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NOTICE TO AUTHORS

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Science and Philosophy

A COMMENTARY ON EVOLUTION

Alwyn Harry, S.J.

Introduction

Some ninety years ago, when Darwin published his famous book entitled "Origin of the Species", many of his contemporaries attacked his conclusion that man is descended from animal ancestors as downright blasphemy. In the battle which ensued, Darwinists asserted, and many still maintain, that man was and still is nothing but an animal species. On this question of evolution Churchmen (many of them reputable scientists), as well as other outstanding scientists, have expressed many important opinions, especially within the past 12 years. However, there is still almost universal confusion and misconception on the part of Catholics as well as non-Catholics with regard to the Church's position on this scientific question. Too often does one find even educated Catholics regarding the theory of Evolution in any form as a challenge to be met with every adverse argument available and to be condemned as vigorously as any heresy against the Faith (1).

The purpose of this article is to present quotes from experts in the fields of Theology, Philosophy and Science (especially Biology), and thereby to show that Reason and Faith do not at all exclude one another but that, very much to the contrary, when both are genuine, they confirm each other.

To show the universality of the discussion of the Theory of Evolution, I have selected excerpts from articles published in scientific, philosophical and theological journals in France, England, Italy, America, Ireland, Spain, and India.

In Part I of this paper I will quote from the most recent pontifical pronouncements on the subject of Evolution, and will consider the comments of Professor Dobzhansky on the Allocution of Pope Pius XII delivered on September 7, 1953. I will then give excerpts (with my own comments) from reputable Catholic biologists, philosophers and theologians. In Part II I will give quotations from eminent scientists who favour the Theory of Materialistic Evolution, and will endeavour to show, briefly, that such a theory is biologically erroneous, philosophically absurd, and contrary to theology. Part III will contain my conclusions, and Part IV, a Bibliography.

PART I

In 1941, Pope Pius XII in his Allocution to the Pontifical Academy of Sciences said:

> Only from a man could there proceed another man who would call him father and progenitor; and the helpmate given by God to the first man also comes from him and is flesh of his flesh. . . . *Man, endowed with a spiritual soul, was placed by God at the summit of the ladder of living beings*, to be the head and lord of the animal kingdom. The many researches conducted in the field of paleontology or of biology and morphology have not yet furnished any positively clear and certain evidence bearing on other problems respecting man's origins. Therefore we can only leave to the future the answer to the question whether science, illuminated and guided by revelation, may some day be able to present secure and definite results with regard to so important a subject (2).

From this passage it seems clear enough that the Holy Father does not exclude the evolution of man's body from some sub-human species. It is likewise clear that he is asserting:

(i) that man is not the son of a brute animal;
(ii) that man is distinguished from the animal by his spiritual soul;
(iii) that man is not in the animal kingdom as one of a series, but in it as the king;
(iv) that for the other problems, and manifestly for that which concerns the formation of the human body, the natural sciences have not to date a certain solution; and
(v) that the natural sciences themselves, aided by Revelation, may some day come forward with certain evidence on this subject, the formation of the first human body (3).

The encyclical, *Humani Generis*, is considered the first official text of the *Magisterium* which takes a positive stand in the matter of evolution (4).

> The Church does not forbid that the theory of evolution concerning the origin of the human body as coming from pre-existing and living matter . . . be investigated and discussed by experts as far as the present state of human sciences and Sacred Theology allows. However this must be done so that reasons for both sides, that is, those favourable and those unfavourable to evolution, be weighed and judged with the necessary gravity, moderation and discretion . . . on the other hand, those go too far and transgress this liberty of discussion who act as if the origin of the human body from pre-existing and living matter were already fully demonstrated by the facts discovered up to now and by reasoning on them, and as if there were nothing in the sources of divine revelation which demanded the greatest reserve and caution in this controversy (5).

One may justly conclude from the above that in the Holy Father's mind, evolution is far from untenable; in fact, that it has much evidence in its favour.

Perhaps the latest statement of the Holy Father on this subject is his Allocution to the First International Symposium on Medical Genetics on September 7, 1953. In this allocution, the Pope said that the Church raises no bar against the quest for scientific truth; but he warned the geneticists that hypotheses cannot be accepted as fact. Here is a pertinent quotation from the speech:

> In recent works of geneticists, we read that there is no better explanation of the inter-relation of all living beings than the picture of a common genealogical tree. But at the same time the authors of these works stress that this is only an illustration, a hypothesis, and not a proved fact. They even go so far as to add that although most of the researchers present the doctrine of evolution as a "fact", this is only anticipatory judgment. They say that other hypotheses just as plausible can be proposed. They say also that many reputable scientists have formulated other hypotheses without at the same time denying that there is evolution of life, and that certain discoveries can be interpreted as pre-formations of the human body. But these reputable scientists have stressed in the clearest way that, according to them, we do not yet know exactly what is the exact and precise meaning of the terms "evolution", "descendants", "passage." And that, on the other hand, we know of no natural processes by which a being could produce a being of a different nature; that the processes by which a species may give rise to another species remain completely impenetrable, despite the numerous intermediary steps which we already know of; that nobody has ever succeeded experimentally in producing a species from another species; and finally that we would not be able to know absolutely at what moment in evolution that the hominids suddenly emerged into a man (6).

Commenting on this speech of the Holy Father, Professor Dobzhansky of the Institute for the Study of Human Variations at Columbia University, praised very highly the Holy Father's remarks on the importance of Genetics in the study of man:

> A vastly greater honour is bestowed upon genetics by the statement of His Holiness, Pius XII. . . . Geneticists will be pleased to have so high an authority recognize that *among diverse branches of biology, perhaps the msot dynamic studies are those of genetics.*

Professor Dobzhansky then proceeds as follows:

> It comes, then, as a surprise that a much less hospitable view is taken of evolution. Evolution is certainly not denied, but it is admitted only as a possibility, as a hypothesis not yet verified, the opinion of some scientists which is not shared by others. One is left

to wonder who are the "reputable scientists" who are said to have formulated "other hypotheses," and what these hypotheses are. Nor can one agree that the processes whereby one species may give rise to another still remain completely impenetrable. In all modesty and humility, and fully conscious of the admonition that one should not mistake hypotheses and opinions for established facts, a biologist may claim that he has at least some plausible models of how the origin of species may take place.

Moreover, it is factually incorrect to say that "one has not yet succeeded in making a species from another species." The scientific advisers of His Holiness have been guilty of negligence when they have failed to point out that the feat of obtaining a new species in experiment was accomplished more than a quarter of a century ago. The classical example is a completely new plant, *Raphanobrassica*, obtained through allopolyploidy. *Raphanobrassica* is a new species by any reasonable definition, since it is not only distinct in appearance but also reproductively isolated from its ancestors, and yet quite fertile with itself. . . . It is, indeed, incontestable that we do not know the complete story of evolution and do not yet understand all the mechanisms which bring it about. Most biologists will be willing to go farther and admit that, despite the great forward strides made in recent decades, the understanding of evolution is still in its infancy. The situation of evolution is, however, not appreciably different from that of other aspects of genetics. Assuredly there is much to be learned also about the mechanisms of the transmission of heredity (7).

Undoubtedly, the remarks of both the Pope and Professor Dobzhansky are reconcilable by a consideration of the meaning of the term, *species*. As Simpson of the American Museum of Natural History, said, addressing the Cold Spring Harbor Symposium on Quantitative Biology (1950),

> It is, to be sure, impossible to define the word *species* in any way theoretically acceptable and practically applicable to all cases without ambiguity (8).

In connection with the change of species to another species, Simpson's most recent book just published "The Major Features of Evolution" (1953), says on pp. 104-105:

> . . . it is well known that numerical chromosome mutations, especially polyploidy, may in one discontinuous step give rise to new groups of plants. Examples are given in all discussions of general or plant genetics and the whole subject has recently and thoroughly been reviewed by Stebbins (1950). *No one can doubt that numerous species of plants have arisen in this way,* and that it remains possible that some species of animals have, also, although no example seems to be surely known (9).

At this same Symposium, Adriano Buzzati-Traverso, of the Institute of Genetics, Pavia, Italy, stated that in his talk he had used Ernst Mayr's definition of Species:

> species are groups of actually or potentially interbreeding natural populations which are reproductively isolated from other groups (10).

Perry of Marquette University states that as a result of the efforts of many biologists in recent years to develop a more accurate concept of a biological species, it may be stated that the members belonging to any particular species should exhibit the following characteristics:

1. They should have a basic similarity of structure at corresponding stages of their life cycle.
2. They should exhibit a basic similarity in function due to the same or very similar causes of this function.
3. There should be a definitely demonstrable genetic continuity from generation to generation.
4. The various members should be a distinct ecologically adapted group.
5. They should be geographically isolated for long periods of time from other groups which may be in many respects similar to them.
6. They should be interfertile among themselves but generally incompatible with other geographically isolated groups.
7. Finally, a common gene pool should exist within this isolated group.

"In final analysis," he concludes, "a definition of a biological species is subject to inadequacies in much the same manner as is a definition of life itself" (11).

I feel sure that the scientific advisers of His Holiness must be aware of the difficulties underlying the definition of what constitutes a species in biology; and also aware of the progress made and referred to by Professor Dobzhansky, in "making one species from another." It therefore seems to be the more prudent thing to conclude that His Holiness had in mind a metaphysical species, and here one must agree that "the processes whereby one species may give rise to another remains impenetrable."

Many statements concerning evolution have been expressed by other eminent Catholic theologians, philosophers, and scientists (clerical as well as lay) during the past ten years. I would like to quote a few.

Msgr. Delephine, an eminent geologist, and Rector of the Catholic University of Lille (1946), wrote:

> In short, when you view living things in their total assemblage, this (evolution) is no longer an hypothesis, but an unavoidable

observation. We find an organic increase of perfection through the ages, from inferior beings up to man. . . . We can be ignorant of the mechanisms, we can discuss the immediate causes and the manner in which they work . . . but there remains one undeniable fact: the continuous ascent in each line of living beings towards forms having a superior organization (12).

In 1947, Bruno de Solages, Rector of the Catholic Institute of Toulouse, in his Rectoral address at the opening of the school year at the Institute said:

It is necessary for the Christian thinker to adopt the evolutionary outlook and to present the facts of Revelation within the framework of an evolutionary concept of the universe (13).

Father Charles Boyer, S.J., Professor of Dogmatic Theology at the Gregorian University, Rome, concludes his arguments in his thesis on the Formation of the Human Body, with the assertion that the evolution of man, considered scientifically (biologically, paleontologically) is still an hypothesis with many difficulties annexed, which would be in conflict with sane philosophy and theology, unless it is ready to attribute to God alone the principal causality in the formation of the first human body (14).

In 1951 the Pontifical Academy of St. Thomas Aquinas, Rome, sponsored a series of addresses on the Encyclical *Humani Generis*. Fr. Marcozzi, S.J., a specialist in anthropology, discussed the present role of scientific knowledge on the origin of man's body. He pointed out that materialistic evolution, since it denies the existence of God and identifies matter and spirit, is *philosophically* absurd. It is also *scientifically* erroneous since it opposes biological finalism, mathematical probability, and certain psychological data. Concerning *theistic* evolution, Father Marcozzi said that both morphologically and physiologically man's body shows a direct continuity with lower forms of life. . . . Observations lead one to suspect that between the human organism and that of the anthropoid ape there exists not only an ideological nexus in the mind of God, but also at least an indirect physical and genetic bond. . . . Since man and apes are classified biologically in the same "family", paleontology poses the problem of the origin of man's body through evolution (15).

Fr. Bermudo Meléndez, Professor of Geology at the University of Granada in Spain, has also come out in favour of evolution. Commenting on the finalistic theory proposed by Professor Leonardi of the University of Ferrara, Fr. Meléndez stated that the theory of Professor Leonardi which is a new finalistic theory of evolution, is wholly orthodox from the Catholic viewpoint . . . and though still a hypothesis, it explains fully well the evolutionary process such as paleontology presents it to us (16).

From England, Canon Humphrey T. Johnson, who has published a book as well as many well-known articles on evolution, is also an advocate of the evolutionary theory. In an article published in 1952, Canon Johnson wrote:

> Most of those Catholics who refuse to accept the evidence for the evolutionary origin of the human body do accept evolution as an explanation of organic changes observable in the lower creation. But such a compromise does not help their case. For if evolution could have bridged the gulf between Australopithecus and the amoeba it is not easy to see why it could not have spanned the much smaller one between Australopithecus and Pithecantropus. This being the case it is not surprising that the leading Catholic authorities on the subject of paleolithic man, the Abbé Breuil, the Abbés A. and J. Bouyssonie, Père Teilhard de Chardin and Count Bégouen in France and Dr. Garrod in England all favour the idea of an evolutionary origin of the human body. Something which is, however, especially noteworthy is that this theory has been sympathetically received by the well-known Jesuit Padre Marcozzi in his book "Le Origine dell'Uomo" (2nd edit. 1944) (17).

Writing in 1950, Fr. J. Franklin Ewing, S.J., Assistant Professor of Anthropology in the Fordham University Graduate School, asserted that evolution is more than a theory; it is an attitude of thought and a basic methodology (18).

Philip S. Fothergill, who, in 1952, published a well-documented book on organic evolution, maintains that on *a priori* grounds alone one would expect evolution to have occurred. And there seems to be no scientific, philosophical or theological reason why evolutionary changes should not take place (19).

Part II

I will now give a few excerpts from the writings of other reputable scientists who, unfortunately, would divorce science from philosophy or even from theology, and who would attribute evolution to mere chance. An example of a materialistic concept of evolution can be seen in this statement of Gaylord Simpson (already referred to), in his book "The Meaning of Evolution" (1953):

> In preceding pages evidence was given, thoroughly conclusive evidence, as I believe, that organic evolution is a process entirely materialistic in its origin and operation. . . . Man arose as a result of the operation of organic evolution, and his being and activities are also materialistic. . . . Man's intellectual, social and spiritual natures are altogether exceptional among animals in degree, but they arose by organic evolution. They usher in a new phase of evolution, and not a new phase merely but also a new kind, which is thus also a product of organic evolution and can be no less materialistic in its essence . . . (20).

Richard B. Goldschmidt, Professor Emeritus of Zoology at the University of California, and President of the Ninth International

Congress of Genetics to whose members the Pope gave the allocution already referred to, is very vehement in his remarks concerning philosophers and even theologians:

> The theory of evolution is a biological theory, not a philosophical one. . . . The scientist can only work with data which are derived from observation and experiment and which can be checked, measured, analyzed, confirmed. . . . If he meets with difficulties, as invariably he will, he hopes for a future solution in the same basic terms, and he works towards this goal. He refuses to take refuge in metaphysics, believing this to be scientific defeatism. . . . Actually the theory of evolution, has, since its origin, been especially favoured by the attention of groups who tried to introduce metaphysical ideas into a field which should belong to the naturalist. . . . Such ideas, whether coming from philosophers, novelists, naturalists, theologians, or even great statesmen, have never helped our science to make the smallest step forward into unknown territory (21).

Another very outstanding scientist in the fields of General Genetics and Human Genetics is Curt Stern, Professor of Zoology at the University of California. He ends one of his articles (1953) with this conclusion:

> To the geneticist the majestic flow of evolution represents the outward calm of an unceasingly stirring world. Everywhere he discovers chance: chance in the origin of mutations, chance in their consequences upon development, chance in their shuffling into innumerable combinations. Indeed, the realm of chance is awe-inspiring. Granted the origin of life on earth, the evolution of none of its specific, present or extinct forms seems to have been of a higher necessity. Their peculiar existence, our own existence, is or was accidental. . . . But perhaps more awe-inspiring yet is the fact of evolution itself. Given the existence of matter in its elementary physical form, it was inherent in this matter to compound itself into self-reproducing elementary biological units (22).

It is obvious that any theory, scientific or otherwise, must not contradict certain facts in other fields of knowledge; therefore the scientific theory of evolution should not contradict sane philosophy and above all, theology. The above excerpts do contain tenets of materialistic evolution, and do therefore contradict philosophy and theology; and, in fact, are scientifically erroneous. As already pointed out in this article, materialistic evolution is scientifically erroneous since it opposes biological finalism, mathematical probability, and certain psychological data. A digest of Fr. Marcozzi's proof of this assertion is now given:

> Biological finalism holds that organs were made for their function. Materialistic evolution demands that functions be derived from various organs only after these organs have been evolved by blind

chance. It might be maintained that secondary characteristics, vestigial organs, or, under the influence of natural selection, even a new systematic species could arise through chance; but the appearance of an entirely new structure or organ (the fundamental point of evolution) cannot be explained except by biological finalism. An organ such as the eye with its many complex and integrated parts could never arise by a chance mutation or by natural selection.

Mathematical probability also proves that materialistic evolution is a practical impossibility. It has been estimated that a mass of atoms the size of the earth changing positions 500,000 billion times per second would require 10^{243} billion years to produce even the simplest protein molecules capable of sustaining life. These figures, besides simplifying the problem considerably, disregard the affinity and valence of the atoms which would tend to make the chance formation of the molecules more difficult. Moreover, to say that the mere existence of enough thermodynamic energy to cause all this changing explains the formation of organic substance is as absurd as to claim that the mere existence of a car with a good motor and enough gas is sufficient for a trip from 'New York to Chicago' without a driver. The car cannot find the way itself. Materialistic evolution also contradicts psychological data. The finalism of reflex actions and especially of numerous complex instinctive operations is certain; but finalism presupposes intelligence and intelligence presupposes the existence of a spiritual being (23).

The tenets of materialistic evolution are philosophically absurd as they contradict the principle of sufficient causality. A cause is a sufficient principle of its effect, for what is greater cannot arise from what is less. And the cause not only produces its effect, but in some way assimilates the effect to itself. The likeness may fall short of the specific perfection proper to the cause, or it may attain to specific identity with the cause. But the effect can never excel its adequate cause in metaphysical richness. "Omne generans generat sibi simile" (24). If the proximate cause is not sufficient to account for the perfection found in the effect, the reason is that it served merely as an instrument employed by some higher cause (25).

The statement of Simpson that "man's intellectual and social and spiritual natures arose by organic evolution" would make a material being the sufficient and adequate cause of a spiritual being (man's soul), a result which is patently a contradiction of the principle of sufficient causality explained above. His statement, which repeats the principle of materialistic evolution, must therefore be rejected as philosophically absurd.

Many theories, which are quite possible, have been formulated to "explain" the evolution of man, but, of course, all demand "a special intervention of God." It would imply a metaphysical contradiction to assert that a spirit emerges from the potentialities of matter, just as much as if we were to say that a contingent being can exist without being caused. Matter can perhaps conceal some "material" forms of living beings, but not a form of a totally and essentially different order as is a spirit. God can, for instance, educe from the potency of matter, or, to be more exact, from the *obediential potency* of matter (not from the *natural potency* of matter which a created agent is able to actuate), a sufficient disposition of a body for a spiritual soul and infuse the soul into it (26). To develop and clarify this statement, I will quote from Fr. Gilleman, S.J., who cited in his article, such authorities as Fathers Boyer, S.J., Sertillanges, O.P., Bea, S.J., and Flick, S.J.:

> Now, this intervention of God by the infusion of a spiritual soul is a fact of the ontological order which, as such is experimentally unperceivable, it leaves no discontinuity on the phenomenal plane with which science is concerned. The behaviour, however, of the new being will soon prove to be specifically different from an animal's behaviour. . . .
> Philosophy can go further and say that, should the soul be infused into an organism coming from an anthropoid, by that very information the body would be intrinsically and deeply recast, and would fundamentally differ from an anthropoid's body in the ontological order, because the soul is the substantial form of the body (27).

This last statement is of great importance for, as Our Holy Father said (as cited), "Only from a man could there proceed another man who would call him father and progenitor."

Since, as we have shown, materialistic evolution is philosophically absurd (as it denies an essential principle of philosophy), it can be concluded that it is in opposition to theology, of which philosophy is the "*ancilla.*" Moreover, because it identifies matter and spirit, it would eventually deny the very existence of God, if carried to its logical conclusion. Finally, the *creatio ex nihilo* of the soul is a matter of faith, as pointed out in the Encyclical "*Humani Generis,*" which referred to the decrees of the Vatican Council, *Constitutio de fide Cathol* (28).

Part III

Conclusions:

1. The Holy Father does not exclude the possibility of the evolution of man's body from some sub-human species.
2. Evolution is not a proved fact. But it is a very likely hypothesis, a postulate almost universally admitted by scientists because it harmoniously synthesizes a great amount of scientific observations.
3. The attitude of Catholic scientists as a group is, in the main, that of adherents of the Evolution Theory, and they employ it as an attitude of thought and a basic methodology.
4. Materialistic Evolution is biologically erroneous, philosophically absurd, and contrary to Theology.

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28. Cf. H. Denzinger, *"Enchiridion Symbolorum et Definitionum,"* Conc. Vat. *1783.*

Biology

MECHANISM OF PHOTOSYNTHESIS

JAMES A. MCKEOUGH, S.J.

Within the past few years so many advances have been made in photosynthetic research of green plants, that those who are teaching Botany or General Physiology can no longer be content with the simple classical equation of the process of photosynthesis. The object of this article then is to give a rapid summary of some of the recent techniques and results of various investigators. Perhaps part of the matter that will be presented may be useful for a classroom presentation of this complex reaction called photosynthesis.

Photosynthesis is that process by which green plants convert the electromagnetic energy of the sun into the potential energy of reduced carbon compounds, simultaneously evolving molecular oxygen. Three elements—carbon, hydrogen, and oxygen—come into the plant as carbon dioxide and water; then, through the agency of light which is absorbed by the chlorophyll pigment, oxygen is evolved and reduced carbon generated. The action of the light, which we call the *photo* part of the process, can be separated fairly distinctly both theoretically and physically from the reduction of carbon dioxide, which we will call the *phyto* part of the process.

A series of experiments made by different investigators within the past 10 or 15 years have established the basic over-all reaction of photosynthesis. Two molecules of water are decomposed to yield four protons, four electron equivalents, and one molecule of oxygen:

$$2\,H_2O \xrightarrow[\text{}]{\text{nhv}\atop\text{chlorophyll}} 4H^+ + 4e + O_2$$

In this equation, (e) represents the electrons which may be considered as the chemical bonds of organic molecules. The potentials or energies, (E_0), of these electrons, as well as the number of light quanta, (nhv), which are required to decompose water, will be considered in a moment.

We have just seen that in this equation the chlorophyll pigment may be considered to serve as a catalyst to absorb a certain number of light quanta and bring about the over-all reaction of photosynthesis, namely the decomposition of water. There is no point here in discussing the investigations of all the scientists—Van Neil, Ruben, Hill, Warburg, Holt and French—so let us confine our discussion to the work of Ruben. We choose him because he was the first to show that oxygen liberated in photosynthesis is derived from the oxygen atoms of water rather than from the oxygen atoms contained in carbon dioxide; and secondly, his work is a fine example of the use of radioactive substances in a scientific investigation. Ruben placed *Chlorella* cells in water containing heavy oxygen atoms, H_2O^{18}, and containing $CO_2{}^{16}$; then he illuminated the cells. The oxygen which was liberated in this photosynthesis was found to be labelled with heavy oxygen, i.e. O^{18}. The reverse experiment, using $CO_2{}^{18}$ and H_2O^{16} did not result in the release of O_2 labelled with heavy oxygen. Therefore he concluded that oxygen is derived from the oxygen atoms of water and not from carbon dioxide.

One of the features of the equation that we have cited above that is still in doubt is the potential, (E_0), of the electron which will bring about the reduction of carbon dioxide. Knowledge of the potential is important because these electrons take part in and supply the energy for bringing about the conversion of carbon dioxide to carbohydrates through a complex series of reactions. There are two ways to secure information about the potential of the electron: 1) Determine the minimum number of light quanta which could bring about the reduction of one molecule of carbon dioxide. 2) Identify the natural electron acceptor in the chloroplast.

Quantum Controversy

Various attempts have been made to determine the quantum yield in photosynthesis, i.e., the number of light quanta required to bring about the reduction of one molecule of carbon dioxide. By exact measurements of the light energy absorbed and the volume of oxygen produced, Warburg claimed that only four quanta of light are absorbed per molecule of oxygen produced. These results did not go unchallenged. Emerson and others were unable to confirm Warburg's observations and estimated from their own experiments that eight to twelve quanta were required per molecule of oxygen. In 1948 when the four quanta proof had been questioned, Warburg teamed with Burk; both of them verified the proof of the earlier experiments and further extended the technique. Just recently they discovered a one quantum reaction in photosynthesis.

At the Kaiser Wilhelm Institute, Warburg and Burk subjected *Chlorella* to very short periods of light and darkness. They discovered, under controlled conditions, that "although the complete over-all photosynthetic process still must have the energy of three to four light quanta per molecule of oxygen produced, from the standpoint of mechanism the process starts when the green part of the plant, the chlorophyll molecule, first absorbs and uses a single quantum of light as is shown by the following diagram:

Photosynthetic Energy Transformation Cycle

I. Photophase

1 quantum (about 40,000 calories)

$$CO_2 + Chl \rightleftharpoons Chl' + O_2 + \text{product}^*$$

II. Chemosynthetic Phase

(Combustion: resynthesis of Chl)

(about 70,000 calories)

*Carbohydrate or near equivalent.

"What this diagram illustrates essentially are three steps forward and two steps back. The forward steps occur when the plant is exposed to light. In each forward step, one molecule of oxygen is liberated per quantum of light absorbed, or three molecules of oxygen per three quanta. Then the plant takes two steps backward during the dark period by consuming two thirds of the liberated oxygen, i.e., two out of the three molecules of oxygen formed are used up in the back reaction. In consuming these two molecules of oxygen, the energy is not wasted by the plant as heat, but it is put back into a chemical cycle insuring the continuation of photosynthesis by restoring the photosynthetic machinery to its original state before the light was turned on. In short what the plant is doing during this cycle is manufacturing a molecule of organic food and a molecule of oxygen and doing it at 90% efficiency, i.e., converting light energy into chemical energy."[1] In regard to this one quantum reaction it is of interest to note that as early as 1911, Einstein had proposed that in all primary photochemical reactions only one quantum is used.

[1]CEN, 1953, p. 997.

Calvin of the University of California has recently commented on Burk's proposed one quantum reaction: "This proposal presumes that there is a rapid equilibrium between the measured oxygen gas and the oxygen within the cell wall; otherwise, the slopes of the curves of oxygen evolved versus time, during one minute intervals, upon which the conclusions are based, are meaningless. If these proposals and assumptions are correct and if the gaseous oxygen in contact with the cell suspensions is labelled with O^{18}, then the rate of entry of O^{18} into the water and into the organic compounds within the cell should be greatly enhanced in the light, as compared with this rate in the dark."[2]

We stated previously that one of the ways to secure information about the potential of the electron was to determine the minimum number of light quanta which could bring about the reduction of one molecule of carbon dioxide. Granick of the Rockefeller Institute stated that "if only four quanta are necessary then one may calculate that the potential of the electron produced in photosynthesis would be at the level of the hydrogen electrode; that is, the electron would have strong reducing properties."[3] Ochoa and Vishniac have shown that the electrons produced by the chloroplasts in photosynthesis are capable of reducing the pyridine nucleotide coenzymes. This finding would suggest that the potential of the electrons may well be in the neighborhood of the potential of the hydrogen electrode.

*Phyto*SYNTHESIS

Another method of obtaining information about the potential of the electron is, as we said, to identify the natural electron acceptor. This leads us naturally into our second main division, namely the *phyto*synthetic part of the process. For this discussion we will rely upon the work of Melvin Calvin, professor of Chemistry of the University of California, and director of the bio-organic group of the Radiation Laboratory there. We will mention his methods and the kind of information that has resulted from his research.

A watery suspension of green algae is placed in a flat circular vessel called a lollipop. Light from sources located on either side of this vessel is allowed to pass through infrared filters. Carbon dioxide enters in a continuous stream through a bubbler tube above the lollipop. At a time, $t = 0$, labelled CO_2 enters the vessel with the main stream of carbon dioxide. Then at suitable time intervals, the stopcock at the bottom of the vessel is opened and the algae suspension is drawn into alcohol in a beaker. This stops the biological reaction in as mild a manner as possible so that analyses of the extract form the algae can be made in order to determine which compounds in the extract contain radiocarbon and to determine the order of appearance

[2] Bassham, Benson, Calvin, 1953, p. 275.
[3] Granick, 1953, p. 751.

of radioactivity in those compounds. The principal purpose of the experiment is to shorten the time until the earliest compounds, into which radioactive carbon is incorporated, can be found.

To analyze the extracts from the algae, three methods have been employed: 1) isolation, 2) paper chromatography plus the Geiger counter, 3) paper chromatography plus X-ray film. The latter method according to Calvin is the most practical and rapid for his research project on the process of photosynthesis. X-ray film is placed in contact with the paper that has absorbed algae extract and wherever there is a radioactive spot on the paper, i.e., a compound containing radioactive carbon, the X-ray film is exposed. When the film is developed, a black spot appears, its darkness being relatively proportional to the amount of radioactivity in the compound. Thus radioactive compounds can be located readily and easily. By yet another method the specific compound can be identified.

The data obtained from a series of chromatogram X-ray film exposures, resulting from varying the length of the photosynthetic activity are then graphed in time-quantity relationships. Thus by gradually shortening the time of the photosynthetic reaction from ten minutes to that of a few seconds or so, and by making a series of analyses, the intermediate compounds of the process have been identified. As far as we know today, the earliest compound into which radioactive carbon is incorporated is *phosphoglyceric acid*:

$$CH_2 — CH — CO_2H$$

$$/ \qquad |$$

$$OPO_3H_2 \qquad OH$$

Calvin's next problem was to determine which carbon atom in this acid was labelled first. He discovered that the distribution of radioactive carbon is 50% in the carboxyl carbon with the remainder split equally between the alpha and beta carbons of the phosphoglyceric acid. Then he made a whole series of degradations using shorter and shorter times and finally determined that the first carbon atom to be labelled is the carboxyl group of the phosphoglyceric acid. The carbon dioxide presumably enters that position first.

Chloroplasts and Chlorophyll

Before we can give a summary of Calvin's explanation of the photosynthetic mechanism, we must say a few things about chloroplasts and chlorophyll. Chlorophyll is located in the leaves of plants in microscopic green bodies called *chloroplasts* where the first stages of photosynthesis occur. The detailed structure of these bodies can be readily seen in the electron micrographs of the tobacco and spinach leaves which were taken by Granick, Porter, and Palade of the Rockefeller Institute. Within the chloroplast membrane are grana with lamellae, the stroma, and certain unidentified granules. The spinach chloroplast, for example, contains 40 to 60 grana. According to the present measurements each granum is about 6000 A in diameter and about 800 A thick. By preparing ultra-thin sections of Chloroplasts, Palade, has shown that a granum actually consists of a stack of 10 to 20 thin discs or lamellae each lamella being 75 to 100 A thick. It is assumed that the chlorophyll molecules are localized in these lamellae.

An essential requirement for photosynthesis is the presence of *chlorophyll* the pigment to which the color of green plants is due. Around the turn of the century Willstatter and Stoll isolated these pigments and showed that the chloroplasts contained a mixture of green pigments, the chlorophylls, and yellow pigments, the carotenoids. The chlorophylls consist of two chemically allied pigments, chlorophyll-a ($C_{55}H_{72}O_5N_4Mg$) and chlorophyll-b ($C_{55}H_{70}O_6N_4Mg$), both of which are related in structure to hemin, the red pigment of the blood. Both Fe protoporphyrin 9 and the chlorophylls are of the same biosynthetic chain and both are concerned with oxidative reactions. What can be said of the chemical participation of chlorophyll in photosynthesis? Recent theories suppose that the chlorophyll takes part in a photochemical reaction whereby a primary reactant, carbon dioxide or water, or a derivative of it is reduced or oxidized, the chlorophyll at the same time being oxidized or reduced. This means the chlorophyll exists in a reduced or an oxidized form, although these forms are no longer supposed to be chlorophyll-a and -b.

Calvin's Explanation

In an article that appeared in a recent issue of the *Chemical and Engineering News,* Calvin has given a probable and possible explanation of the photosynthetic mechanism. "The granum appears to be a relatively concentrated package of chlorophyll, together with a number of other things, particularly the carotenoids. One could visualize its structure diagramatically as determined principally by the flat porphyrin rings arranged in an orderly array of some sort in these single packages. For approximately each thousand chlorophyll molecules contained in a granum there is a disulfide in some conjugate coenzyme form situated around its surface. This disulfide goes under various names: protogen, pyruvic acid oxidase factor. Recently it has been identified as 6,8 *thioctic acid*:

"The light may be absorbed anywhere in this package of chlorophyll. A quantum absorbed by any one of these molecules is absorbed by them all or is available to them all. Because of the intrinsically stable nature of this electronic excitation it has time to wander around in this condensed phase until it finds itself adjacent to an absorbed disulfide.

"There is certainly a chemical interaction here which immediately leads to the dropping of that quantum into the energy of two sulfur free radicals. This is presumed possible primarily because of the strain in the ring. Now some knowledge of the energy needed to split a disulfide link is required. . . . There are available only somewhere between 30 to 40 kilocalories. This is only an approximation—the excited state of chlorophyll in the condensed phase is in this range. In a word there are approximately a maximum of 40 kilocalories to dissociate this disulfide.

"After the initial conversion of the quantum into the potential energy of the dithiyl radical, this free radical can pick off suitable hydrogen donors. What these donors are cannot be specified now, except that it is likely that water is not one of them, because the energy available seems hardly enough to do it."[4] According to the latest reports from the University of California, Calvin is now of the opinion that water may very well be the hydrogen donor, and that it reacts with the activated thioctic acid disulfide to form thiol sulfenic acid, which is unstable and of high energy content. The energy of the light quantum is thus trapped and fixed as chemical energy. Then by a process of reduction, dithiol, a powerful reducing agent is formed for carbon dioxide reduction. At the same time, by a process of oxidation, a system near the level of hydrogen peroxide is formed from which oxygen is derived.

Through the indirect method of model experiments and through direct methods of treating photosynthetic material, such as green algae, with 6,8 thioctic acid, Calvin was able to suggest the possible mode of action which we have quoted and explained above. It remains to be demonstrated that one can isolate these cyclic disulfides from the plant and that light action is very closely associated, very directly concerned with the opening of the disulfide ring. If thioctic acid disulfide is the neutral electron acceptor in the chloroplast then we have a way of securing information about the potential of the electron as we mentioned earlier in the discussion.

This whole article has treated mainly the light reaction which involves the production of oxygen and the reduction of carbon dioxide. Perhaps at some future date we will have more to say about the so called "dark" reaction in which the plant releases carbon dioxide and water; in other words the reverse process.

From all that has been said "it is evident that the studies of photosynthesis in plants are still of purely academic interest, like nuclear physics in the early 1930's. Yet the amount of energy from the sun reaching the earth's surface is of great magnitude and is of great practical interest. . . . This energy of available sunlight has scarcely been tapped. Locked in the features of photosynthesis are the secrets for transforming this light energy into chemical energy.

"Although our knowledge of photosynthesis is yet meager, it does not require too great an imagination to realize that once we are able to understand the key features of photosynthesis we shall be able to use not merely the 1 to 3% of the sunlight that plants use, but much more of this energy. We shall be able to make pigments that

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[4]Calvin, 1953, p. 1737-8.

can absorb all portions of the sun's spectrum with high efficiency and perhaps even produce electrons more reducing than those at the potential of the hydrogen electrode. The energy of the sunlight could then supply us with unlimited amounts of pure hydrogen and oxygen for heat and for synthetic chemical transformations. Then surely could it be said we had harnessed the sun for the betterment of mankind."[5]

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Chemistry

THE DEPENDENCE OF CELL GROWTH ON NUCLEIC ACIDS

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Tissue growth is measured biochemically in terms of the increase of protein values, especially protein-nitrogen, in the cells. But cellular protein synthesis is brought about under the stimulation of DNA and RNA (desoxyribose nucleic acid and ribose nucleic acid, respectively) present in different sections of the cell. Consequently, nucleic acids play a very important part in cell and tissue development.

Today biochemists believe that both plant and animal tissues contain both types of nucleic acids in the form of nucleoproteins, where

[5] Granick, 1953, p. 751.

the nucleic acids are bound up with simple proteins. The nucleic acids themselves are complexes of purine and pyrimidine bases, sugar, and phosphoric acid. The protein component of nucleoproteins may vary from the relatively simple polypeptide protaminin in salmon sperm to complex protein molecules found in virus nucleoproteins.

It appears, however, that the DNA occurs only in the cell nucleus itself, while the RNA may exist in both the nucleus of the cell as well as in the cell's cytoplasm. The nucleolus is now known to contain both DNA and RNA. The experiments of Davidson and Waymouth (23) have shown that RNA is concentrated in the central region of the cell nucleoli of rat liver, while the DNA is found in the peripheral region. A high content of DNA is noted in tissues containing large amounts of nuclear material, such as the sperm and glandular organs. Present indications are that DNA is the most important constituent of cell chromosomes, although some RNA is also present (48). The synthesis of cytoplasmic proteins is controlled by the RNA, but that synthesis is indirectly affected by DNA of the nucleolus (49).

This role of nucleic acids in cellular growth is found to be true not only in normal tissues, but also in neoplastic (i.e., carcinogenic) animal tissues, whether the neoplasm be due to transplantation or to induced chemical agents. Plants, too, show a dependence on nucleic acids for their protein biosynthesis.

The experiments of Caspersson (13) have shown a rapid increase of nucleic acid content in developing embryonic tissue. His work with the ultraviolet microscope revealed that the greater portion of those acids was pentosenucleic acid in the cytoplasm. His investigations revealed also that the protein of the embryo differed from that of the adult cells in that the former is of the basic histone type, while that of the adult protein contains the more complex tryptophane and tyrosine molecules.

Several other workers (35, 5, 6) have studied the chemical changes taking place during embryonic development. Very little nucleic acid was found in the hen's egg, but a considerable synthesis of both desoxypentose nucleic acid (DNA) and pentose nucleic acid (RNA) takes place in the embryo (8, 36, 40). Work in the biochemistry laboratories of Fordham University (44) has shown that from the 7th through the 19th day of embryonic development of the chick considerable synthesis of both nucleic acids occurs in the embryo. The synthesis is most marked during the most rapid growth period of the embryo. These results agree with those obtained by previous investigators (4, 7, 14, 25, 36). A point of interest is the observation (43) that in the mouse gestation is accompanied by an increase in the nucleic acid content in the liver, kidney, and lung of the parent animal.

The experiments of Caspersson (12) have shown that protein synthesis in the cells requires the presence of nucleic acids. Apparently, the RNA present in the cytoplasm regulates the protein synthesis in that part of the cell, as mentioned above. The DNA in the nucleus seems to control the synthesis of chromatin proteins.

Kosterlitz (26) has reported that rats kept on a diet free from protein lost 15% of their initial liver cytoplasm on the first day, 7% on the second day, 5% during the second week of their treatment. It appears that about 20 to 25 percent of liver cytoplasm of animals fed sufficient protein is lost with ease by the organism. Kosterlitz suggests calling this fraction the *labile liver cytoplasm*. Later experiments by Kosterlitz and Campbell (28) have demonstrated that the amount of non-glycogen, non-lipid solids (*labile cytoplasm* fraction) present in the liver is in direct proportion to the logarithm of protein intake. It is thus possible to construct straight regression lines for the various proteins.

Cooper (19) in his studies of the effect of diet and fasting on the content of radiophosphorus and its rate of incorporation into the nucleic acids in organs other than the liver reports significant results; viz. [1] In fasted animals the DNAP (desoxyribose nucleic acid phosphorus) of the liver and kidney increase while the ratio RNAP/DNAP decreases. This indicates that the rate of formation of both phosphorus compounds is not equal and that that for RNA tends to decline as growth progresses. This finding is in agreement with that of Kosterlitz (27). No change was observed by Cooper in the nucleic acid content of the intestine. The spleen showed a decrease in both RNAP and DNAP. [2] The animals fed an 8% protein diet showed only a decrease in RNAP and DNAP content in the intestine with a decrease in the relative specific activities (*) of the RNAP. [3] The relative specific activities of RNAP and DNAP decreased in fasting. This was expected since during fasting protein synthesis is diminished. This view is compatible with that of Thorall (47), Caspersson (15) and others who have studied the relation of RNA to protein synthesis.

Mandel and Beeth (33) have reported on DNA values in the brain of some mammals. DNA is an essential constituent of chromosomes, so that the amount of this acid in the brain is directly proportional to the multiplication of cell nuclei. In the guinea pig one day old the amount of DNA is the same as that in the brain of the adult animal. Therefore, they conclude that its brain cellular growth is completed at birth. In the rat cellular growth stops after 16 days, in the cat after one month, and in the dog after 5 months. In their experiments the amount of RNA reached a maximum at the same time as the DNA when working with the rat and cat, but at a later time in the case of the guinea pig.

Davidson (21), Kosterlitz (27), and Campbell and Kosterlitz (9) have reported that diets free from proteins, or fasting cause a diminution in the ratio of RNAP to DNAP in the liver of the rat. Under these conditions they found an increase in the relative specific activity of RNAP, following administration of radiophosphorus (10, 44), as well as incorporation of isotopic nitrogen into liver RNA, as reported

(*) The *relative specific activity* refers to the ratio of liver phospholipid (or RNA or DNA) $P^{32}:P^{31}$ to tissue. It is a measure of turnover rate.

by Davidson (22). The latter (21) has calculated the nucleic acid content of the whole liver of the fasting rat and found that the RNA content fell markedly while the DNA value remained unchanged.

Embryonic and adult tissues of sheep (20) have shown a higher water and nucleic acid content for the former. Both RNA and DNA were present. Even in lower forms of animal life this increase in nucleic acids has been observed during development. Price (41) found an increase of both RNA and DNA in the cells of S. *muscae* during early growth, when cell multiplication was non-existent or just starting. Moreover, cell division in this uninfected bacteria was found to start when RNA was 2.5 times as great as DNA. Osawa and Hayashi (37) have found that the RNA content per cell in the oöcytes of the *Triturus* increased during the growing period of the cell, and reached a constant value at a certain stage of the cell growth. But RNA per unit volume of cells decreased gradually with growth. Some agreement seems to exist, then between this last observation and that of Cooper (19) mentioned earlier. Steinert reported that RNA in the oöcyte of the *Rana fusca* increases during its growth (46).

Cancerous tissue has also been found to contain significant amounts of nucleic acids. Recent work at Fordham University has shown that there is an increase in the nucleic acid content of the liver, kidney, and lung of mice bearing a transplanted sarcoma. Payne and associates have independently (39) found increased incorporation of P^{32} into the desoxyribose nucleic acid (DNA) of livers from tumor-bearing mice compared to the controls. Our laboratories (17) have reported increases both in RNA and DNA in the liver and lung of mice bearing sarcoma, and this increment is further confirmed by the corresponding increases in uracil and thymine. Uracil is the pyrimidine base present in RNA, while thymine is the base present in DNA. The fact that only the DNA content of the kidney increases is corroborated by an increase in the thymine values alone, while the uracil content of the kidney remains unchanged.

A second type of neoplastic growth that brings with it significant increases in nucleic acid content is that induced by chemical agents. Wilson and co-workers (50) were first to report on the toxicity and carcinogenic activity of acetylaminofluorene. Engel and Copeland (24) confirmed its toxicity in rats while Armstrong and Bonser (1) showed its carcinogenic action in mice. Lombardo (29) has reported that tumor induction in mice through the administration of 2-acetyl-amino-fluorene produced gradual but very significant increases in DNA values of the liver, kidneys, and lungs, while the RNA increases appeared only in the liver and lungs, and that towards the last stages of tumor development. The spleen gave no significant changes in nucleic acids.

Masayama and Yokoyama (34) observed in rat livers an increase in DNA when the animals had been subjected to the action of another chemical agent: para-dimethylaminoazobenzene. Lombardo (30) in his latest report has studied the effects of liver regeneration in stimulating nucleic acid changes in other organs. As may be recalled, previous workers have shown nucleic acid values to increase during neoplastic growth (16-18, 31, 42) and embryonic development (43). No significant changes were reported by Lombardo for the nucleic acids and purines of the kidney, lung, and spleen during liver regeneration of partially hepatectomized rats. Consequently, it appears that the increase in nucleic acids in the liver, kidney, and lung observed during growth of transplanted sarcoma in mice (16-18, 31, 42) and during embryonic development (43) is absent when a normal growth process, like liver regeneration, takes place.

Other experiments, though, along the same lines as those of Lombardo on regeneration and nucleic acid content, show different results. Barakina (2) in Russia has reported that normal amputation tissue (no regeneration) of the rear limbs of the *Rana temporaria* showed no decline of RNA value. However, in the regenerated tissues of the blastema a supranormal concentration of RNA was found in the cells. In the subsequent steps of limb regeneration, from the blastema, the tissues of the growing limb showed considerable RNA content. The ribose nucleic acid is believed by Barakina to be an essential element in the regenerative process, though it may not be the only cause of regeneration.

Aside from the accepted view that pentose nucleic acid plays an important role in the biosynthesis of protein in animal tissue (11), as well as in that of microorganisms (32) it has been found that RNA concentrations do vary even in some plant species. Osawa and Oota (38) have studied the role of RNA in the biosynthesis of a higher plant, *Vigna sesquipedalis*. Their results show a close parallelism between the increase in RNA and that of protein in all anabolic (growing) organs studied. The experiments seem to suggest that if RNA is involved in protein synthesis, then a synthesis, rather than only the existence or degradation of RNA, may be significant for the formation of protein. This view appears to be supported by several similar findings in animal and microbial materials (41).

There is little doubt then today that nucleic acids are intimately related with cellular growth, and therefore, with the organism's development. Even viruses in general appear to be dependent on these acids for their protein synthesis. This fact opens up new problems for the researcher. The effect of the concentration of these acids on growth is still to be investigated, including a determination of the critical concentrations beyond which growth, both normal and abnormal, begins. Recently Bendich (3) has found more than one fraction of DNA, different in metabolism and rates of turnover. It would therefore be necessary to find out which DNA fraction has a greater influence in cellular growth. Then, too, a clearer insight into the inter-relationships between RNA and DNA is needed. When cultivated in the absence of vitamin B_{12}, DNA acts as a growth factor in the *Lactobacillus bifidis*, but RNA inhibits multiplication (51). Similarly, RNA has been found to inhibit the activity of the enzyme desoxyribonuclease on DNA. It appears, therefore, that RNA is in some way a regulator of the biological functioning of DNA.

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THE EFFECTS OF THYROXIN ON NUCLEIC ACIDS DURING CELLULAR GROWTH

Miguel M. Varela, S.J.

Claude Bernard in 1855 was the first to recognize and describe the thyroid as a ductless gland, located in the neck. By 1893 Ord and White (14) reported an increase of nitrogen excretion with increasing amounts of thyroid extract. That same year Müller (13) had noticed increased nitrogen metabolism in cases of exophthalmic goiter (Graves' disease).

Thyroxin is the only amino acid known to have hormonal properties. It was first isolated by Kendall in 1915. It occurs naturally as the physiologically active constituent of the thyroid gland. Thyroglobulin, a protein, on hydrolysis yields thyroxin, whose structure was determined and confirmed by synthesis to be the tetraiodo-substituted derivative of Beta-[4-(4′-hydroxyphenoxy)-phenyl]-alpha-amino-propionic acid. Thyroxin contains not less than 64% iodine, organically combined, and as an integral part of the molecule.

A year after its isolation Kendall (7, 8) proved that the iodine-containing compound was the active constituent of the thyroid gland. In 1926 Harington (5) synthesized thyroxin and proved that the synthetic product had the same effects as that extracted from the gland.

Thyroid physiology in mammals has given ample proofs that the thyroid plays an important role in growth and metabolism. Hammett (3) has shown that experimental ablation of the thyroid of white rats results in retarded growth of the heart, lungs, liver, kidney and spleen due to inadequate thyroid activity. Fishburne and Cunningham (2) observed the same retardation in the total growth of the white rat as a result of thyroidectomy. The same phenomenon was reported by Simpson (15) when working with sheep and goats. Hewitt (6) noted that when adult male white rats were given daily 0.1 gram or more of fresh thyroid, hypertrophy of the heart, liver, spleen, kidney, and suprarenals occurred together with a diminution of the size of the thyroid gland. McEachern (9) reported in 1935 that induction of hyperthyroidism by multiple injections of 10 mg of thyroxin per kilogram of body weight resulted in large and constant increases in tissue respiration. In 12 experiments the mean increase was 46% for the kidney, 73% for the liver, and 75% for the muscle.

Sternheimer (16) reported that thyroxin injection in rats produced chemical and histochemical changes in the liver, the degree of variations depending on the time elapsed after the injection. The chemical changes noted were many, among which were: [1] Loss of glycogen in the liver and the entire animal. [2] During the second period (i.e., 48 hours after injection) the glycogen values rose above normal. [3] In the first period there was noticed a rise in liver protein followed by a decrease (but still to values above normal) in linear proportion to the increase in liver glycogen. [4] An increase in the fresh weight and dry weight of the liver. [5] The loss in liver glycogen, increase in liver protein, and liver size started before the rise in oxygen consumption, i.e., during the latent period. From these observations Sternheimer concludes to liver growth due to the thyroxin administration.

Mandel and associates (10) reported their results of feeding adult rats 1 mg of thyroxin daily. They observed increased protein nitrogen of from 15 to 26 percent, of a 26 to 33 percent rise in pentose nucleic acid, and a 22 to 32 percent increase in desoxypentose nucleic acid. Their experiments also showed that the cytoplasmic mass of the kidney does grow under the influence of thyroxine administration, and that nuclear proliferation rises. Hypertrophy as well as hyperplasia are therefore the natural effects of thyroxine feeding.(*)

Handley and collaborators (4) studied the renal response to thyroxin administration to dogs. Daily intravenous injections of this substance produced [1] A marked rise in the rate of glomerular, filtration, renal plasma flow, tubular transport of glucose, and para-aminohippurate. [2] Increased kidney consumption of oxygen. They believe that these effects are due to the diuretic action of thyroxin.

Mandel (10) has observed an increase in nucleic acids of the kidney during compensatory renal hypertrophy in rats subjected to the action of thyroxin. Rats with one kidney excised were injected with one milligram of thyroxine per day for 15 days. Their RNA and DNA (°) values in the remaining kidney was far greater than that observed in the non-injected controls, by about 50%. Another set of experiments by the same authors (12) was conducted on the action of thyroxine on renal hypertrophy. Rats that had undergone unilateral nephrectomy and two months later were injected with one milligram of thyroxine for 15 days were sacrificed 75 days after the nephrectomy. The kidney tissues showed increases in nucleic acid phosphorus of from 35 to 60 percent.

Experiments were conducted at Fordham University to obtain a further insight into the action of thyroxin on nucleic acid values. Twenty male Wistar albino rats, with an average weight of 125 grams, were kept on a stock diet for 4 days. On the fourth day after their arrival, and for the following 15 days the animals were injected one milligram of thyroxin per day. On the 7th and 15th days after the first injections one half of the experimental and control animals were sacrificed.

(*) *Hypertrophy* is the condition of overgrowth of an organ due to excessive use, or to compensate for a deficiency elsewhere. *Hyperplasia* is the abnormal increase of the cells of a tissue.

(°) RNA is the abbreviation for ribosenucleic acid, and DNA is for desoxyribosenucleic acid.

All the animals were sacrificed by stunning, followed by decapitation. All livers, kidneys, lungs, on excision were blotted free of blood, quickly weighed, and then immediately frozen on dry ice. All tissues were then stored in the deep freeze at —20° until analyzed. It was necessary to homogenize the tissues in an ice-water mixture at 0°. For nucleic acid analysis and dry weight determinations aliquots of 2 ml were removed from the homogenate. The nucleic acid fraction was extracted by the trichloroacetic acid method of Schneider. Pentose nucleic acid was estimated according to the method of Euler and Hahn (1), while desoxypentose nucleic acid was determined by the Stumpf's method (17).

Results with rat kidneys tend to confirm the work of Mandel (10). The extension of the experiment so as to include also the liver and lungs seems to point to significant increase only for the DNA value of the liver. The fact that only the DNA portion of the nucleic acids showed a rise does not necessarily argue to a definite constancy in the RNA value. It may well be that longer thyroxin administration or greater concentrations of it are required in order to affect the RNA content of the tissue. It seems natural that DNA values should be the first to increase during growth since they are believed to be present in the cell nucleus itself. The lungs appear to decrease in their content of both RNA and DNA. No definite explanation is yet found for the negative values obtained for these organs. It may be that the pulmonary fluids act on the nucleic acids of the lungs as solubilizing agents.

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Mathematics

DEVELOPMENT AND SCOPE OF TOPOLOGY

JOHN J. MACDONNELL, S.J.

Topology, it has been said, suffers from a split personality. A large part of it deals with such notions as continuity, limits, and distances, which cannot be dissociated from geometry. This branch of topology is known as point-set or abstract space topology. The other branch which is variously known as algebraic topology or combinatorial topology is more concerned with analysis of spaces as a whole. This paper will deal chiefly with point-set topology. Hence there will be little or no mention of Moebius bands, Klein bottles, knots, and braids which are more the province of combinatorial topology.[1] After giving a descriptive definition of the subject and noting a few of the men who pioneered in the field, I will then give an abstract definition of a topological transformation, describe the structure of a topological space and finally note some of the properties of these spaces which remain invariant under topological transformations.

Topology is a kind of geometry. Just as elementary geometry deals with the magnitudes (length, area, and angle) that are unchanged by the rigid motions, and projective geometry deals with concepts (point, line, incidence, and cross-ratio) which are unchanged by projective transformations, so topology deals with those properties of figures which persist even when the figures have been subjected to transformations so drastic that all their metric and projective properties are lost. Imagine a figure such as a sphere or a triangle to be made from or drawn upon a thin sheet of rubber, which is then stretched or twisted in any manner without tearing it, and without bringing distinct points into coincidence. The final position of the figure will then be a topological image of the original. For example we can imagine an inner tube to be deflated. The resulting amorphous figure is a topological image of the original inflated inner tube.[2]

This strange new field of geometry began to develop only about 100 years ago. In 1858 one of the great geometers of the time, A. F.

[1] Cf. Albert Tucker and Herbert Bailey, Jr., "Topology," *Scientific American*, (Vol. 182, No. 1), Jan. 1950; pp. 18-24.

[2] Cf. Courant and Robbins, *What is Mathematics*, (New York; Oxford University Press, 1941) pp. 235-71.

Moebius, submitted to the Paris Academy a memoir on "one sided" surfaces that contained some of the most surprising facts of this new kind of geometry. The Moebius band and Klein bottle mentioned earlier are classical examples of one sided surfaces of two dimensions and three dimensions respectively. Independently of Moebius, the Goettingen astronomer, J. B. Listing, made similar discoveries, and published them under the title *Vorstudien zur Topologie.* When Bernhard Riemann, who has made so many brilliant contributions to the fields of geometry and analysis, came to Goettingen as a student, he found that interest in this strange new field of mathematics was running high. He soon realized that this topology held the key to the understanding of some of the deepest properties of analytic functions of a complex variable.

Another great name in the field is that of L. E. J. Brouwer who, around the turn of the century, pioneered the work of organizing the field according to the traditional postulational method of geometry; and hence can be credited with introducing rigor into the new field. Mathematical intuition had played a leading role in the early development of topology, and it was necessary that some of its theorems be based on the firmer foundations of rigorous proofs. Hence the work of Brouwer and his successors in bringing topology within the framework of rigorous mathematics, where intuition remains the source but not the final validation of truth, has been invaluable. The contributions of other men such as Poincaré, Cantor, Fréchet, Urysohn, and Menger will be noted as the subject is developed.

We see from this brief historical sketch that topology is a field of roughly 100 years standing. Before topology came into its own, however, there were isolated instances of topological discoveries. The most notable of these, discovered by Descartes in 1640, rediscovered and used by Euler in 1752, is an excellent illustration of what we mean by a topological property. This formula of Euler shows that there is a fixed relationship between the vertices, faces, and edges of all *simple* polyhedra. We recall that a polyhedron is a solid whose surface consists of polygonal faces. A polyhedron is called simple if it has no "holes." That is, it can be shrunk continuously to a point. Euler's formula says that for all *simple* polyhedra $V - E + F = 2$.

This property of simple polyhedra is a typical example of a topological property, because it holds even if the polyhedron is deformed either by bending or stretching. The formula, notice, is concerned *only* with the *number* of vertices, edges, and faces, and not with metric and projective properties such as length, area, incidence, and cross ratio.

Up to this point we have been giving a general and intuitive notion of topological transformation. We have spoken of stretching and twisting a figure in such a way that the figure is not torn and distinct points are not brought into actual coincidence. What do these conditions mean when translated into abstract axiomatic language? A topological transformation or homeomorphism of a figure R onto a figure R′ is a mapping or function of a special type. We recall that a function f is nothing more or less than a rule of correspondence between two sets of objects. Here we are speaking of sets R and R′ whose elements are the points of the geometrical figures.

A homeomorphism, then, is some rule of correspondence between the points, p of R and p' of R' (in symbols: $f\colon p \to p'$) which satisfies the following two conditions.

1) The correspondence is 1 — 1 (biunique). That is, to each point, p of R there corresponds exactly one point, p' of R' and vice versa.

2) The correspondence is continuous in both directions (bicontinuous). That is, the function f mapping R onto R' is continuous, and the inverse function f^{-1} mapping R' onto R is continuous.

We recall the ϵ, δ definition of the continuity of a function. Both f and f^{-1} must satisfy this definition or an equivalent definition of continuity.

Both of these conditions must be fulfilled. I will give an example later of a mapping which is 1 — 1 but not bicontinuous.

The first condition corresponds to the stipulation in the intuitive definition of a homeomorphism that distinct points not be brought into actual coincidence. The second condition corresponds to the stipulation that the figure not be torn in the process of stretching, twisting or bending.

Now that we have an idea of what constitutes the essence of a topological transformation or homeomorphism, it is reasonable to inquire about the structure of a topological space. What axioms must be satisfied that a space may be considered topological? Prescinding from this or that geometrical figure, we take the more general concept of a set of points to define a topological space. This is the contribution to topology of George Cantor, who, around 1880, originated and developed that branch of mathematics known as set theory.

Now, since we are constantly dealing with bicontinuous transformations in topology, a set cannot be considered a topological space until it has been implemented with certain cohesive properties which enable us to define continuity.

We define a topological space, then, to be a set R, certain subsets of which have been distinguished and called open. These open sets must satisfy the following two conditions.

1) *Every* union of open sets is an open set.

2) Every *finite* intersection of open sets is an open set.

Since among the selected spaces must be included the classical spaces, the structural axioms given above of a topological space are dictated by the behaviour of open and closed sets in Euclidean space.

To give a trivial example of a topological space: consider the set R consisting of the three pts. a, b, c. The open sets are defined to be the empty set and a u b u c, (i.e., the whole space). These satisfy conditions 1) and 2); hence R is a topological space.

Very often, however the class of open sets is not given directly, as above, but by various auxiliary devices such as neighborhood systems (N.S.), closure operators (C.O.), or metrics (M). The following diagram shows the successive steps taken in the definition of open sets by means of these auxiliary concepts.

1) N.S. → O.S.
2) C.O. → C.S. → O.S.
3) M → N.S. → O.S.

For the sake of brevity we will consider in detail only the third mentioned method above for topologizing a set. I choose 3) because it also gives us an idea of how 1) works, and because metric spaces, first developed in their full generality by Fréchet in 1906, are among the most important topological spaces.

To topologize a set R by means of a metric:

1) We define a metric ρ on R. A metric is a function ρ of R onto itself which defines the distance between points of R. It must satisfy the following conditions.

a) $\rho(x,y) = o \rightleftarrows x = y$

b) $\rho(x,y) = \rho(y,x)$

c) $\rho(x,y) + \rho(y,z) \geqslant \rho(x,z)$

2) Once a metric has been defined on R we can define a system of neighborhoods as follows: The neighborhood of a point p, an element of R, is the set of all points x whose distance from p, $S_\varepsilon(p,x)$, is less than ϵ where ϵ is any real or rational number.

3) Then an open set is defined to be a set which contains a neighborhood of each of its points.

Examples: The familiar. Euclidean spaces.

$R1$ where the metric is $\rho(x,y) = y\text{-}x$

$R2$ where the metric is $\rho(x,y) = \sqrt{(x_2-x_1)^2 + (y_2-y_1)^2}$

Now that we have an idea of the structure of a topological space and the nature of a topological transformation, we can take a look at the subject matter proper of topology; namely, the properties which remain invariant when a topological space is transformed homeomorphically. I will mention several of them and then treat a little more in detail of a few which are directly studied in point-set topology and are defined by the cohesive properties which we have established as belonging to topological spaces.

Some topological invariants, then, are:

1) The Jordan curve property,[3]
2) The genus of a surface,[3]
3) The Euler characteristic of a surface[3] (not to be confused with the Euler formula mentioned earlier),

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[3]Courant and Robbins, op. cit., pp. 244, 256, 258.

4) The dimension of a figure,
5) The connectivity of a figure (not to be confused with connectedness),
6) Compactness,
7) Connectedness,
8) The property of being dense-in-itself.

Let us take a closer look at the last three. A space R is *compact* if every infinite subset of R has a limit point in R. A limit point of R is a point, every neighborhood of which contains at least one point of R.

A space R is *connected* if it is not the union of two disjoint closed sets. That is, it cannot be broken into two mutually exclusive sets.

A space R is *dense-in-itself* if every element of R is a limit point of R.

This is not to say that every topological space is compact or connected or dense-in-itself, but, if a space R has any or all of these three properties, then every homeomorphic image of R will have these same properties. For instance, if the unit segment of the real line $(0 \leqslant X \leqslant 1)$ which is connected, compact, and dense-in-itself were to be stretched to a finite length greater than one (e.g., $0 \leqslant X \leqslant 8$) by a one-one bicontinuous transformation, then the resulting line would be connected, compact and dense-in-itself.

Before closing, I would like to say a word about dimension, an important topological invariant, and dimension theory, the result of Poincaré's insistence on the need of an abstract definition of dimension. It was Brouwer who finally arrived at the following recursive definition of dimension: a figure is n-dimensional whenever, to isolate parts of it from the rest of the figure, it may be necessary to surround these parts with walls as high as dimension $n - 1$, but no higher. The definition is completed by assigning to vacuum (no wall at all) dimension -1. Thus a line segment is one-dimensional because, to isolate parts of it, it is necessary to use only points (and these are zero-dimensional). Points, obviously, are zero-dimensional because a point is inseparable; or, in the words of the definition, vacuum would be necessary to separate a point into parts. In this case, then, $n - 1$ equals -1; therefore n equals zero.

From this simple root there has stemmed a mighty and beautiful branch of topology known as dimension theory, the simultaneous and independent creation of Paul Urysohn of Moscow and Karl Menger of Vienna.

One final note on the topological property, dimension, will illustrate the fact that, although a mapping may be one-one, the figures need not be homeomorphic. A square and a line segment have the same cardinal number; hence there is a one-one correspondence between the points of the two figures. Since, however, a square has dimension 2 and a line segment has dimension 1, they cannot be homeomorphic images of each other. Any mapping of one into the other, therefore, will not be bicontinuous; and the second condition of a topological transformation is not fulfilled.

Although, for the sake of brevity and clarity, this paper has been necessarily incomplete, inasmuch as I have barely touched upon the basic notions of topology, it is hoped that the object of the paper has been realized, and that some idea has been given of the nature and scope of topology.

Varia

THE NATIONAL SCIENCE FOUNDATION PREDOCTORAL AWARDS FOR 1954-1955

JOSEPH F. MULLIGAN, S.J., AND JAMES J. RUDDICK, S.J.

On March 17, 1954, the National Science Foundation announced the awarding of 657 predoctoral graduate fellowships in the natural sciences for the academic year 1954-1955. The winners were selected from 2,865 applicants on the basis of competitive examinations for scientific aptitude and achievement and of recommendations concerning each candidate's abilities. In addition, 1,355 applicants were accorded Honorable Mention. Of the 657 fellowships awarded, 220 went to students who will begin their first year of graduate studies in September, 1954, while 240 went to those who have already commenced their graduate studies and 197 to those beginning their last year of doctoral work. In what follows these will be referred to as first-year, intermediate, and terminal fellowships, respectively.

The publication of these National Science Foundation awards affords an opportunity for judging the adequacy of the scientific training being given by our Catholic colleges, and in particular by our Jesuit colleges. For this reason a statistical analysis has been made of the students from Catholic colleges receiving National Science Foundation fellowships or Honorable Mention. The results are given in the accompanying tables.

The number of students from Catholic colleges obtaining fellowships for 1954-1955 is disappointing, though it is an improvement over previous years. Only 13 students out of 657 were attending Catholic colleges or universities at the time they received fellowships. This is 2.0% of the total as compared with 1.3% (7 out of 557) in 1953-1954 and 1.4% (8 out of 569) in 1952-1953. These statistics, however, can be quite misleading. Since Catholic graduate schools in science are few and small, one would not expect many of the fellowships to go to students who were in Catholic universities at the time the awards were made. A much more significant fact is the number from Catholic schools of the 220 first-year fellowship winners. There are 11, representing 5% of the first-year awards. This is somewhat low, for the statistics of the Walters survey in *School and Society* (December 12, 1953) indicate that Catholic schools have 9.7% of the full time students in American colleges and universities. A list of Catholic schools whose students received fellowships and the fields in which they receive them is given in Table 1.

TABLE 1
NATIONAL SCIENCE FOUNDATION FELLOWSHIPS, 1954-1955
CATHOLIC COLLEGES AND UNIVERSITIES

College of Great Falls (Mont.)	engineering
College of St. Thomas	physics
Manhattan College	engineering
Marquette University	biophysics
Regis College (Colo.)	chemistry
Trinity College (D.C.)	chemistry
University of Detroit (2)	physics, microbiology
University of Notre Dame (4)	chemistry, physics, engineering (2)
Villanova University	chemistry

The Honorable Mention awards are both more informative and more encouraging. The published list breaks down those receiving this citation into first-year, intermediate, and terminal graduate students. An analysis of the results is given in Table 2 along with the cor-

TABLE 2
NATIONAL SCIENCE FOUNDATION HONORABLE MENTION CITATIONS, 1954-1955*

	Mathematics	Physics	Chemistry	Life Sciences	Engineering	Other	Total
All First Year	42 (53)	107 (94)	122 (112)	67 (59)	96 (69)	12 (21)	446 (408)
Catholic	7 (1)	18 (7)	15 (22)	5 (1)	3 (3)	1 (2)	49 (36)
All Intermediate	52 (45)	123 (106)	140 (161)	159 (137)	54 (70)	35 (23)	563 (542)
Catholic**	0 (1)	5 (1)	7 (5)	4 (3)	0 (0)	0 (0)	16 (10)
All Terminal	11 (24)	48 (75)	87 (101)	69 (79)	28 (27)	12 (18)	255 (324)
Catholic***	0 (0)	1 (0)	3 (2)	1 (0)	0 (0)	0 (0)	5 (2)

* The numbers in parentheses give the corresponding totals for 1953-1954.
** Intermediate Honorable Mention:
Physics: Catholic U. (2), St. Louis U. (2), U. of Detroit.
Chemistry: Catholic U. (2), De Paul, Fordham (3), U. of Notre Dame.
Life Sciences: Marquette U., St. John's U. (N.Y.) (3).
*** Terminal Honorable Mention:
Physics: Catholic U.; Chemistry: Fordham (2), U. of Notre Dame; Life Sciences: Georgetown.

responding data for 1953-1954. As was to be expected, the number of intermediate and terminal Honorable Mentions from Catholic schools is quite small. The first-year Honorable Mention results are, however, much more encouraging. Here, out of 446 receiving Honorable Mention 49 are from Catholic colleges. This is 11% of the total, and is an improvement over the 8.6% (36 out of 408) for the year 1953-1954.

Perhaps the most significant result of this study is the first-year Honorable Mention list. For this reason in Table 3 we have broken down this list according to colleges and to scientific fields. Several items of interest emerge from the table. First of all, Notre Dame stands far ahead of any other Catholic college or university on the list, producing half as many Honorable Mentions (9) as all the

TABLE 3
CATHOLIC SCHOOLS ATTENDED BY STUDENTS RECEIVING FIRST-YEAR HONORABLE MENTION CITATIONS

	Math.	Phys.	Chem.	Life Sci.	Engg.	Other	Total
Caldwell C. for Women	—	—	—	1	—	—	1
Cath. U. of America	1	—	—	1	—	—	2
Chestnut Hill C.	—	—	2	—	—	—	2
C. of Great Falls (Mont.)	—	—	2	—	—	—	2
C. of Notre Dame (Md.)	—	—	1	1	—	—	2
C. of St. Elizabeth	—	—	—	1	—	—	1
C. of St. Rose	1	—	—	—	—	—	1
Fordham U.	—	2	1	—	—	—	3
Georgetown U.	—	2	—	—	—	—	2
Immaculata C.	—	—	1	—	—	—	1
Holy Cross C.	—	—	1	—	—	—	1
Loyola U. (La.)	—	1	—	—	—	—	1
Manhattan C.	—	1	—	—	1	—	2
Notre Dame C. of Staten Is.	1	—	—	—	—	—	1
Regis C. (Mass.)	1	—	1	—	—	—	2
St. John's U. (N.Y.)	—	1	—	—	—	—	1
St. Joseph's C. (Pa.)	1	—	1	—	—	—	2
St. Louis U.	—	1	—	—	—	—	1
St. Mary's C. (Minn.)	—	1	—	—	—	—	1
St. Mary's U. of San Antonio	—	1	—	—	—	—	1
St. Peter's C.	—	—	1	—	—	—	1
Seattle U.	—	1	—	—	—	—	1
Seton Hall U.	—	—	1	—	—	—	1
Siena Heights C.	—	—	1	—	—	—	1
Spring Hill C.	—	1	1	—	—	—	2
U. of Detroit	—	1	—	—	—	—	1
U. of Notre Dame	2	3	1	—	2	1	9
U. of Scranton	—	2	—	—	—	—	2
Villanova U.	—	—	—	1	—	—	1
Totals	7	18	15	5	3	1	49

Jesuit schools on the list (17). Only 11 of the 26 Jesuit colleges and universities appear on the list. In general Catholic women's colleges show up very well, especially in mathematics and the life sciences where they account for half (6 out of 12) of the first-year Honorable Mentions. There are significant improvements over last year in mathematics, physics, and the life sciences and a drop in chemistry Honorable Mentions, though the record of Catholic colleges in chemistry is still quite good. Closer inspection of the published list shows that the fields in which Catholic schools appear best of all are theoretical physics, physical and organic chemistry, and microbiology.

It is a little dangerous to draw conclusions from data as limited as those presented here. Furthermore, there are a number of variables that would have to be considered if these statistics were to be completely valid, for example, the possibility that students in some colleges which do not appear on the list have not been encouraged to take the competitive exams for these fellowships. It can be safely said, however, that the paucity of fellowship winners from Catholic colleges indicates that there is still much room for improvement, but that the increase in fellowships won by Catholic schools and the goodly number of Honorable Mentions give promise for the future.

Finally, it may be of interest to note that at least five Jesuits, all scholastics, appear on the Honorable Mention list. They are James S. Albertson, S.J. (Harvard, physics), James C. Carter, S.J. (Catholic U., physics), Frank R. Haig, S.J. (Catholic U., physics), Robert J. Ratchford, S.J. (Spring Hill, chemistry), and William J. Schmitt, S.J. (Fordham, chemistry). There may be other Jesuits who received awards, but a fairly careful check of the published lists did not reveal them.

THE ODYSSEY OF THE WASMANN MUSEUM

B. A. Fiekers, S.J.

When the great Jesuit Entomologist, Erich Wasmann, died in 1931, he bequeathed to the world not only an outstanding example of energetic Jesuit prowess in scientific work, but also lasting evidence of it in the form of a number of collections of insects, along with all of the apparatus, scientific, documentary and bibliographical, that was necessary to keep alive the work he so ably founded. For years this collection was housed in our theologate of St. Ignatius College at Valkenburg in the Netherlands, and it was enlarged by the duly appointed Curator and successor of Father Wasmann in this work, Father Hermann Schmitz of the Lower German province of the Society of Jesus. It was to be known as the Wasmann Museum. Supplementary material became known as the Schmitz Collection.

Ignatiuskolleg, to give the College its German title, was the theologate of the Lower German Jesuit Province. Prior to 1936, philosophy was also taught at Valkenburg. The college had its beginnings in the exile from Germany of many religious orders in the time of the *Kulturkampf* in the days of Bismark during the latter half of the nineteenth century. It was then of necessity beyond the reaches of the Reich and the Netherlands was chosen for the location. For years it enjoyed the financial support of the German provinces. But during the regime of the National Socialists, this flow of funds was reduced to all but a trickle. This was due to the so-called Nazi *divisen-laws*, which prohibited the export of money beyond the borders of Germany, except to the extent of small percentiles, even for legitimate international debts, which the Berlin masters at the financial throttle would allow periodically, not unlike a large corporation declaring dividends for its stockholders.

Such a state of affairs jeopardized these scientific collections more than once. Superiors looked for such tangible assets in the many financial crises they had to face; at times they were tempted to put them to good use; but to their eternal credit, be it said, they always found other sources, better adapted to their needs, and so the Wasmann Museum survived the hazards of the pre-World War II days. Rumors of sale, there always were: at one time to the Natural History Museum of Vienna; at another, to the University of Chicago; rumors enough to keep the professional world cognizant of this collection; but rumors that would lengthen the Nazi army in its day of power, only to have it maimed on the morrow of defeat. That is the Odyssey of the Wasmann Museum. That of the Schmitz Collection cannot be omitted.

After the German occupation of the Netherlands, the Nazi confiscation in February, 1941, of Valkenburg's nearest neighboring seminary, which belonged to the German Oblate Fathers, gave warning of what treatment the Jesuits could expect. Father Schmitz heeded this warning by transferring the most valuable parts of the Wasmann Museum into storage in the bomb-proof cellars of the Municipal Building in Maastricht.

Then the blow fell. The Gestapo took over Ignatiuskolleg on July 7, 1942. Its occupants were given but minutes or hours to get over the nearby border into the Reich. The Museum was sealed and guarded. Marshall law provided penalties for looting, no doubt; but the official looters of religious property stood above the law.

Peacable negotiations with the Gestapo in the Hague seemed to be promising at first. Father Schmitz, and his Socius, Father Hirschmann, returned from Germany on a three-day permit to pack the Schmitz Collection at Valkenburg and take it with them to the Reich. Here they met one Dr. Bischoff, Curator of the Natural History Museum in Berlin, who with Gestapo aid was to supervise the work. Inquiries threw light on the whereabouts of the main Wasmann Collection. Once values were fairly well assessed, and the location of everything was known, Bischoff saw fit to announce that the permit was void, and that the complete collection were to be shipped to

Berlin and there await decisions as to ownership! The Curator may not have masterminded such a holdup. But he was certainly a willing tool in Gestapo hands.

For Father Schmitz this blow to his life's work was catastrophic. It brought on a recurrence of an old ailment and he had to spend some weeks in the hospital. On returning to the College shortly after dismissal from the hospital, he discovered that Bischoff had made off with that part of the booty undeterred.

It was not that easy, however, with the Wasmann Museum in Maastricht. The Burgomeister, though a member of the Nazi Party as we might expect, gave Maastricht patriotic priority over Nazi headquarters in Berlin itself, and opposed the transfer of the Museum out of Maastricht where it had been established. Nor could Gestapo Headquarters for the Netherlands in the Hague force him to acquiesce. For they seem to have been at swords points with General Christiansen who was military Governor of the Netherlands at the time. The delay, we will see, had some significance.

When, however, the last signed protocol was clipped to the decree of the confiscation of Ignatiuskolleg some months later, the authorization to move both collections to Berlin did not take long to follow. From Maastricht then, never seriously bombed as we now know in the war, to Berlin already bombed during this period of delay, went at least a freight car full of the Wasmann items—all in the name of protecting and safeguarding it from the ravages of war! And the Schmitz Collection found its way to Waischenfeld in Southern Germany, a name notorious for its greed of cultural treasures.

It was the Directress of Maastricht's Museum of Natural History, Mrs. Dr. Nimis van de Guyn, who on VE day set wheels awork for the recovery of the Museum. Major John W. Bailey, U.S.A., Professor of Comparative Anatomy on leave from the University of Richmond in Virginia, undertook the task. He was as prudent as he was capable and energetic. By this time the Wasmann Museum was to be found somewhere in the Russian Sector of Berlin. It finally took him a day's dickering with the Russians to get an authorization for the release, and only after he had fêted them through a long evening.

Major Bailey's encounter with Bischoff has been amusingly dramatized in one of the New Orleans newspapers for November 11, 1945. In effect Bailey first sought Bischoff's advice on where to find entomological material, feigning mere professional interest. He then registered astonishment at his good fortune in stumbling upon the very best collection in all the world, namely the Wasmann Collection right there in Bischoff's quarters. After examining the collection, he then turned on Bischoff and upraided him for fetching the collection from Maastricht, where never a bomb had fallen, into Berlin, the very inferno of the War, and at that, all in the name of protective custody. Bailey also recovered the Schmitz collection from Waischenfeld.

It is not unlikely that Major Bailey rode the ties with the Wasmann Collection to safeguard its return every mile of the way from Berlin to Maastricht. His arrival in Maastricht was triumphal. He made the newspapers and the newsreels. Banquets were given in his honor. He received an honorary scroll from the new Burgomeister and, from the Government of the Netherlands, the order of Orange Award.

All of this is Providential. Had those collections remained in Ignatiuskolleg they would no doubt have constituted part of the damage from a bomb that fell there in 1943. Further, this Odyssey paralleled Father Erich Wasmann's own journey on a round trip to Berlin and back, long ago in the decade before the first World War. He gave there three lectures defending the Catholic attitude towards evolution. The lecture course was followed by one of the most remarkable scientific discussion periods ever to be found in the annals of science. He had to face a very Sanhedrin of the Science of his times. Enemy after enemy of the so-called "ultramontane" doctrines of Christ's Church got up that night and had his say. Father Wasmann was allowed only a half hour's rebuttal to all of them. It was after midnight when he got to his feet to speak. One of his opponents was an ex-Jesuit, whose arguments touched on the Society's Institute to the oblivion of everything scientific, thus attempting to besmirch Wasmann's scientific reputation. Wasmann's rebuttal to von Hoensbroeck touched the zenith of eloquence; for, in his rebuttal, he passed him by completely.

But Wasmann returned to Valkenburg to tend his ant colonies and to peer into the depths of other worlds with the aid of his microscope. He had another quarter of a century to spend in the scientific apostolate. His work was never in vain; nor were his sufferings.

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2. Obituary, Erich Wasmann, S.J., 1859-1931, Entomologist, Jesuit Science Bulletin, *8* (4), *6* (1931); Bibliography, ibid., *8* (4), *9* (1931).
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A History of Science by George Sarton. Harvard University Press, Cambridge, 1952. Pp. xxvi 646. $10.00.

When a religious scientist thinks of the discoveries of modern research he sings, with the Psalmist in the 8th Psalm "O Lord, Our Lord how glorious is thy name in all the earth. — When I gaze at the Heavens, the work of thy fingers, the moon and the stars which thou has made." Then if he is also a humanist, reflecting on the greater wonder of man's intellect in discovering the nature of God's stars, he continues in the next verse, "What is man that thou art mindful of him? or the son of man that thou hast care of him? And thou hast made him a little lower than the angels, thou hast crowned him with glory and honor."

Dr. Sarton is a scientist who is likewise an ardent humanist and a vivid historian. His valuable book is a richly-woven tapestry tracing the deepening penetration of ancient man's mind into the mystery of his cosmos. Like the Psalmist, this learned writer is more fascinated by the light of man's piercing intellect tracing out the course of the stars than he is, even, by the brilliant marvels of those stars themselves.

This is the first in a proposed eight volume series that will cover the history of science up to the modern period. It is a less technical, more popular distillation of Dr. Sarton's classic definitive "Introduction to the History of Science," (5 volumes, Williams and Wilkins, Baltimore, 1927-1948). This fascinating story of human groping in the dark and of the progressive enlightening of the mystery of matter unfolds from the dawn of science to the end of Greece's Golden Age in this volume. There is a balanced presentation of the social background that influenced thought and discovery for science is a human activity that does not grow in a vacuum.

To. Dr. Sarton science is a tree whose seed was planted in the very beginning of man's history. Present science's wonders have a richer meaning when we can trace them back to their first roots. Science "began whenever and wherever men tried to solve the innumerable problems of life." (pg. 1) To take one example, modern mathematics with its dizzying heights seems even more wonderful when we read of its embryonic beginning in the fractional computations of the Rhind papyrus in Egypt, its gradual growth in the intricate algebra of the Sumerians and the Pythagorean square number theorems, through the irrationals and methods of exhaustion of Eudoxus to Aristotle's theories of infinity and continuum. The discovery of the calculus owes much to the thought and theory of Aristotle.

All the familiar figures of ancient science, and many new ones, breathe again between the pages of this vividly written history. We see Thales ("a sort of Greek Ben Franklin") using his meteorology to predict a great harvest of olives. We watch Anaximandros observing insects issue from marine larvae while he excogitates the first theory of animal and human evolution. We hear Pythagoras picking away on a zither while he evolves his theory of the mathematics of harmony.

Dr. Sarton pictures the discoveries and theories of the ancient scientists as partly influenced by their social, political and religious milieu. Yet their work is essentially *personal* though carved out of personal experience and emotional intuitions. For example, Heraclitus was a sad man and his pessimistic theory of the passing nature of all things led him to postulate the flitting flame as the universal element. Anaxagoras, the friend of Pericles, had such a passion for order and reason that he was called "The Brain." His own rationality led him to postulate a cosmogony of an immaterial mind organizing the innumerable "seeds of matter." The poet-philosopher Empedocles imbibed his theory of the "tides in the human blood" while contemplating the sea at beautiful Agrigentum.

Dr. Sarton's background as a classicist and a scientist is an apt instrument for his excellent "full-size" portraits of Plato and Aristotle. Those geniuses were truly universal men and their character as contemplaters of all things orientated their science. To Plato, Science—and mathematics in particular—was necessary "for conversion of the soul itself from the world of generation to essence and truth." (Republic 525 C-D)

Aristotle, the son of a court physician, was imbued with the truly scientific *a posteriori approach*. In his astronomy, for example, he sought a mechanical and tangible explanation of the observed planetary movements. Unlike Plato, Aristotle sought to know the "forms" of things by rising from the individual. For the Stagirite "mechanism alone can never explain the universe, yet analyses, descriptions and inductions must precede every synthesis. That procedure is essentially the procedure of modern science." (pg. 516)

This is an eminently scholarly work. The copious references are invaluable for the student. They point out, moreover, the life-long devotion to his subject of the Harvard emeritus professor who wrote them. He is the recognized leader in the field of the History of Science. The mighty Homer, however, is allowed a few nods. On page 53 the First Dynasty of Egypt is dated at 3400 B.C. instead of the date 3000 as revised by the work of Scharff. In one place (page 50) Queen Nefertete is placed in the Twelfth Dynasty instead of in the magnificent Eighteenth. A footnote on page 74 would seem to assume that a value for "pi" (namely 3) was used in *calculating* the thirty cubit circumference of the "molten sea" of Solomon's Temple. Actually the text of 3 Kings and of Paralipomenon give no indication of a calculation—they read, rather, like actual measurements. Finally, the statement that "Out of the immemorial wisdom of the Ancient East, the Hebrew *prophets* (italics supplied) had developed the idea of monotheism" on page 74 is counter to the certain tradition of revelations made to Abraham and Moses.

Apart from the few slips mentioned above, this is a most authoritative book. The scientist, the historian and the general reader will be fascinated by the humanistic, vital presentation of the parade of lives, thoughts, discoveries and influences of the forefathers of our scientific tradition.

BERNARD SCULLY, S.J.

COLLEGE OF THE HOLY CROSS DEPARTMENT OF CHEMISTRY

The College of the Holy Cross appears on the American Chemical Society's list of approved schools in Chemical and Engineering News, 32, 1902 (1954).

Dr. Andrew P. VanHook of this staff will attend the meeting of the International Society of Beet Sugar Technologists (part of the Tenth International Congress of Agricultural and Food Industries) at Madrid in Spain, May 30 to June 6, 1954, where he will deliver a paper on "Practical Implications of Sugar Crystallization Theory." This will be followed by a meeting of the 11th session of the International Commission for Uniform Methods of Sugar Analysis to be held from June 9-14, 1954 in Paris, France, where he will be chairman of the committee on Viscosity and Surface Tension. He is also a member of the committee on the Evaluation of Crystallizing Qualities of Sugar Juices. These two meetings will be followed by a visitation of British Refineries and Research Laboratories, before his return to this country about the First of July. During the summer of 1954, Dr. VanHook will be working in the department on a substantial grant from the U.S. Department of Agriculture in connection with sugar crystallization. We are glad also to announce that Father Martus has received from the U.S. Army Ordnance Department a grant to continue his work on chelation for 1954-1955.

Talks, lectures and papers given by the staff include the following: Dr. Baril: on Chemicals and Health before the Kiwanis Club in Millbury, Mass., on the Standardization of Clinical Procedures on Jan. 21, 1954, before the Worcester Dist. of the Assn. of Med. Technologists; on Opportunities for Women in Chemistry at CROSS & CRUCIBLE'S Open House to the High School Students of Worcester County, held at the College on Feb. 15, 1954; Father Fiekers spoke to the same group on Teaching and Vocational Opportunities for Chemists; The Chairman also appeared before the Weston College Science Colloquium on Feb. 21, 1954 and spoke on the Rev. Theodor Wulf, S.J., a Jesuit Physicist, 1868-1946; at CROSS & CRUCIBLE'S annual banquet, held at Hillcrest Country Club, May 11, 1954 he gave his Crusader, Kreuzfahrer, Gentleman address; and finally he gave a paper on Teaching Techniques for Selected Topics in Chemistry at the 276th Meeting of the New England Association of Chemistry Teachers, held at Emmanuel College in Boston under Father Martus' chairmanship on May 15, 1954. On Nov. 18, 1953, Dr. VanHook conducted the evening seminar at Clark University on Sugar Crystallization. Father Martus and Dr. Baril were judges at the R. I. State talent for Science Fair. Father Martus also judged at the Massachusetts Fair.

Offices held during the past year include Dr. VanHook as Treasurer, Dr. Baril and Father Fiekers as members of the executive committee of the Cen. Mass. Sec. of the Am. Chem. Soc. Dr. Baril functioned on the nominating committee; Fr. Fiekers becomes National Councillor for the Section commencing Jan. 1, 1955. Fr. Martus was chairman for the Central Div. of the N.E. Assn. Chem. Tchrs. Fr. Fiekers was faculty advisor for the Intercollegiate Chemical Society, and was on the Executive Committee of the Worcester Engineering Soc. Mr. Chester L. Sutule, BS Chem. '54, was president of the Intercollegiate Chemical Society; Mr. Carl D. Orio, BS Chem. '55 is chairman elect of that organization.

Recent departmental publications include: 72) Martus, J. A. and Hovey, R. J., Studies of a series of related ligands with specific metals at constant ionic strength at three different temperatures, 20 pp. illustr., tables, (15 Jul. 1953). Contract DA 19-020-ORD-1614. Listed in ASTIA, Bull. No. U-28, 19 Oct. 1953. AD 14H376. Tech. Rept. no. 1. 73) VanHook, A., Sugar Crystallization, SOCKER, Handlingar II (Malmö), *8* (6), 45-51 (1953). 74) VanHook, A. and Brodeur, E. A., Rate of Adjustment of Seeded Sucrose Solutions, Internat. Sugar J., 55, 332-4 (1953). 75) Fiekers, B. A., Alternative Method for the Calculations of Indirect Gravimetry, J. Chem. Educ., *31*, 100-1 (1954). 76) Fiekers, B. A., Determination of the Density of Oxygen Gas, J. Chem. Educ., *31*, 139-40 (1954). Author index of Chemical Abstracts for 1953 lists at least 22 publications or patents by HOLY CROSS ALUMNI. This brings the known alumni publications total up to at least 274 items in chemistry and allied fields. Fathers Fiekers and Martus have published in the JESUIT SCIENCE BULLETIN and have items in the two issues of the HORMONE which appeared this year.

New acquisitions of equipment in the department this year include a vacuum tube voltmeter, a Gow-Mac Thermoconductivity apparatus, two refrigerators, a bench drill press, magnetic stirrers, radioactive minerals, a Polaroid camera and microscope attachments, new fire blankets, reprint volumes to complete the Journal of Physical Chemistry and, last but not least an 8 by 18 foot Periodic Chart of the Elements, done in the long form on metal wall tile, and dominating the large lecture hall (Rm 19) to the delight of the chemists and even of the philosophers who hold their early lectures there. Credit for a beautiful job of hand-lettering the 10 x 10 inch plates for each of the elements goes to Fr. Gerard M. Mears of the Art Department for his patient, enthusiastic and beautiful work. Credit for tiling material goes to the Chairman's brother, Mr. Edmund J. Fiekers, of Duratile of Ohio in Fremont, Ohio. A *black* cross is planted in the open spaces of the short periods at the top, rooted in ${}_{27}Co^{58.94}$, and with ${}_{94}Pu^{239}$ at the very bottom of the line of the cross.

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It would be appreciated if any errors of commission or omission are brought to the attention of the Secretary of the Association at Woodstock.