier, and the factor matrix on the right as the operand or multiplicand) has the following form:[2]

	b_{11}		b_{21}		b_{31}
	b_{12}		b_{22}		b_{32}
	b_{13}		b_{23}		b_{33}
a_{11}		a_{12}		a_{13}	
a_{21}		a_{22}		a_{23}	
a_{31}		a_{32}		a_{33}	

This schematic arrangement consists in placing the multiplier (in the lower portion of the diagram) and then placing above it the multiplicand, whose rows are now written as columns.

[1]cf. Maxime Bôcher: 'Introduction to Higher Algebra', p. 63.
R. A. Frazer, W. J. Duncan, A. R. Collar: 'Elementary Matrices', p. 6 et seq.

[2]For further application and reference to this subject: cf. Father Sohon's hectographed notes on Vector Analysis p. 70-71, Cracovian Multiplication: 'It was pointed out by Turner and later by Banackiewicz that the multiplication of matrices is facilitated if all after the first are turned over on a diagonal.'

RULES:

1. To get the elements of the result, multiply and sum the individual products of the corresponding elements in the multiplicand and multiplier rows.
2. If the row of the multiplicand (in any single operation) denotes the column-element of the result, and if the row of the multiplier designates the row element of the result, then any given element of the result may be put down by performing the operation of multiplying the correct row of the multiplier by the desired row of the multiplicand.

Applying the rules for the product AB, we have:

To get the element-result in:	*Multiply and sum the individual products of the corresponding elements*:
The 1st column and 1st row	In the 1st row of the multiplier by the 1st row of the multiplicand $a_{11} b_{11} + a_{12} b_{21} + a_{13} b_{31}$
The 1st column and 2nd row	In the 2nd row of the multiplier by the 1st row of the multiplicand $a_{21} b_{11} + a_{22} b_{21} + a_{23} b_{31}$
The 3rd column and 2nd row	In the 2nd row of the multiplier by the 3rd row of the multiplicand $a_{21} b_{13} + a_{22} b_{23} + a_{23} b_{33}$
etc.	etc.

If the process is carried out completely, we will finally come out with the same result as in (4). This method once explained after an accompanying illustration (as above) has been found very helpful for a lasting knowledge of matrix products.

Moreover, since matrix multiplication in general is not commutative, the product BA can be just as simply derived:

$$BA = \begin{array}{ccc|ccc|ccc} & & a_{11} & & & a_{21} & & & a_{31} \\ & & a_{12} & & & a_{22} & & & a_{32} \\ & & a_{13} & & & a_{23} & & & a_{33} \\ \hline\hline b_{11} & & & b_{12} & & & b_{13} & & \\ b_{21} & & & b_{22} & & & b_{23} & & \\ b_{31} & & & b_{32} & & & b_{33} & & \end{array}$$

The complete product then BA is:

$$BA = \begin{bmatrix} b_{11}a_{11}+b_{12}a_{21}+b_{13}a_{31}, & b_{11}a_{12}+b_{12}a_{22}+b_{13}a_{32}, & b_{11}a_{13}+b_{12}a_{23}+b_{13}a_{33} \\ b_{21}a_{11}+b_{22}a_{21}+b_{23}a_{31}, & b_{21}a_{12}+b_{22}a_{22}+b_{23}a_{32}, & b_{21}a_{13}+b_{22}a_{23}+b_{23}a_{33} \\ b_{31}a_{11}+b_{32}a_{21}+b_{33}a_{31}, & b_{31}a_{12}+b_{32}a_{22}+b_{33}a_{32}, & b_{31}a_{13}+b_{32}a_{23}+b_{33}a_{33} \end{bmatrix}$$

The simplicity and operational facility is even better demonstrated by a numerical example (especially where the numbers involved are relatively small.)

e.g. The Product CD can be readily calculated, where:

$$C = \begin{bmatrix} 2 & -1 & 2 \\ 4 & 5 & -8 \\ 3 & 2 & 1 \end{bmatrix}, \qquad D = \begin{bmatrix} 4 & 3 & -4 \\ 4 & -3 & 2 \\ 1 & 2 & 5 \end{bmatrix} \quad \text{.......... (5)}$$

The old method gives the product CD as follows:

$$CD = \begin{bmatrix} (2x4)-(1x4)+(2x1), & (2x3)+(1x3)+(2x2), & -(2x4)-(1x2)+(2x5) \\ (4x4)+(5x4)-(8x1), & (4x3)-(5x3)-(8x2), & -(4x4)+(5x2)-(8x5) \\ (3x4)-(2x4)+(1x1), & (3x3)+(2x3)+(1x2), & -(3x4)-(2x2)+(1x5) \end{bmatrix} \quad \text{(6)}$$

$$= \begin{bmatrix} 6 & 13 & 0 \\ 28 & -19 & -46 \\ 5 & 17 & -11 \end{bmatrix} \quad \text{.......... (7)}$$

The new method gives the same product:

CD =

	4		4		1
	3		—3		2
	—4		2		5
2		—1		2	
4		5		—8	
3		—2		1	

$$= \begin{bmatrix} 6 & 13 & 0 \\ 28 & -19 & -46 \\ 5 & 17 & -11 \end{bmatrix} \quad \text{(8)}$$

The general process also applies to rectangular matrices:

$$E = \begin{bmatrix} 4 & 2 & -1 & 2 \\ 3 & -7 & 2 & -8 \\ 2 & 4 & -3 & 1 \end{bmatrix}, \qquad F = \begin{bmatrix} 2 & 3 \\ -1 & 0 \\ 3 & 5 \\ 4 & 1 \end{bmatrix} \quad \text{(9)}$$

EF =

	2		—1		3		4
	3		0		5		1
4		2		—1		2	
3		—7		2		—8	
2		4		—3		1	

$$= \begin{bmatrix} 11 & 9 \\ -13 & 11 \\ -5 & -8 \end{bmatrix} \quad \text{(10)}$$

(The multiplication and addition being done mentally.)

Further applications are also true for complex matrix products and products involving complex conjugates, of which only the complex product is shown below.

$$G = \begin{bmatrix} 1 & 2+i & 3-2i \\ 4 & 5-i & 6+3i \\ 7 & 2 & 9 \end{bmatrix}, \qquad H = \begin{bmatrix} 2 & 1+i & 2-2i \\ 3 & 3-i & 3+i \\ 4 & 1 & 4 \end{bmatrix} \quad \text{(11)}$$

Then GH is found by:

2		3		4	
$1+i$		$3-i$		1	
$2-2i$		$3+i$		4	
1		$2+i$		$3-2i$	
4		$5-i$		$6+3i$	
7		2		9	

$$GH = \begin{bmatrix} 20-5i & 11 & 19-5i \\ 47+9i & 24-i & 48+6i \\ 56 & 22+5i & 56-12i \end{bmatrix} \quad (12)$$

This method for the complex matrix product is, from practical considerations, not intended to minimize the work involved in the calculation, but rather to give a clear and unconfusing format from which the result can be derived.

Since the general result of this schematic arrangement for multiplying matrices has been shown to be identical with the classical product, its applicability will also hold for all other similar cases. The student of applied mathematics (if he deals extensively in matrices) will appreciate the above simplified form, and the teacher, from a pedagogical point of view, can easily introduce it as an alternate method in the classroom.

THE NEW MATHEMATICAL TABLES

Rev. Frederick W. Sohon, S.J.

Under the sponsorship of the National Bureau of Standards, the Federal Works Agency Work Projects Administration for the City of New York is engaged in the computation of mathematical tables that by shortening the arithmetical labor may make the difference between the possibility and the impossibility of solving a given problem. In this paper we shall be concerned with three of the volumes produced by this agency:

Publication Number 2. Tables of the Exponential Function.

Publication Number 3. Tables of Sines and Cosines for Radian Arguments.

Publication Number 4. Tables of Circular and Hyperbolic Sines and Cosines for Radian Arguments.

Publication No. 3 tabulates the functions at intervals of .001 from 0 to 25 radians, while Publication No. 4 tabulates the four functions at intervals of .0001 from 0 to 2.

The speed and convenience of a table is determined by the ease with which it can be interpolated. In these volumes no tabular differences are to be found, nor are any other aids to interpolation given, except that Table VI in Publication No. 3 gives values of the quantity $p(1-p)$, which is twice the Besselian coefficient of the mean second difference. But if it be called to mind that (except for sign) the sines and cosines are the derivatives of each other, and that the exponential function is its own derivative, then if you choose to make use of Taylor's series

$$F(x_0 + h) = F(x_0) + h\,F'(x_0) + \tfrac{1}{2}\,h^2\,F''(x_0) + \frac{1}{6}\,h^3\,F'''(x_0) +$$

etc. or, as we shall write it,

$$F = F_0 + h\,F'_0 + \tfrac{1}{2}\,h^2\,F''_0 + \frac{1}{6}\,h^3\,F'''_0 + \text{etc.},$$

you will find all the quantities F_0, F'_0, F''_0, right there before your eyes.

With $\quad h < 10^{-3}, \quad \frac{1}{6}\,h^3 < 2 \times 10^{-10}$

and with $\quad h < 10^{-4}, \quad \frac{1}{6}\,h^3 < 2 \times 10^{-13}$

so that except in the case of the exponential and hyperbolic functions where the argument is large, the third order term will be negligible if we are only interested in 8 or 9 decimal places.

In the nine place table (Publication No. 4) the interval is 10^{-4}, and by always working from the nearest entry we can make

$$h < 5 \times 10^{-5} \quad \text{and} \quad \tfrac{1}{2}\,h^2 < 1.25 \times 10^{-9}$$

so that the second order term can be dropped if we are content with 8 correct decimal places. To get the full accuracy of the tables the following formulas can be used for interpolation:

$$\sin(x_0 + h) = (1 - \tfrac{1}{2}h^2)\sin x_0 + h\cos x_0$$

$$\cos(x_0 + h) = (1 - \tfrac{1}{2}h^2)\cos x_0 - h\sin x_0$$

$$\sinh(x_0 + h) = (1 + \tfrac{1}{2}h^2)\sinh x_0 + h\cosh x_0$$

$$\cosh(x_0 + h) = (1 + \tfrac{1}{2}h^2)\cosh x_0 + h\sinh x_0$$

We might also construct a small table for $\frac{1}{2}h^2$:

h	$\frac{1}{2}h^2$
	0×10^{-9}
.0000 31622	
	1
54772	
	2
70710	
	3
83660	
	4
.0000 94863	

or we may use with advantage a table of squares, or a slide rule. The process is as follows. Look up sin x_0. Put this in the keyboard of your computing machine and multiply by $1 - \frac{1}{2} h^2$. Clear the keyboard and the multiplier tally, but not the carriage. Then put cos x_0 in the keyboard and multiply by h. The carriage register will then read the value of $\sin(x_0 + h)$. Only five decimal places of the cosine need be used.

The tables of the exponential function are much more ambitious as they run out to 12, 15 and 18 decimal places. Taylor's series for the exponential function appears as

$$e^{X_0+h} = e^{X_0}\left(1 + h + \frac{1}{2} h^2 + \frac{1}{6} h^3 + \text{etc.}\right)$$

When the numbers are longer than the computing machine is wide, things are not so nice. If you are content to work with eight or nine decimal places, you have the same convenience that you had before. If eight decimal places suffice, then in Tables I, II and V where the interval of the argument is .0001, you will use linear interpolation:

$$e^{X_0+h} = e^{X_0}(1+h)$$

If you find yourself in Table III in which the argument runs from 2.5 to 5 at intervals of .001 you can either subtract from your argument

log 10 = 2.30258 50929 94046
log 100 = 4.60517 01859 88092

which will bring you into Table I or II, and then you shift the decimal point in your answer. Otherwise you can use the next term of the series:

$$e^{X_0+h} = e^{X_0}\left(1 + h + \frac{1}{2} h^2\right)$$

The relative merit of the different methods of interpolation can be discussed by taking as exact the formula

$$F = F_0 + h F'_0 + \frac{1}{2} h^2 F''_0$$

which gives the maximum accuracy obtainable with the eight and nine place tables. In direct linear interpolation by means of the derivative we form an approximation

$$F = F_0 + h F'_0$$

and the value so obtained is too small by the amount $\frac{1}{2}$ h F''_0. If w is the interval of the argument so that $x_0 + h$ lies between the two tabulated values x_0 and $x_0 + w$, and if

$$F_1 = F(x_0 + w) = F_0 + w F'_0 + \tfrac{1}{2} w^2 F''_0$$

then the interval between the tabulated values of the function

$$F_1 - F_0 = w (F'_0 + \tfrac{1}{2} w F''_0)$$

and the linear approximation obtained in the usual fashion is

$$F = F_0 + \frac{h}{w} (F_1 - F_0)$$

$$= F_0 + h F'_0 + \tfrac{1}{2} wh F''_0$$

This value is too large by the amount $\frac{1}{2}$ h (w-h) F''_0. By working from the nearest tabulated value of the argument we can keep h numerically not greater than $\frac{1}{2}$w, and this means that the use of the derivative in direct linear interpolation will always be superior to the method of differences if the third order term can be neglected.

For inverse interpolation the matter is not quite so simple. The functions as tabulated may be considered as having an uncertainty of one half a unit in the last decimal place and this amounts to $w^2/20$. Corresponding to this uncertainty in F there will be an uncertainty in the argument x which we may represent by u, where

$$F(x+u) - F(x) = u F' + \tfrac{1}{2} u^2 F'' = \pm \frac{w^2}{20}$$

In the case of the functions under discussion, when F' vanishes F'' will be numerically equal to unity, and

$$u = \pm \frac{w}{\sqrt{10}}$$

Otherwi... we can take for the approximate value of this uncertainty

$$u = \pm \frac{w^2}{20 F'}$$

even when F' is as small as w. This uncertainty is inherent in the inverse function and is not due to interpolation. If greater accuracy is desired transformations must be used so as to use the complementary function.

For linear inverse interpolation by the method of differences we should write

$$x = x_0 + \frac{F - F_0}{F_1 - F_0} w$$

$$= x_0 + \frac{F'_0 + \tfrac{1}{2} h F''_0}{F'_0 + \tfrac{1}{2} w F''_0} h$$

$$= x_0 + h - \frac{\tfrac{1}{2} h(w-h) F''_0}{F'_0 + \tfrac{1}{2} w F''_0}$$

$$= x_0 + h - \frac{\tfrac{1}{2} hw(w-h) F''_0}{F_1 - F_0}$$

and the last fraction represents the error of linear inverse interpolation by the method of differences. Linear inverse interpolation by means of the derivative gives

$$x = x_0 + \frac{F - F_0}{F'_0}$$

$$= x_0 + h + \tfrac{1}{2} h^2 \frac{F''_0}{F'_0}$$

in which the last term again represents the error of the method. These two errors are equal in magnitude but opposite in sign when

$$\frac{h}{F'_0} = \frac{w\,(w-h)}{F_1 - F_0}$$

or when the interval is divided in the ratio

$$\frac{h}{w-h} = \frac{w\,F'_0}{F_1 - F_0} = \frac{\text{slope of the tangent}}{\text{slope of the chord}}$$

Before starting to make rules about when to use which method, it is well to stop and consider the intrinsic uncertainty of the tables. In terms of this, the error of inverse linear interpolation with the derivative (provided the derivative does not vanish) is equal to

$$\tfrac{1}{2}\, h^2 \frac{F''_0}{F'_0} \simeq 10 \left(\frac{h}{w}\right)^2 F''_0\, u$$

In the middle of the interval this amounts to 2.5 F''_0 u. The possible improvement is small, and it seems more profitable to derive the corrections than to establish a criterion for the choice of method. If we propose to use the difference, compute

$$p = \frac{F - F_0}{F_1 - F_0}$$

The approximate value of h will then be pw. The value $x_0 + pw$ is too small by

$$\frac{\tfrac{1}{2}\, hw\, (w - h)\, F''_0}{F_1 - F_0} = \tfrac{1}{2}\, p(1 - p) \frac{w^3 F''_0}{F_1 - F_0} \text{ approximately.}$$

Hence an improved formula for inverse interpolation is

$$x = x_0 + pw + \tfrac{1}{2} p\, (1 - p) \frac{w^3 F''_0}{F_1 - F_0}$$

This is the interpolation formula given in the Introduction. The formula using the derivative may be improved in the same way by taking $(F - F_0)/F'_0$ as an approximation for h in the error found above. In this way we obtain

$$x = x_0 + \frac{F - F_0}{F'_0} - \tfrac{1}{2} \left(\frac{F - F_0}{F'_0}\right)^2 \frac{F''_0}{F'_0}$$

This formula is the one obtained if the inverse function is expanded by Taylor's series.

PHYSICS

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Rev. Bernard A. Fiekers, S.J.

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[1]*In his Presidential Address, Cosmic Rays and Logic, delivered at the twentieth annual meeting of the American Association of Jesuit Scientists, held at Holy Cross College, Sept. 2, 3, 4 of this year, Fr. Tobin, S.J. paid tribute to Fr. Theodore Wulf, S.J. for his outstanding work in this field. (cf. this Bulletin Vol. 19, pg. 12, 1941). Due to the untiring efforts of Fr. Fiekers we are fortunate in being able to present this Bibliography of Fr. Wulf's works.—Editor.*

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The contributor has no intention of consigning any additional items to oblivion. Should a notable number of them come to light supplementary publication might be desirable.

Abbreviations

Sitsber Akad Wiss Wein Math-naturw Klasse—Sitzungsberichte der Akademie der Wissenchaften in Wien. Mathematische-naturwissenschaftliche Klasse.

Z physik chem Unterricht—Zeitschrift fuer den physikalischen und chemischen Unterricht.

Ann Physik—Annalen der Physik.

Z physik Chem—Zeitschrift fuer physikalische Chemie.

Physik Z—Physikalische Zeitschrift.

Ann Soc Sci Bruxelles—Annales de la société scientifique de Bruxelles.

Ber deut physikal Ges—Berichte der deutschen physikalischen Gesellschaft.

THE NEW ATOM

ROBERT B. MACDONNELL, S.J.

We frequently hear the charge that modern physics changes so rapidly that the contemporary physics of today will be completely out-of-date a year from now. Recent discoveries are admittedly tremendous, and there is every indication that they will continue at an even greater pace in the future, but for the most part the change in the body of scientific knowledge is one of accretion, with new experiments and discoveries shedding further light upon the old. The data of physics are generally permanent, but may be subjected to new interpretations or represented by new models.

In the field of atomic physics, only a few years have passed since we spoke rather apodictically about the atom as if it were certainly composed of but two particles, the proton and the electron. But now we have a completely different picture, so much so that we may speak of the "new atom", or of the "1941 atom", which has many sub-atomic particles instead of a single pair. Because of the rapid progress in atomic physics, articles in the scientific journals present the latest findings about the mesotron and the positron, they may offer some new theory about the neutrino, but they rarely correlate the various data into an organic whole. The scope of the present paper is to describe in a rather general manner the various sub-atomic particles, and explain the function of each in the atomic picture.

First of all there is our old friend, the electron, whose part in the atomic picture is for the most part unchanged. With a mass of 9.035×10^{-28} gms. and a charge of 15.99×10^{-20} coulombs, the number of extranuclear electrons, and in particular the number of those in the outer shell, determines an atom's chemical properties and explains the familar periodic chart of the elements.

Elements have been torn away from their natural place in the atomic shell and ejected from various kinds of matter in a number of different ways: by light, heat, electric discharges, some chemical reactions, and by the impact of fast electrons or of other charged particles already set free. As individuals these electrons are perfectly similar, but different terminology is used to designate electrons according to the cause of their emission. Thus electrons coming from radioactive substances are called beta-rays; from the cathodes of discharge-tubes, cathode-rays; from incandescent metals, thermionic electrons; and as propelled from metals by ultra-violet light, photoelectrons. The speed of emergence of beta-rays is the greatest of all, and is sometimes as great as 99% of the speed of light (3×10^{10} cms. per sec.); cathode-rays sometimes attain a speed of 10^{9} cms. per sec., depending upon the voltage; thermionic electrons and photoelectrons, on the other hand, have a comparatively low speed.

Lately it has been shown that the electron is not a simple particle with behavior like that of a bullet. Electron streams have manifested certain wave properties, such as interference, and these may be utilized in the study of surface structure and film structure. Furthermore, as will be shown later in this paper, there is evidence that electron may be produced and absorbed in the transformation of sub-atomic particles.

Theoretical physics predicted a new particle when Dirac set up wave-equations primarily designed to explain the spin and magnetic properties of the electron. A further study of the Dirac equations showed that they predicted a twin of the electron, a particle with the same mass and with a charge identical in quantity but opposite in sign. Moreover, Dirac predicted that this new particle could combine with an electron sending out short-wave photons with an energy of a million volts, and conversely that from the collision of a photon of sufficiently large energy with an atomic nucleus, both a positron and an electron could be produced. At the time of Dirac's prediction there was no experimental evidence for any such particle.

While investigating cosmic rays by means of a cloud chamber in 1932, Dr. Carl D. Anderson of the California Institute of Technology discovered the Dirac particle, and named it the positron. Subsequently, the positron was observed in other experiments, and many of its properties are now known. As Dirac had predicted, it has the same mass and spin as the electron while its charge had the same quantity but opposite sign. Both Dirac and Anderson received Nobel prizes. It is interesting to note that Irene Curie and Joliot observed positron tracks before Anderson, but rather than interpret the tracks as having been made by positive particles, they assumed that the tracks marked the path of negative electrons going towards the source of irradiating rays. Later Anderson hesitated for some time before deciding that the tracks must have been made by positive electrons moving in the opposite direction from that ascribed by Joliot and Curie. This conclusion has since been confirmed many times.

Positrons have been artificially produced together with electrons from gamma-rays. Using Einstein's equation for the relation of energy to mass, the mass of the electron corresponds to an energy equal to the product of the electronic mass (9.0×10^{-28} gms.) and the square of the velocity of light, i.e. (3×10^{10} cms. per sec.)^2. Thus we conclude that the energy necessary to produce an electron s 8.1×10^{-7} ergs or more than one-half million electron-volts. From the law of the conservation of electricity we know that whenever a quantity of either positive or negative electricity is produced, there is also produced an equal quantity of opposite sign. Therefore, in order to produce a single positron, we should expect an expenditure of energy of more than a million electron-volts, since the positron is always accompanied by an electron. Anderson and Neddermeyer, Joliot and Curie, and others have produced positrons by the use of very hard gamma-rays having photon energies above 10^9 electron-volts.

Best known of the intranuclear particles is the proton, whose mass is about 1840 times that of the electron and whose charge is identical with that of the positron. The number of protons in any nucleus equals the element's atomic number and also determines the number of electrons in a particular atom, thus indirectly determining the element's chemical behavior.

A short time ago the atomic picture was considered quite simple, with protons in the nucleus and with electrons somehow revolving about that nucleus in various layers or shells. That simplicity was destroyed by the discovery of isotopes. There are but 92 known elements, but many more than 92 kinds of atomic nuclei; in fact, about 270 stable kinds are known, and there is an ever increasing number of unstable and transitory nuclei. By means of the mass spectrograph it was shown that nuclei of the same element, i.e., with the same number of unit charges and the same atomic number, can have different atomic weights. For example, most hydrogen nuclei have an atomic weight of 1, but some have an atomic weight of 2. These latter are called deuterons. There are 10 different kinds of nuclei (or isotopes) for tin, atomic number 50, whose mass numbers vary from 112 to 124. (The mass number of an isotope is the integer closest to the value of an isotope's atomic mass, while an element's atomic weight is the average weight of the various atoms found in any measurable quantity of the element. Thus ${}_{10}Ne^{20}$ and ${}_{10}Ne^{22}$ are isotopes of Neon, atomic number 10, and the mass numbers of these particular isotopes are 20 and 22. The atomic weight of Neon is 20.2) On the other hand, nuclei of the same atomic weight may have different atomic numbers. There are, for example, nuclei of tin, atomic number 50, tellurium 52, and xenon 54, all with mass number of 124. Expressing this in the symbolism of isotopes, we may say that there are ${}_{50}Sn^{124}$, ${}_{52}Te^{124}$ and ${}_{54}Xe^{124}$. Likewise there are ${}_{52}Te^{130}$, ${}_{54}Xe^{130}$ and ${}_{56}Ba^{130}$ as well as other similar sets.

Out of this apparent confusion in the subatomic universe simplicity was restored by the discovery of the neutron. In 1930 Bethe and Backer working at the Reichsanstalt discovered that a weak but highly penetrating radiation is produced when beryllium is bombarded by alpha-particles. Joliot and Curie examined this radiation at the Institut du Radium, and found that the rays can eject atomic nuclei with an energy of several million electron-volts from the material through which they pass. They concluded, however, that the particles emitted were protons, and the evidence seemed to support that conclusion. It remained, then, for Chadwick of the Cavendish Laboratories to explain the nature of these particles. The kinetic energy of the particles was so great, about 5 Mev, that they could not have such great penetrating power if they were similar to gamma-radiation, but must be material particles like alpha- or beta-rays. Further, Chadwick concluded that the radiation consisted of uncharged material particles, and he introduced the present name "neutron".

The lack of charge explains the late discovery of the neutron. It has ionization effect, and for that reason cannot be directly detected by photographic methods. Unlike the various charged particles, the passage of a neutron through matter is invisible, and the effect of a neutron is apparent only when it strikes and ejects a nucleus.

The neutron has no electric charge and its mass is about the same as that of the proton. It is now known that nuclei are built of protons and neutrons. The number of protons equals the element's atomic number, while the total number of protons and neutrons equals the atomic weight. The existence of isotopes is due to an excess of neutrons in the nucleus.

An unexpected development came from the bombardment of nuclei by high-speed particles. Under such bombardment it seems that a neutron may pick up enough energy to change into a proton giving off an electron. Likewise a proton may change into a neutron giving off a positron, while sometimes a proton may change into a neutron through absorption of an electron while giving off energy as a photon.

In addition to these lightweight particles, the electron and the positron, and the heavyweight particles, the proton and the neutron, there are also some of intermediate weight. This was first predicted by the Japanese physicist, Yukawa, from a study of the non-electrical forces between nuclear particles. Yukawa calculated that the new particle would weigh about 100 times the electronic mass, or about one twentieth of the proton mass. This particle was first observed in 1936, and was at first called by many different names: the barytron, heavy electron, yukon, mesotron and meson. Finally at a symposium on cosmic rays held at the University of Chicago in June 1939, the matter was put to a vote, and the name "mesotron" was the popular choice. This name seems likely to remain in use.

The mesotron was discovered to be one of the constituents of cosmic rays; in fact, it is the mesotron which explains the great penetrating power of cosmic rays. Experiments with cloud chambers give direct evidence of both positive and negative particles of mass intermediate between the electron and the proton. Even yet, however, there is a great diversity of opinion among physicists regarding the mesotron's mass. Anderson's opinion places the mesotron's mass about 200 times as great as that of the electron, while other estimates range from 100 to 400 times the electronic mass. Incidentally, Shonka and others have found some evidence for a neutral mesotron, and this is sometimes called the neutretto.

The case for each of the particles mentioned thus far is supported by experimental evidence. But theoretical physics does not wait for experiments. The law of the conservation of energy does not seem to hold in some nuclear transformations, and to explain this Fermi suggested the neutrino, a very light neutral particle with mass much less than that of the electron. There is some evidence that the neutrino may be produced along with an electron or a positron when a proton changes to a neutron, or a neutron changes to a proton, but up to the present only one set of experiments seems to prove the existence of the neutrino. Within the past few months a new theory has appeared which attributes to the neutrino a role of primary importance in the disappearance of energy from exploding stars, but as yet there seems to be no experimental confirmation of this theory.

An examination will show that of the eight particles described up to this point, the lightweight class claims positive, negative and electrically neutral particles, and that the same is true of particles intermediate in weight. But in the heavyweight class there are only two kinds of particle, the proton and the neutron. It is not surprising, therefore, that Gamow predicts a negative proton; in fact, it is to be expected that symmetry reigns in the sub-atomic world just as in the universe about us.

NEWS ITEMS

BOSTON COLLEGE

Chemistry Department

The following Seminars will be presented by the Faculty and Graduate Students during the current school year (1941-42)

EACH TUESDAY AT 9:15 A.M. IN MASTERS' ROOM

	Topic	*Director*
Sept. 30—Fr. McGuinn, S.J.	Biological Oxidation	
Oct. 14—Dr. O'Donnell	Chemical Literature	
Oct. 28—Dr. Carmody	Electrolytic Dissociation Theory History and Present Status	
Nov. 18—Dr. Guerin	Electrolytic Theory of Corrosion	
Dec. 2—Mr. Grapes	Hydrides of Boron	Dr. Guerin
Dec. 9—Mr. Cincotti	Sulfur Compounds in Medicine	Mr. Fagan
Dec. 16—Mr. Rohan	Structure of Liquids	Dr. Carmody
Jan. 6—Mr. Ryan Mr. Greeley	Thesis Seminar — Identification of Alcohols with Bromo and Iodo-Acids	Dr. O'Donnell
Jan. 20—Mr. Lynch	Thesis Seminar— Polarization Studies	Dr. Carmody
Feb. 3—Mr. Pillion	Thesis Seminar — Electrodeposition of Manganese	Dr. Guerin
Feb. 17—Mr. Ryan	Determination of Melting Point	Dr. O'Donnell
Mar. 3—Mr. Buck, S.J.	Theories of Acid-Base Phenomena	Fr. McGuinn, S.J
Mar. 17—Mr. Greeley	Determination of Boiling Point	Dr. O'Donnell
Mar. 31—Mr. Lynch	Industrial Uses of Less Common Elements	Fr. Butler, S. J.
Apr. 14—Mr. Pillion	Use of Organic Reagents In Inorganic Analysis	Mr. Fagan

Two new Professors have been added to the department, the Rev. Thomas P. Butler, S.J., and Dr. Walter Carmody, to replace Rev. Anthony Carroll, S.J., and Dr. John Rouleau, respectively. The latter two are now in the army.

Physics Department

Rev. Peter J. McKone, S.J., has joined the Physics Faculty this year and is the professor of General Physics to the Freshman B. S. This year we have 104 students in this class. The Senior and Junior classes in Physics are large this year as many of the A. B. students are majoring in Physics to prepare for defense work.

A new course of four years that gives the degree of B. S. in Electrical Engineering was started this year. A new machine shop was equipped in the basement of the Science Building and the Freshmen are taking this course this year, with a course in Mechanical Drawing and Machine Design. The other courses in Freshmen are the same as the B. S. in Physics. Next year they start A. C. and D. C. Machinery laboratory and two new laboratories are being built in the basement. Valuable gifts from the Edison Co., and loans from Harvard and M.I.T. have made it possible to set up these laboratories. The course at present is limited to the Communications Option of Electrical Engineering.

There are three defense courses at present given under the directions of the Physics Dep't. Prof. Malcolm Gager was appointed Coordinator of the Engineering, Science and Management Defense Training Courses here. A class of seventy-five men who are working in defenses industries was selected for Radio Communications Course. On Monday and Wednesday nights they have three hour classes of lectures and demonstrations. On Friday nights there is a three hour laboratory. Fr. Tobin is Coordinator of Civilian Pilot Training and the Ground School at Boston College has received a certificate to train students in the elementary and secondary courses. The Radio Club has a big membership as the defense needs operators.

Four graduate students are working on their theses for the M. S. in Physics and four others started their work this year.

CANISIUS COLLEGE

Chemistry Department

PROGRAM OF THE CANISIUS COLLEGE ALUMNI CHEMICAL SOCIETY

1941

Monday, Oct. 6

"INDUSTRY'S CHALLENGE TO RESEARCH"
William B. Foley
Liberty Bank of Buffalo

Monday, Nov. 3

"PHOTOGRAPHIC SENSITIZING DYES"
Leslie G. S. Brooker
Eastman Kodak Company

Monday, Dec. 1

"SURFACE ACTIVATION"
LAWRENCE H. FLETT
National Aniline & Chemical Co.

1942

Monday, Feb. 2

"DETERGENTS"
WILMER H. KOCH
The Mathieson Alkali Works, Inc.

Monday, March 2

"STEEL"
HERBERT J. CUTLER
Bethlehem Steel Corp.

Monday, April 13

"CHEMICALS FROM SALT"
HAROLD J. BARRETT
R & H Chemicals Dept.—E. I. du Pont de Nemours & Co.

Monday, May 4

"VITAMIN B COMPLEX"
LEO K. ROCHEN
Lucidal Corporation

HOLY CROSS COLLEGE

Chemistry Department

The following Seminars will be presented by the Students of the Department

HISTORY OF CHEMISTRY
MADAME CURIE
Mr. William J. Fox, B.S., (M.S.,'42) October 27, 1941
Directed by Professor Tansey

INORGANIC CHEMISTRY
ACIDS AND BASES
Mr. John E. Shea, Jr., B.S., (M.S.,'42) November 3, 1941
Directed by Professor Sullivan

THERMODYNAMICS
THE DROPPING MERCURY ELECTRODE AND ITS APPLICATIONS
Mr. Anthony N. Sinclitico, B.S., (M.S.,'42) November 10, 1941
Directed by Professor Tansey

ADVANCED ORGANIC CHEMISTRY
SEX HORMONES
Mr. William F. MacGillivray, B.S., (M.S.,'42) November 17, 1941
Directed by Professor Baril

ATOMIC STRUCTURE

ULTIMATE PARTICLES OF THE ATOM

Mr. James F. Little, B.S., (M.S.,'42) November 24, 1941

Directed by Professor Sullivan

REACTION RATES

EXPLOSIVES

Mr. Cornelius B. Murphy, B.S., (M.S.,'42) December 1, 1941

Directed by Professor Tansey

ANALYTICAL CHEMISTRY

SEMI-MICRO QUALITATIVE ANALYSIS

Mr. Michael F. Kilty, (A.B.,'42) December 15, 1941

Directed by Professor Charest

ORGANIC CHEMISTRY

SYNTHETIC FABRICS

Mr. Bernard J. Digris, (B.S.,'42) January 5, 1942

Directed by Professor Baril

PHYSICAL CHEMISTRY

ELECTROLYTIC DEPOSITION OF THE METALS

Mr. John A. Green, (B.S.,'42) January 12, 1942

Directed by Professor Tansey

ORGANIC ANALYSIS

DYE ANALYSIS

Mr. John P. Hardiman, (B.S.,'42) January 19, 1942

Directed by Professor Baril

ORGANIC CHEMISTRY

GASOLINE

Mr. Clifton R. Largess, (B.S.,'42) February 9, 1942

Directed by Professor Baril

ANALYTICAL CHEMISTRY

RECENT ADVANCES IN COLORIMETRIC ANALYSIS

Mr. Frederick C. Adams, (A.B.,'42) February 16, 1942

Directed by Professor Charest

INORGANIC CHEMISTRY

THE IRON-CARBON DIAGRAM

Mr. Robert M. Dee, (B.S.,'42) March 2, 1942

Directed by Professor Sullivan

ORGANIC CHEMISTRY

FRACTIONAL DISTILLATION

Mr. James M. Owens, (B.S.,'42) March 16, 1942

Directed by Professor Mitchell

COLLOID CHEMISTRY

PARTICLE SIZE IN A COLLOID SYSTEM

Mr. John J. Killoran, (B.S.,'42) March 23, 1942

Directed by Professor Mitchell

ORGANIC CHEMISTRY

MODERN SOLVENTS

Mr. Andrea V. Vaccarelli, (B.S.,'42) March 30, 1942

Directed by Professor Mitchell

LOYOLA COLLEGE

(Baltimore, Md.)

Chemistry Department

The Loyola Chemists' Club will present the following programme of Lectures, during the present Scholastic Year

1941

Tuesday, October 28

DR. FREDERICK Y. WISELOGLE, Ph.D.
Assistant Professor of Chemistry
The Johns Hopkins University
"ORGANIC CHEMISTRY IN NATIONAL DEFENSE"

Tuesday, November 4

DR. STANLEY P. WATKINS, Ph.D.
Manager of Development Division
Rustless Iron & Steel Corporation
"CHEMISTRY INVOLVED IN MAKING STAINLESS STEEL"

Tuesday, December 9

MR. JOHN F. GARGES
Chief Chemist
McCambridge & McCambridge, Washington, D. C.
"CHEMISTRY IN THE PREPARATION OF PHARMACEUTICALS"

Tuesday, February 10

DR. JOHN C. KRANTZ, Jr., Ph.D.
Professor of Pharmacology
University of Maryland Medical School
"CHEMISTRY IN MEDICINE"

1942

Tuesday, March 10

DR. CARL HOFFMANN, Ph.D.
Superintendent of Blast Furnaces
Bethlehem Steel Corporation
"CHEMICAL CONTROL OF BLAST FURNACES"

Tuesday, April 21

DR. ALEXANDER O. GETTLER, Ph.D.
Professor of Chemistry
New York University, Washington Square
Toxicologist of New York City
"CHEMISTRY IN CRIME DETECTION"

Physics Department

A new Instructor in Mathematics and Physics has been announced in the person of Mr. James E. Gallico, S. J., filling the vacancy left by Mr. Charles G. Neuner, S. J., on his return to Woodstock for Theology. Mr. Gallico comes immediately from Philosophy at Spring Hill College, and is a graduate of Fordham University where he studied Physics under Father Lynch.

During the summer the Physics lecture room and laboratories were completely renovated and handsome new instrument cabinets were installed. New registrations in Physics surpass all previous records, nearly filling the newly doubled seating capacity of the lecture room. Nine seniors and seventeen juniors are taking advanced courses in Physics. It has been found impossible to fill during the last summer the demands for physicists, and very attractive offers from Brooklyn College of N. Y. U., St. Louis University and Georgetown University had to go unfilled. One of the seniors majoring in Physics resigned his Instructorship in the C. A. A. to complete his course in Physics.

ST. MARY'S COLLEGE
(Halifax, N. S.)

Physics Department

In an address delivered at the Sixth Annual Meeting of the Allegheny Section of the Society for the Promotion of Engineering Education, Dr. William P. Tolley, president of Allegheny College, is reported to have said:

> Somewhere in the programme of education attention must be given to a study of values as well as facts, to the problem of social control as well as technical advance.
>
> The so-called three-two plan for engineering education has been proposed as partial answer to this problem. Under this plan a student spends three years in a college of liberal arts and two years in an engineering college. At the conclusion of the fifth year he receives the degree of Bachelor of Arts from the College of Liberal Arts and the Bachelor of Science in Engineering from the School of Engineering.
>
> The plan is not a Utopian solution. It has a number of disadvantages.*

In the discussion which followed the paper, Professor William R. Work, Head of the Department of Electrical Engineering, Carnegie Institute of Technology, remarked:

> Mr. Alan Bright, Registrar here at Carnegie for many years, studying certain statistics in his office, became im-

*—*The Engineering Journal*, October, 1941, 488.

pressed with the fact that a large number of students had had some liberal arts training. Further, he found that as a group these men had done very well; they had scholastic records distinctly above the average. . . . . This was the genesis of the 3-2 plan. . . . . The Carnegie Institute of Technology has this plan now in operation. Arrangements have been made not only with Allegheny College, but also with five others, Washington & Jefferson, Denison, Albion, Geneva, and Westminster.

A Jesuit College which joins in a 3-2 plan is St. Mary's College, Halifax (Canada). Those who follow the 3-2 plan at St. Mary's obtain no degree from St. Mary's; at the end of five years they obtain a B. E. degree from Nova Scotia Technical College. However, there is also a 4-2 plan, by which students get a B.Sc. from St. Mary's at the end of four years, and a B.E. from N.S.T.C. at the end of six years.

Curiously enough, a degree in Engineering cannot be obtained in Nova Scotia except on a 3-2 or 4-2 plan. Nova Scotia Technical College is the only College in Nova Scotia awarding a degree in Engineering. N.S.T.C. is affiliated with the following Universities and Colleges —Acadia, Dalhousie, King's, Mount Allison, St. Francis Xavier, St. Mary's, and Memorial University College of Newfoundland. By the terms of the affiliation, the separate Universities offer a course in Engineering covering the first three years, and the Technical College offers professional courses in several departments of Engineering covering the last two years of a five year course. The course in Engineering of the first three years varies in some minor details in the different affiliated Colleges. At St. Mary's the course comprises three years of Mathematics, Physics and Apologetics, two years of Chemistry, Drafting, English and Surveying, and one year of Philosophy, Descriptive Geometry, Materials of Construction, Applied Mechanics, Mechanics of Machines, Graphic Statics, Economics, Geology and French or German. For Field Work in Surveying the affiliated Colleges have a common camp to which all students go during the first three weeks of September; each College provides an instructor.

The 3-2 plan has its disadvantages. But, for the University or College which has not a School of Engineering it is an advantage. It gives the "college of liberal arts" a hand in the formation of Engineers. This is a great good. Engineers have souls to be saved; their children will have souls. Engineering students are the raw materials of future citizens, and maybe statesmen. The world of to-morrow may see more Engineers in key positions. To-day, two of Canada's outstanding leaders are Engineers, the Minister of Transport, C. D. Howe, and the Officer Commanding the Canadian Army Corps in England, Lieut-General A. G. L. McNaughton, C.B., C.M.G., D.S.O. To the present prejudiced correspondent, having a hand in the moulding of Engineers is an apostolic and social work not to be despised.

M. W. Burke-Gaffney.

WESTON COLLEGE

Physics Department

With the opening of the new academic year the Theologians who are interested in Physics resumed their work in their Physics Seminar under the direction of Rev. Thomas J. Smith, S.J. The plan outlined for this year consists of a review of current periodical literature.

Experience has proved that it is impossible for any individual to keep abreast of modern trends in all fields of Physics while devoting the greater part of his time to the study of Theology. The present plan seems to afford a good solution of this difficulty. Members select their own topic, and present their seminar after several months of reading in the recent journals.

This year there are six members of the seminar, and bi-weekly meetings are held.

THE SEISMOLOGICAL OBSERVATORY

During the month of October and part of November Fr. Linehan was engaged in conducting a seismic survey across the Connecticut River Valley in Central Massachusetts. As was mentioned in a former issue of the BULLETIN, this survey was financed by a grant by the Geological Society of America.

The survey was begun in Southwick, Mass., and continued through Agawam, Springfield and North Wilbraham in a West to East line. Despite the fact that this survey was of a preliminary character to ascertain the feasibility of making a more extensive survey in the future, many places were surveyed in detail especially within the limits of the City of Springfield. In these latter instances, refraction technique was employed with a view to discover preglacial conditions, while in the less detailed sections surveyed, reflection technique was used to study the deeper horizons of Triassic and pre-Triassic formations.

Professor Howard A. Meyerhoff of Smith College, and Professor Chester P. Longwell of Yale University assisted Father Linehan in the field with interpretations of the local geology.

Plans are being made at present to make an under water survey at the mouth of the Mystic River in Boston. At this point is supposed to be one of the pre-glacial river beds, and this knowledge will be added to the already extensive survey that has been made of the Boston area by the Harvard Dept. of Geology and the Weston Dept. of Seismology working in combine.