radio waves filled the whole atmosphere between the surface of the earth and the Heaviside layer. I also believe the cinema (if properly used) will widely help in the education of our time. There is no need to claim for these inventions a place in history for their influence is obvious.

But it is also true, that scientific discoveries are themselves products of history. We still find the belief that the chief lines of the history of sciences were laid down by the spontaneous appearance of great minds — of a GALILEO, NEWTON, LAVOISIER, DARWIN, EINSTEIN. However, if we analyse the real development of those ideas, which are known as the ideas of these men, we find besides numerous attempts in the same direction. Some of them were even successful; we remember later one name only, who summarises in the most logical and often the most radical way, the new conception, as the achievement.

It is not a pure coincidence that NEWTON, HOOK and HUYGENS simultaneously worked on the same problems, that BOHR and RUTHERFORD, DE BROGLIE and SCHRÖDINGER, BORN, HEISENBERG and DIRAC have within a few years introduced a new world of ideas known as quantum mechanics. Hundreds of papers were necessary to make it possible. Ten years later one will remember the quantum theory of DIRAC as an astonishing achievement of a great spirit. Even the striking radical ideas of EINSTEIN were not unexpected, LORENZ and FITZGERALD, BUCHERER and RITZ (who died at 26 and did not solve the problem he tried to attack), prepared the new conception, generalised and formulated by EINSTEIN. The discovery of X-rays said to be purely unexpected would surely be found by LENARD or by J. J. THOMSON some time later. In physics, which I overlook, I do not see any fact or idea which did not have a history.

It is well known that the discovery of FARADAY led to dynamos, MAXWELL's ideas and HERTZ' experiments to radio. It is less appreciated what influence the methods of radiotechnique had on the pure science of physics. That is the way we know the mechanism of the spark, both the finest details and the general nature of surface and of molecular structure. We lost interest in electrisation by friction as soon as galvanic cells were discovered. No new cells were invented since dynamos have appeared. Both electrisation by friction and galvanic cells are nevertheless fundamental for our ideas on the nature of the bound between electricity and matter. Physics and chemistry, being next to industry, feel its influence most clearly. It would, however be quite shortsighted to neglect the stimulation and the guiding part of the life on science in general.

PAPER by N. BUKHARIN, *Moskva.*

We, the representatives of the Soviet Union, working in various spheres of intellectual labour, are adherents to the view that *all* science should be *historical*. Consequently we have been extraordinarily interested in this London Congress. In the Soviet Union a swift rapprochement is proceeding between theory and practice, and consequently a rapprochement between pure and applied science. In the Soviet Union a simultaneous process is occurring of *rapprochement between various disciplines*, growingly united by a single method, the method of dialectical materialism. This method regards all forms of existence as historically changing quantities. Everything passes. Existence is not a grammar and its laws cannot have exceptions to them. But just as all existence is historical, so *all science* also should be historical, as a reflection of this existence. This very general postulate has nevertheless the closest relationship to the question of the connection between theory and practice.

One of the defects of almost all the scientific tendencies of the present day *is the immovable formalism of their categories*, in other words, their anti-historical nature. That is the very reason why modern science is passing through a crisis. Its formally logical definitions cannot embrace the contradictorily dynamic quality of real existence. In the social sciences history customarily is recognised only as a matter of the past. But history ceases to exist as a matter of the future, for the capitalist system is declared a 'natural' one the only « normal » one, and is an immutable (everlasting) category. Consequently, if a new social and economic system (socialism) emerges, the attitude adopted towards it is not that of a scientific, but that of a *magician's* viewpoint. It is *adjured* to begone and the sooner the better. They cannot and know not how to *explain* it. In the *natural sciences* the formalism of the categories is becoming a tremendous obstacle to an understanding of the basic processes of the movement of matter: the contradictory character of movement and the consequent 'antinomies' (its continuities and discontinuities, evolution and revolution etc) considered from the aspect of formal logic, are unexplainable. The idea of *historical development* presupposes the formation of new and continually more complex qualitatively distinguished series of phenomena, with special, more complex governing laws. Objective reality is unity in multi-variety, is developing *historical matter*. From the aspect of formal logic this is impossible. Formal logic demands either *identity* (hence arises *mechanistic materialism*, for which there are no objectively differing qualities, and every quality is only the subjective aspect of quantity) or *variety* (hence arises *idealistic pluralism*, which denies the unity of the world and comes to an astonished halt before sensuous variety). These problems, which were at the basis of the discussions which have taken place at this congress, cannot be solved if we move on the plane of formal logical definitions. They can be solved only on the basis of a *higher form of logic*, namely on the basis of materialistic dialectics, which embraces the objective contradictions and simultaneously their unity, the *interpenetration* of antitheses, the *transition* of one into another, and so on. Unfortunately all these questions cannot be discussed in five minutes, and I can only touch on them. I will cite only one example from physico-chemistry and biology. The organic world emerged *historically* from the unorganic. Consequently the governing laws of the biological series of phenomena include in themselves the governing laws of the physico-chemical series. Here they have taken on a complex, particular form. Here was formed a new, objective quality, for a new, *more complex form of the organisation of matter* had emerged. What element is there here of the surprising, the miraculous, the supernatural? Absolutely nothing. All attempts to return to Aristotelean teleology must be resolutely

17021

condemned. These attempts, and all vitalism equally inevitably lead in the last resort to theological conceptions and must be rejected as anti-scientific.

The question of the inter-relationships between pure and applied sciences must also be approached *historically*. The fashionable viewpoint which severs the intellectual life of society from the other aspects of its life will not withstand criticism. The history of knowledge must be a component part of social history. It is absolutely incorrect to regard a system of theoretical truths as a self-complete and perfect whole *outside* history and *outside* life. The logical connections and governing laws immanent to this or that discipline can be taken in their logical bareness only conditionally. For theory is a reflection of the *inter-relationships between* subject and object; it is true to the extent that it *correctly* reflects the objective connections of things and processes. On the other hand, it is the product of cognitive *activity*. And finally, being a generalisation of practice, it is *verified* by practice. Consequently, if we do not wish to have a one-sided substitute for analysis, then for the cognition of *theory* (history of knowledge) we must analyse its connection with *practice*. We postulate that theory *grows out* of practice; that in transforming the world, material practice serves as the basis of theory; that theory for its part in turn influences practice.

From this aspect it is easy to understand the inter-relationships between the so-called 'pure' and the so-called 'applied' disciplines. By 'pure' one can very conditionally signify the formulae of *objective governing laws*. By 'applied' the formulae of the *rules of action*. Nevertheless it is necessary here also to observe that the one passes into the other, for the *selection* of the object of investigation is determined *as a whole* by the necessities of the period; and on the other hand, any *system of rules* (technology) operates on the cognised objective governing laws. Hence the conditionality of the division is obvious.

In essence there are no and can be no such thing as 'pure' sciences, i. e. sciences lying outside the vital needs of society and its classes, just as there can be no forms of cognition outside the cognising subjects, and just as there cannot be a society which only cognises and does not produce. The conditional division into theoretical and applied disciplines reflects something of extraordinary interest from this very aspect of history.

In history we have various types of social and economic structures. Correspondingly we have various types of inter-relationship between intellectual and physical labour. The social gulf between these forms of labour evokes in the representatives of intellectual labour the illusion of a super-social existence of science, in which scientific abstractions are hypostasised and sometimes are transformed into the sole substance: such for example is *Pythagoreanism*, such is the *pan-logism of Hegel*, such is the *fetishism of pure science*».

From this *historical* aspect it is understandable that the radical transformations occurring in Soviet Russia in the sphere of the material life of society, in the «*mode of production*», were bound to evoke corresponding transformations in its «intellectual» life, ie., in the «*mode of conception*». In the U. S. S. R. the growth of planned economy and the enormous swing of the construction has raised the task of uniting theory and practice. This finds the clearest expression in the *planning of scientific work*, i. e., in the conscious co-subordination of the direction of this work to the enormous needs of technical and economic development. Planned economy is rational economy. Science is the rational element. The formula of the law (given A, B follows) is transformed into a rule of conduct (in order to get B you must produce A) on a *social* scale, the possibility of a swift transformation of the one into the other being an *historical* quantity given by the definite historical-social structure.

That is why we can say that in the U. S. S. R. the problem of theory and practice is resolved not only as a theoretical problem, but as a problem of practical *social activity.*

PAPER by PROFESSOR B. HESSEN.

(*Physical Institute of Moscow University*)

The division of science into pure and applied science is primarily a conventional one.

In reality, if we are going to accept a complete demarcation between pure and applied science, we should use the term «pure» science so long as it is without practical application and the term «applied science» when it has been so applied in practice.

Thus Maxwell's equations, and the study of their solution was pure science until the work of MARCONI, and became applied science after wireless telegraphy had developed from them.

It is of interest to ask: «What is the reason for this division of science?» We Marxists see the cause in the circumstance that all bourgeois philosophy regarded the problem of cognition of the world as purely contemplative.

However, the task of cognition consists in the very fact that it organises and directs our activity. In reality there is no absolutely contemplative cognition.

We can have cognition of the world only by changing it, and so we always proceed, whether we are working on a given physical experiment or on the most complex of all political and economic activity. The very confirmation and proof of our cognition inevitably presupposes activity. NEWTON delayed the publication of his «*Principia*» for twenty years because he did not possess accurate data on the radius of the earth. And these data were only obtained by sea voyages. Thus, even the law of gravitation, which would appear to be pure abstract thought, could not be completely enunciated so long as practical human activity had failed to supply his material.

In distinction from other views we specially emphasise this active aspect as a component part of knowledge and science. Thus the separation and contraposing of pure and applied science has as its basis the dismemberment and severing of a single process of contemplation and activity.

In capitalist society this severance leads to the task of pure science being regarded as a «higher and more exalted one». Activity and practice are regarded as something lower and science is justified only by pure cognition. This view was represented in the paper of Professor WHETHAM.

We start from the conception of the unity of knowledge and action, consequently we recognise only a single science. With us, for instance, there are not pure and applied physics, but only the one science of physics.

THE HISTORY OF SCIENCE

LONDON CONGRESS OPENED

USE OF INVENTIONS

The International Congress of the History of Science and Technology was opened yesterday in the Great Hall of the Royal Geographical Society by the President of the Board of Education, Mr. Lees-Smith, who welcomed the delegates in the name of the Government.

The greatest events in the history of the world had taken place, Mr. Lees-Smith said, in the realm of ideas, and we were now realizing more than ever that ideas which emerged and developed in the minds of men of science and technology moulded the history of mankind. The history of those great creative forces should be studied side by side with other aspects of history, which we were beginning to suspect were less important than those hitherto ignored.

The achievements of science and technology were now progressing with such cumulative rapidity that the mind became dazed and almost lost the capacity for surprise. During the 18 months which he had himself spent recently as Postmaster-General, he had gone into a little room in the Post Office and inaugurated the first public service by which photographs, plans, and sketches had been sent abroad by telegraph; he had exchanged photographs with the German Minister of Posts in 20 minutes; he had signed a paper by which for the first time wireless telephony was established between this country and ships that traversed the seas; and he had taken part in the opening from 10, Downing-street of a telephone service with Australia.

ENRICHMENT OR DESTRUCTION?

Science and technology were, he said, immeasurably beneficent, but completely merciless. The same science which produced the shell which blew the features off a man's face also produced the plastic surgeon who did his best to put together some sort of new face in its place. Science and technology furnished us day by day with fearful instruments and left it to us whether man rose through them to heights as yet impenetrable or fell with a crash more sudden and complete than any yet known to civilization. We might come to the conclusion that the inventions of our time were proceeding with greater rapidity than ever before, but was the moral progress of mankind keeping up with men's material advancement? The supreme question which now rested between nations was whether these great conquests of nature achieved by science were to be used for the enlargement and enrichment of life, or for the destruction of our fellow men. If ever again they were utilized on a large scale for purposes of destruction Western civilization would disappear—and rightly disappear—because it would have failed to answer the great moral tests by which in the last resort any civilization must be judged.

DR. SINGER, in his presidential address, turned to the possible effects of the Congress in advancing scientific ends, and especially the teaching of history, at present too little occupied with the affairs of the mind. The rise of science was, he said, the most important event in human history since the fall of the Roman Empire, and a text-book of history which did not say so did not teach the truth. None of them did. He had glanced through the history-book of his own little girl, and found the name of Newton absent. The critical years which saw the foundation of the Royal Society, the publication of Robert Hooke's "Micrographia," Newton's work on prisms, and his great "Principia" were apparently occupied exclusively by battles.

BEGINNINGS OF SCIENCE

He summarized an address he had prepared on "The Beginnings of Science," in which he pointed out that the belief of the Greeks that they had learnt science from Egypt seemed, after all, well-founded, despite a common theory that science came from Mesopotamia. Within the past few months two papyri had been published which threw light on Egyptian science. One was the "Edwin Smith" surgical papyrus of the sixteenth century B.C.,

Next Page

THE ARTICLES AND THE CREEDS

BISHOP OF BIRMINGHAM'S WARNING

The proposal appearing in the recent Report on the Staffing of Parishes that assent to the Thirty-nine Articles should no longer be required of ordinands was discussed yesterday by the Bishop of Birmingham (Dr. Barnes) in his opening address at the Birmingham Diocesan Conference.

He said that we were witnessing the beginning of that movement for doctrinal readjustment within the Church which Archbishop Davidson foresaw. He (DR. BARNES) viewed with much concern the present proposals to change or repudiate our Articles of religion. Though such change as was advocated might be begun with the ostensible object of giving relief to tender consciences, he was certain that they would find at the end that sacramental truth had been abandoned. Already there had been a virtual repudiation of the doctrinal position of the Articles in negotiations with the Orthodox Church and the Old Catholics. In defence of such action it was urged that we ought to make alliances with those bodies that there might be, in political language, a *bloc* to oppose the Roman Church. He distrusted those politico-ecclesiastical negotiations. When ecclesiastical politics entered by the door religion flew out of the window. He was more concerned to preserve religious truth and Christian morality than to construct ecclesiastical alliances. The sacramental doctrine alike of the Orthodox Church and of the Old Catholics was unscriptural and untrue, and, moreover, the moral witness of the Orthodox Church in Russia and the Eastern Mediterranean had left, and still left, much to be desired.

Commenting on the argument that able men were to-day repelled by the Articles, the Bishop said he was for many years a Cambridge tutor and he learned that to most men the Creeds were the stumbling-block to ordination. The Articles barely entered into their field of vision. To-day that fact remained true. Personally he regarded the Creeds not as verbally infallible in both religion and science, but as witnesses to spiritual truth.

INDIAN MEMORIAL ON SUSSEX DOWNS

QUESTION OF PRESERVATION

FROM OUR CORRESPONDENT

BRIGHTON, JUNE 29

Complaints are being made here regarding the condition of the Chattri, or temple, the impressive Indian memorial which stands on a lonely site on the Sussex Downs about a mile and a half north of the village of Patcham. The memorial was erected at the expense of the India Office and the Brighton Corporation to the memory of the Indian soldiers who gave their lives in the service of the King-Emperor during the Great War, and the unveiling ceremony was performed by the Prince of Wales in February, 1921.

The condition of the white Sicilian marble of the Chattri proper seems as perfect as on the day it was unveiled, but the stone and granite work beneath has become dirty through the ravages of rough weather, while the grounds surrounding the memorial, despite recent work carried out, are somewhat untidy. Much of the unkempt appearance of the wire-fenced grounds surrounding the Chattri is, however, due not to lack of effort on the part of those responsible but to the persistent depredations of rabbits.

Brighton Corporation have recently received representations about the memorial and the condition of the site, and a committee has been examining the question, which is to come before the Council at an

FIRST DAY OF THE SALES

BIG CROWDS OF BUYERS

The crowds at the sales yesterday were greater than any seen for some years. From early morning until closing time the stream of shoppers poured into the West End and the neighbourhood of Knightsbridge.

The reductions in model gowns in the exclusive houses was specially appreciated by well-dressed women who have had to deny themselves many frocks during the past season. In one famous house the buyer had made a point of getting in touch with a number of customers who had liked, but had not been able to afford, certain models. They were very glad to have them at a big reduction. One woman who is a good customer at a great model house chose 20 of the loveliest frocks as gifts for five granddaughters.

There were dress rails in departments in which washing frocks were sold that were entirely cleared by mid-day, and counters on which skirts and blouses at bargain prices had been banked up at 9 a.m. were empty at lunch time. This is the first time since blouses and skirts have returned to favour that they have been in a sale and the fact that they are generally worn was evidenced by the onslaught on the bargain tables.

Lingerie bargain tables met the same fate, but, in the big shops at least, it was the cheaper end that moved quickest. On a half-price table where satin, silk, and cotton underwear was heaped at an extraordinarily varied range of prices, the satin and the heavier silks, though half price, still remained in the afternoon, while everything that was cheap had been cleared away.

Bargains in materials met the same fate. Anything that was good and in a good colour and at a fraction of its former price disappeared very quickly. Materials that were what is called "running" numbers, with a shilling or two off, were left. The quest of the right colour was urgent all day.

Buying was brisk, but it was also methodical. Price was not the chief factor. Again and again women refused excellent bargains because the colour was not right.

Gloves are very cheap, and thousands of pairs were sold yesterday, women buying as many as they could afford now that they are cheaper than they have been for years. Stockings, handbags, and the oddments in neckwear to be found in lace departments achieved a ready sale among those who make a point of buying such things on the first day before they have been tumbled about by eager shoppers.

BARGAINS FOR THE HOME

Things for the house appeared to be bought by women who came out solely for that purpose. Carpets at half price appeal to the houseproud just as strongly as half-price models to the woman who loves clothes, and many homes which have grown a little shabby during recent months will now have smart carpets and curtains and their furniture will have pretty new covers in flower-strewn cretonnes or glazed chintz. This year there are some wonderful bargains in glazed chintz, which looks well among old furniture. Handsome glass bowls and table decorations were selling at a third or a fourth of their usual prices.

Men were, of course, outnumbered by women, but it was far from being a manless world, and there were men buying things for themselves as well as things for the house, smart tweed coats at half price and bargains in dressing-gowns, gloves, and shoes, and choosing as many of their holiday requirements as they could at bargain prices. They appeared to be just as keen judges of colour as their wives and sisters. Tweeds and ties were tested with the aid of mirrors for their becomingness, and as in the women's choice of clothes, price was not the ultimate factor.

MIDDLESEX HOSPITAL

OPENING OF NEW NURSES' HOME

The new Nurses' Home of Middlesex Hospital was opened yesterday by Princess Alice, Countess of Athlone. The gift of an anonymous donor, it has cost £100,000 ... The foundation-stone was laid

SALVAT[...] CO[...]

POWE[...] GE[...]

MODIFICAT[...]

The Bill prom[...] Army to modify [...] which embodied [...] Booth, founder [...] a Select Committ[...] yesterday. The [...] through the H[...] substantial ame[...] Committee.

Sir Lynden M[...] Thomas, K.C., a[...] now supported th[...] was opposition [...] Booth (daughter [...] Booth and grandd[...] Salvation Army [...] Booth, Colonel G[...] Lamb, and other [...] Army. None of th[...] by counsel.

Sir Lynden Ma[...] tion Army was [...] which the intenti[...] be carried into effi[...] contravening the [...] changed from t[...] necessary a modi[...] Parliament had [...] provisions of a [...] it had been prove[...] of the trust that [...] made.

The Bill was [...] John Higgins, w[...] of the Salvation [...] and was sole [...] trustee of the pr[...] in Great Britain [...] was promoted [...] passed in Nove[...] ference of comm[...] specially summon[...] world.

The first alter[...] of the appointin[...] vation Army [...] provided that th[...] should place th[...] sealed envelope [...] to the method of [...] The High Cour[...] the general had [...] envelope or pres[...] or if the gener[...] office under the [...] Bill was that [...] be made by th[...] stances.

A CUST[...]

Another prop[...] with the proper[...] day the general [...] administrative [...] In the event of [...] greatest moneye[...] to conveyancing [...] in the Bill exc[...] Dominions and [...] to provide for t[...] be custodian tr[...] property in G[...] Ireland, leaving [...] of the general.

The reason fo[...] to relieve the [...] opinion that [...] Army, threateni[...] existence and de[...] gress of its wo[...] visions of the d[...] ditions of to-da[...] intentions of th[...] recurrence of s[...] the illness and [...] Bramwell Booth [...] Sir Lynden fact[...] of charitable t[...] proposals.

This set of [...] nothing whatev[...]

science was, he said, the most important event in human history since the fall of the Roman Empire, and a text-book of history which did not say so did not teach the truth. None of them did. He had glanced through the history-book of his own little girl, and found the name of Newton absent. The critical years which saw the foundation of the Royal Society, the publication of Robert Hooke's "Micrographia," Newton's work on prisms, and his great "Principia" were apparently occupied exclusively by battles.

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He summarized an address he had prepared on "The Beginnings of Science," in which he pointed out that the belief of the Greeks that they had learnt science from Egypt seemed, after all, well-founded, despite a common theory that science came from Mesopotamia. Within the past few months two papyri had been published which threw light on Egyptian science. One was the "Edwin Smith" surgical papyrus of the sixteenth century B.C., dealing with injuries. Some of the observations, for instance the association between injuries to one side of the brain and paralysis of the opposite side of the body, could reasonably be called scientific. The Moscow mathematical papyrus of about the same age (now published in Berlin by Professor Struve) calculated the surface of a hemisphere from its diameter, and gave the constant π as 3.16, a very fair approximation.

Guests were afterwards received for tea at the Science Museum by the President of the Board of Education and Mrs. Lees-Smith, the Director of the Museum (Sir Henry Lyons), and Lady Lyons. In the evening the President of the Congress and Mrs. Singer gave a reception at the Royal Society of Medicine, Wimpole-street.

Mr. G. H. Gabb displayed his unique collection of relics, instruments, portraits, and medals relating to Joseph Priestley, and Dr. Reginald S. Clay exhibited part of his collection of historical optical instruments. Professor E. N. da C. Andrade, wearing eighteenth-century dress, gave a lecture, under the impersonation of Francis Hauksbee, a Fellow of the Royal Society, who died about 1713, and was one of the pioneers of the study of electricity. The title of the lecture was "A Discourse with Experiments on various Subjects, giving an account of several Surprising Phenomena, touching Light and Electricity, with many other Remarkable Appearances not before Observed." The experiments shown were all known to have been carried out by Hauksbee, who was the first to build an electrical machine and to obtain electrical discharges in evacuated tubes, on the study of which the physics of to-day is founded. An air-pump used was one actually constructed by Hauksbee about the year 1705, when Sir Isaac Newton was President of the Royal Society.

A special session of the Congress has been arranged for Saturday morning, when the Soviet delegates will read papers on the Marxian view of the history of science.

Among those present at the President's reception were:—

Sir William Bragg and Miss Bragg, Sir Maurice and Lady Sheldon Amos, Sir Robert and Lady Armstrong Jones, Professor and Mrs. Brandin, Mrs. R. S. Clay, Dr. and Mrs. Cruickshank, Dr. Connolly (Director of the American University Union), Dr. and Mrs. Chaplin, Colonel J. Waley Cohen, Sir Robert and Lady Waley Cohen, the Astronomer Royal and Lady Dyson, Lord and Lady Dawson of Penn, Mr. and Mrs. H. W. Dickinson, Lady Evans and Miss Joan Evans, Mr. and Mrs. Arundel Esdaile, Professor and Mrs. Fawcett, Dr. Edith Guest, Sir Philip and Lady Hartog, Professor and Mrs. Julian Huxley, Dr. and Mrs. A. G. Little, Mr. and Mrs. J. Leveen, Sir E. and Lady Graham-Little, Lord and Lady Lansdowne, Sir Herbert and Lady Llewellyn Smith and Miss Llewellyn Smith, Professor and Mrs. Montmorency, the Provost of University College and Mrs. Mawer, Lord and Lady Moynihan, Dr. and Mrs. Robert Mond, Professor and Mrs. Nelson Jones, Sir Percy Nunn, Dr. and Mrs. Needham, Professor and Mrs. Newton, Sir John Parsons, Professor and Mrs. Raymond Pearl, Professor Sydney Philip, Sir D'Arcy Power, Professor Ramsay Wright, Mr. and Mrs. T. H. Riches, Dr. and Mrs. Rolleston, Dr. and Mrs. E. E. Russell, Engineer Captain Frewth, Professor and Mrs. Elliot Smith, Sir Napier Shaw, Professor Sampson, Dr. Still, Dr. and Mrs. Tidy.

THEFTS FROM DICKENS MUSEUM

ACCUSED MAN SENT TO GOAL

John Lewis Wynne Bostock, 35, of Fawnbrake-avenue, Herne Hill, S.E., was charged on remand at Bow-street Police Court yesterday, before Sir Chartres Biron, with stealing some Dickens manuscripts, letters, and books to the value of £1,100 from the Dickens Trust House Museum, Doughty-street, W.C.

He was now further charged with having, at the same place, committed wilful damage to the extent of £100 by tearing leaves from eight volumes of John Forster's "Illustrated Life of Charles Dickens"; and further with stealing a Dickens letter, valued at £10, from a typewriting office in Thurlow Park-road, Dulwich. Of these 15 had been sent to America, 12 of which were now on their way back to this

potation to the memory of the Indian soldiers who gave their lives in the service of the King-Emperor during the Great War, and the unveiling ceremony was performed by the Prince of Wales in February, 1921.

The condition of the white Sicilian marble of the Chattri proper seems as perfect as on the day it was unveiled, but the stone and granite work beneath has become dirty through the ravages of rough weather, while the grounds surrounding the memorial, despite recent work carried out, are somewhat untidy. Much of the unkempt appearance of the wire-fenced grounds surrounding the Chattri is, however, due not to lack of effort on the part of those responsible but to the persistent depredations of rabbits.

Brighton Corporation have recently received representations about the memorial and the condition of the site, and a committee has been examining the question, which is to come before the Council at an early date. It is expected that some measure will be taken to safeguard the site from damage by rabbits and that certain other changes will be made. Increased public interest in the memorial, which is a beautiful and striking landmark on the Downs, would doubtless have a great effect in leading to such improvements as are necessary.

BOSTON STUMP

£11,000 FOR PRESERVATION SENT FROM AMERICA

A gift of $55,000 (about £11,000) from Boston, Massachusetts, to Boston, Lincolnshire, was brought to England by Mr. Walter R. Whiting, who arrived in Liverpool in the White Star liner Baltic last night.

The money has been raised by descendants of some of the Puritan Fathers who hailed from Boston, Lincolnshire, to recondition the tower of St. Botolph's, Boston, England (popularly known as "Boston Stump"). Mr. Whiting is representing a committee from the American Boston which includes the Governor of Massachusetts and the Mayor and three former Mayors of Boston.

WOOL TEXTILE INDUSTRY

EMPLOYERS' REPLY TO REQUEST FOR COUNCIL MEETING

FROM OUR CORRESPONDENT

BRADFORD, June 29

It was stated by Mr. Arthur Shaw, the secretary of the National Association of Unions in the Textile Trade, after a meeting of the executive committee of that body to-day, that the meeting considered the reply given by the employers' side of the Wool Textile Industrial Council to the request of the operatives' side that a meeting of the Industrial Council be held. A draft letter had been prepared, which would be received by the employers' secretary, Mr. Ernest J. Martin, to-morrow, and the executive committee had decided that if Mr. Martin had no objection to the publication of the correspondence the operatives' side was willing that it should be published.

Mr. Shaw also stated in reply to questions:—"There is no indication in the letter we have received from the employers that they are not prepared to meet us." It is evident from Mr. Shaw's statement that he is unable to say that the employers have consented to the proposed meeting. The purpose of the operatives' side in asking for a meeting is ostensibly to discuss the drawing up of a general agreement to cover the industry. In view of the fact that for two years there has been no general agreement the preparation of a new one would take a considerable time, owing to the many difficulties presented by the diversity of rates operating throughout the area covered by the Northern Counties District Council of the National Wool (and Allied) Textile Industrial Council.

Many employers undoubtedly feel that an immediate reduction in rates is warranted by the difference between the cost of living figure shown in the *Ministry of Labour Gazette* to-day, and the figure of 64 per cent. adopted by the employers for the past 12 months, following the report of Lord Macmillan on the position of the industry.

AWARD OF SCHOLARSHIPS FOR MODERN LANGUAGES

Men were, of course, outnumbered by women, but it was far from being a manless world, and there were men buying things for themselves as well as things for the home, smart tweed coats at half price and bargaining dressing-gowns, gloves, and shoes, and choosing as many of their holiday requirements as they could at bargain prices. They appeared to be just as keen judges of colour as their wives and sisters. Tweeds and ties were tested with the aid of mirrors for their becomingness, and as in the women's choice of clothes, price was not the ultimate factor.

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The new Nurses' Home of Middlesex Hospital was opened yesterday by Princess Alice, Countess of Athlone. The gift of an anonymous donor, it has cost £300,000. The foundation-stone was laid in January, 1929, by the Queen.

Prince Arthur of Connaught, the chairman of the hospital, said that the home had been built away from the hospital and its atmosphere, but it was conveniently near. They had tried to avoid the institutional atmosphere and to plan a real residential college for nurses, complete in its facilities for instruction and recreation. By the institution of the College of Nursing and the General Nursing Council, the work of nursing had now been put on a definite professional basis, and the generosity of their anonymous benefactor had enabled them to bring all sides of the nurses' life and training up to university standard. If hospitals provided accommodation of that character and aimed at that high standard they would attract a type of nursing undergraduate equal in culture and in education to those entering any other profession in the country.

Princess Alice spoke of the pleasure it gave her, as wife of a former chairman, to be associated once more with one of the great occasions in the history of the Middlesex Hospital. The Middlesex Hospital had always been in the van of progress, and the housing committee had, by its wise forethought in paying special attention to the comfort, health, and happiness of its nursing staff, attracted the high standard of applicants which made the hospital so proud of its nurses.

Lord Athlone said that they saw in the building a model type of nurses' home. The more they improved the lives of the nurses the better would be the nursing which was obtained.

A tour was then made of the building, which in addition to a preliminary training school and class rooms, has recreation and smoking rooms, badminton and tennis courts, and a swimming bath.

SCHOOL FOR THE BLIND

PRIZE DISTRIBUTION BY THE DUCHESS OF YORK

The Duchess of York distributed the prizes at Guildhall yesterday to the pupils of the School for the Blind, Swiss Cottage, which is associated with the London Society for Teaching and Training the Blind. The Lord Mayor attended in state, accompanied by the Sheriffs. The pupils gave a delightful and in some respects remarkable entertainment. They sang sweetly in part songs, and senior pupils played pianoforte duets and solos. The section of the programme which perhaps astonished the audience most was that devoted to dancing by groups of junior and senior boys and girls. The movements were performed gracefully and with steps perfectly measured to the rhythm of the music.

The Lord Mayor said the society was founded 93 years ago, and although its headquarters had for nearly 90 years been in Hampstead its connexion with the City had been close. In 1918 the number of blind persons for whom it cared was 80, and to-day it was 607. The present time was one of particular anxiety to those who had charge of the affairs of the society. The lease of the present school would run out in a few years, and it was necessary to raise a fund for new buildings. A sum of £50,000 was required, and on behalf of the institution he appealed for financial assistance in order that it might continue its excellent work.

Dr. J. M. Ritchie (the Principal) said the work of the society was made up of three sections: elementary education, professional or industrial training, and employment. Good progress had been made during the year, but their financial position was urgent. If their work was not to come to an end at the expiration of their lease they must have the whole-hearted support of the charitable public.

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The Beginnings of Science.*

By Dr. Charles Singer.

WHEN did science begin? Can any question be more fundamental for the history of rational thought? An adequate answer would doubtless demand the formulation of an exact and generally acceptable definition of science. No one, perhaps, has yet succeeded in accomplishing this seemingly simple task. But without insisting on a precise delimitation of the term 'science', we may get some way, at least, by taking its current if inexact sense. Thus we may treat science as simply the systematic *process* of recording natural happenings with the object of discerning some relation between them.

I would emphasise the word *process*. Science is often discussed as though it could be presented as a body of knowledge or doctrine, but reflection will soon reveal that this point of view cannot be maintained. For is it not the case that science that has ceased to develop soon ceases to be science at all? The science of one age is often the nonsense of the next. Think, for example, of judicial astrology, or of the doctrine of lucky and unlucky numbers. Who, if he did not know their history, would recognise these as the debris of finely conceived and far-reaching scientific hypotheses, which once attracted clear-thinking minds seeking for rational explanations of the world in which they lived? We may smile, if we will, at such an explanation of the face of the earth as the doctrine of successive disasters followed by successive creations. The view that fossils are the early and clumsier attempts of an omnipotent Creator may even move us to theological wrath. Yet such conceptions were but stages in the development of geological ideas, just as the scientific views of our own time are but a stage in a great secular process which will continue when we are no more.

It therefore behoves the historian of science to be very charitable, very forbearing, in all his judgments and presentations. He must not ask too much of previous ages, nor must he judge them by the standards of his own. He needs constantly to recall that he is dealing with work of erring and imperfect human beings, each of whom had, like himself, only a very partial view of truth. There is an unquenchable and irresistible tendency innate in the human mind to erect general laws or rules in explanation of the happenings of the world. That tendency is no less present in the historian of science than in the great minds whose work he records, and if he is to be judged at all by posterity, he can but echo the epitaph:

> Reader, thou that passest by,
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Time, still, like an ever-rolling stream, bears all its sons away. It is the stream itself and the spirit that dwells therein that the historian of science has to study.

Science, then, is a process that can be followed through the ages; it is not a mere passive body of knowledge. The sheer validity and success of the scientific process, as applied in our own time in western Europe and America, has given rise to popular misunderstanding as to the nature of science, and some misapplication of such terms as 'science' and 'scientific'. We hear of the *science* of some prize-fighter, and a book has been published on the "Science of the Sacraments". There is nothing in the laws of this or any other country which forbids its citizens from giving the words of their language such significance as they may choose, but the word *science* as employed in these connotations has no clear link with the great progressive method of acquiring knowledge with which the historian of science has to deal. The very form of the adjective from science might itself give pause to those who would force the word to cover such topics as the skill of the prize-fighter or a knowledge of the theory and practice of religious rites. The word *scientific* means, derivationally, *knowledge making*, and no body of doctrine which is not being progressively *made* can for long retain scientific attributes.

During the last two generations the evolutionary conception of Nature has become so general that it now pervades our thoughts on every aspect of living activity, nor can we understand an organic product until we know how it came to be what it is. Now, the efforts of the human mind are essentially such products. It has thus become generally recognised that to comprehend, for example, the constitution of a State or the teaching of a religion it is absolutely necessary to know its past. This is the true reaction of evolutionary doctrine on the study of history.

On the study of science itself, however, this reaction of evolutionary doctrine has been less generally recognised. Why this should be is perhaps not altogether clear. One reason may be that the triumphant and absorbing successes of the application of the scientific method have deflected attention from the process itself. Another reason, which is perhaps but a restatement of the former, is that the very rapid growth of the products of the scientific process in quite modern times has turned men's thoughts away from its more ancient achievements. Yet it is clear that if we would understand the process itself, we must examine its application in the past and watch its action under conditions different from those in which we ourselves live. Only thus can we hope to attain any real insight into the nature of the process and of the effect it has had on man's estate throughout the ages.

Among the criticisms that can be made of any attempt to trace the history of science, there is one

* Inaugural address delivered to the Second International Congress of the History of Science and Technology, by the president, on June 29, at the Royal Geographical Society.

that should be met at the outset. It has been said that the history of scientific activity presents a field so vast that it cannot be compassed at first hand by any single mind. The criticism is without validity. If pressed, it would not only prevent the writing of the history of science, but would also prevent the writing both of history and of science. Who, of his own knowledge, can compass the history of even a single country? Who, of his own knowledge, can deal with the animal kingdom, with the science of geometry, or with the structure of the earth? Yet this has not prevented, and should not prevent, the writing of histories of England and of Europe, of works on zoology, of treatises on mathematics, or of text-books of geology. The scope of such books in reference to the first-hand knowledge of their writers must be effectively infinite. The difficulty in writing them—as in reading them—is the difficulty in getting a philosophical grasp of the principles involved. In obtaining such grasp, first-hand knowledge is of primary importance. Yet this knowledge, applied in such a field, is but a means to an end, and the writer must be judged by his grasp of the principles he sets forth rather than by the actual number of experiments he has made or experiences that he has undergone.

But to return to our question as to when science began. The question can as little be answered as the question, When does a man begin to grow old? "Before that I to be begun, I did begin to be undone." Anthropologists have detected germs of the scientific process in the lowest and rudest races of mankind. As soon as a child begins to observe, he begins to make generalisations. The savage sees the action of a living thing in the wind and the flow of the water. He generalises from his imperfect observation that movement means life. The baby calls every male "daddy"; his, too, is an elementary generalisation based on imperfect experience. Both ascriptions are imperfect attempts at deducing laws.

Here, however, we encounter a real gap in the historical narrative. We can see the scientific element in the baby's generalisation or in the savage's belief. Yet we cannot, with any confidence, trace them forward in a continuous stream to anything that we should call science in the current use of that term. How far, then, can we trace the matter the other way, ascending the stream of time? In this attempt the last decade has been particularly fruitful, and I shall venture to devote the remainder of my remarks to the special nature of this recent historical achievement. As is too often the case on the scientific front, the pioneers are more concerned with their own progress than with the relation of their advances to those of others. The onlooker truly sees most of the game, and perhaps it is not going too far to say that the game cannot be clearly seen except by the onlooker. This is the justification of the professed historian of science. Without him research in one department would rapidly lose touch with research in other departments. This is so with recent scientific history. Let us seek in the same spirit among the records of a far earlier scientific history.

As we trace the records of science back into the mists that shroud the dawn of history, we see its varied disciplines dwindling to two, namely, to medicine and mathematics. So far as complete works are concerned, the earliest of all scientific treatises that have come down to us are in the medical class. They are contained in the miscellaneous group of tracts known as the "Hippocratic Collection".

The "Hippocratic Collection" takes its name from the alleged 'father of medicine'. In a less critical age this mass of writings was all ascribed to Hippocrates, and there are some who still find it difficult to abandon the old paths. Nevertheless, there is no evidence, worthy of the name, that any part of any of these works was written by Hippocrates, nor indeed is there any real evidence that Hippocrates wrote anything. It is, however, certain that some works in the "Hippocratic Collection" were composed in the fifth century B.C., at which period their eponymous author was born. Sections of some of them may well date back to the sixth, and portions of them even to the seventh century. Moreover, it has long been recognised that these medical writings were an integral part of a far wider and more deeply based contemporary rational movement in philosophy.[1]

It has indeed been argued that the relations between the medical and historical writings of ancient Greece are closely paralleled by the relations between the evolutionary and historical writings of a generation or two ago. We might put it that Hippocrates was to Thucydides as Darwin was to Buckle or Lecky. A good case for the comparison has been made recently by Prof. Cochrane of Toronto.[2]

However this may be, it is evident that behind these earliest surviving scientific monuments of the fifth, sixth, and seventh pre-Christian centuries there must be a scientific tradition that was already ancient when the Greek world was still young. Of this more ancient rational tradition the mathematical fragments have been more successfully pieced together than the medical.[3] Thus we have details of the achievements of the followers of Pythagoras, and perhaps of Pythagoras himself, whose life occupied the greater part of the sixth century. Moreover, Thales, the sage of Miletus, of whose scientific achievements there can be no doubt, takes us yet further back and into the seventh century. He takes us, too, beyond Greece, for his mother was a Phœnician. He himself had travelled in Egypt. Phœnicia suggests contact with Mesopotamia and the ancient Sumerian civilisation. Recent discoveries in that region, notably those that deal with the treatment of metals, suggest a command of natural forces which demanded theoretical scientific knowledge. Yet it is to Egypt that the Greeks commonly ascribed the origin of their medical and mathematical knowledge.

Among the Greeks before Thales and the seventh century, our view of the rational spirit grows very dim. In the "Works and Days" of Hesiod, written in

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the eighth century B.C., we get some astronomical lore. Such knowledge, however, must have been common property in the Near East, and indeed in every early agricultural community. In the absence of an adequate calendar, some astronomical knowledge is necessary for the elementary operations in the field. Hesiod, it is true, has something rather beyond farmers' astronomy, but in him we have the independent scientific element at a well-nigh irreducible minimum.

Can we, then, trace the rational tradition among the Greeks behind Hesiod and the eighth century? I think we can. In the Iliad of Homer we obtain glimpses, distant, it is true, of an independent rational medical system. The Iliad tells of a great deal of fighting, in the course of which no less than 147 wounds are well described, and in many cases their treatment detailed. Now this treatment is always on entirely rational grounds, and magical elements are conspicuous by their absence. This and many other hints in the Iliad imply the practice of scientific medicine by recognised practitioners, without relation to folk-medicine. Thus, with the aid of the Iliad, we may trace the scientific tradition among the Greeks as far back as the ninth or tenth century. It is noteworthy that in the Odyssey the origin of medicines is ascribed to Egypt.

In view of the consensus among the Greeks as to their debt to Egypt, all traces of the scientific spirit revealed in the Egyptian papyri are of peculiar interest. Yet the finds have been, till recently, extraordinarily disappointing, and the contrast between Greek science and Egyptian science is greatly to the disadvantage of Egypt. For the inferiority of the Egyptian position as against the Greek, due weight has not always been given to differences in the records of the two civilisations.

First, we have to remember that the picture that we form of Greek thought is derived from the literary remains of the Greek people. That there have been irreparable losses to that literature is true, but the surviving part has come down to our time because it was read by the generations that came between the Greeks and ourselves, and it was read because, by each succeeding age, it was thought to be worth reading. Greek literature, as we have it, is thus, in essence, a selection. It is far otherwise with the Egyptian records. We have here merely what time has spared, and that old reaper has no more discretion with books than he has with the lives of men. He spares what he will and as he will. What kind of literature should we hope to recover from the wreck of our own civilisation? Daily journalism and trade advertisements occupy many times more bulk, and therefore would have a better chance of survival, than the works of the philosophers and men of science.

Secondly, the remnants that have come down to us from ancient Egypt have mostly been recovered from tombs. They were the kind of things that the men of their day thought suitable to bury with their dead. The commonest of all are, in fact, rolls of the "Book of the Dead". If we had to compare them with something in our own civilisation, they would perhaps correspond to the inscriptions on tombstones, to hymn-books, and to prayers for special occasions. It is true that we have an admixture of other documents, but the proportional distribution of surviving Egyptian writings bears no relation to the proportional distribution of Egyptian interests.

Thirdly, it must be remembered that much surviving Greek literature is from the most vital period of Greek history. On the other hand, the overwhelming mass of Egyptian papyri are from the New or Middle Kingdom, whereas the Old Kingdom was the day of Egyptian power. The later scribes were content with copying earlier material. These later scribes were, moreover, commonly careless and not uncommonly incompetent, and, as it falls out, this was especially the case for the papyri that bear on scientific topics.

Bearing in mind these contrasts in the circumstances of Egyptian and Greek documents, let us turn to the surviving papyri of scientific content. These, like the earliest Greek scientific material, divide naturally into the medical and the mathematical. A number of documents fall into each of the two categories, but most of them are so debased or so trivial that we miss little if we take only the principal specimens. Of these there are two in each class that are of primary importance. In the medical class there is the long known Ebers Papyrus and the recently described Edwin Smith Papyrus. In the mathematical class there is the Rhind Papyrus and the very recently described Moscow Papyrus. These four contain practically all that is known of Egyptian medicine—other than that of a purely magical character—and most that is known of Egyptian mathematics.

The Papyrus Ebers, known for seventy years, is still not completely intelligible. It presents many linguistic difficulties, chief among them being the names of drugs. It is of the New Kingdom, and is generally dated as of the sixteenth century B.C. It is in the main a collection of remedies for various named conditions which are sometimes briefly described. Its general intellectual level is about comparable to an English family receipt book of the seventeenth century, of which several have been published. There is no definite physiological, pathological, or pharmaceutical theory, but there is also little that one can call superstition. The book is taken up with a list of traditional treatments of a more or less disgusting character. That sections are taken from a much older work is evident from a few isolated paragraphs in it that are devoted to anatomy. These are so confused as to be unintelligible, but it is obvious that the scribe is trying to abstract an older and more scientific document.

During the last few months Prof. Breasted, of Chicago, has presented us with his edition of an Egyptian medical document of a somewhat different order.[4] The Edwin Smith Papyrus has had a romantic history, having been originally discovered about the same time, and perhaps in the same tomb, as the Ebers. A series of remarkable circumstances left it in private libraries and unknown to scholars until a few years ago.

In general form the Edwin Smith Papyrus is not unlike the Ebers, in date somewhat similar or a little earlier, and its scribe no less careless and incompetent. He was, however, engaged in copying a document of greater scientific value, and probably of greater antiquity than that which was occupying the scribe of the Ebers Papyrus, for there can be little doubt that the original source of the Edwin Smith Papyrus was of the Old Empire. Moreover, the Edwin Smith Papyrus deals with surgical conditions, and especially injuries, while the Ebers is occupied with diseases. Injuries and their treatment lend themselves to clearer descriptions than do the diseases. We thus have in the Edwin Smith Papyrus a document of high value for comparison with certain works of the "Hippocratic Collection" of about twelve centuries later. Without discussion of details it may be said that through the mist of scribal ignorance and misunderstanding we can see in the Edwin Smith Papyrus an author who not only recorded actual case histories, but was seized at times of the spirit of science; that is to say, he records in order to learn something of the workings of the body as distinct from any attempt to treat his patient. Some of his observations, such as that injuries to the brain on one side result in paralysis of the other side of the body, are repeated in the "Hippocratic Collection", and do, in fact, throw light on the nature of physiological mechanism. The Edwin Smith Papyrus—or at least that part of it which survives—is devoted to injuries about the head. It gives us a glimpse—alas! that it should be so dim—of a lost and more ancient scientific literature to which such magnificent treatises as the "Wounds of the Head" and "Fractures and Dislocations" of the "Hippocratic Collection" may well have been related.

For Egyptian mathematics the most important document is the Rhind Papyrus, which was finely edited a few years ago by Prof. T. E. Peet, of Liverpool.[5] Its age is about that of the Edwin Smith Papyrus, though it is copied from an original of the nineteenth century B.C. It professes to be a 'guide for calculation'. Apart from simple rules for giving the areas of figures enclosed by right lines, we have the measure of a circle from which an estimate of π as 3·16 can be deduced, and a calculation with reference to the proportions of pyramids. In this last a certain relation which, as the Papyrus says, "makes the nature of the figure", is deduced from the side of the square base and vertical height or *per-em-us* as the Papyrus calls it. The word *per-em-us* is doubtless the source of the Greek word *pyramis* and our *pyramid*. The problem clearly links up with the mathematical triumph of Thales in deducing the height of a pyramid from its shadow.

The last scientific document of Egyptian origin to be considered is the Moscow Papyrus, which was only published in full by Prof. Struve a few months ago.[6] It is of the Middle Kingdom and thus older than the others. It contains the determination of the volume of a truncated pyramid and the area of a hemisphere.[7] Both are correct, the latter on the basis of the Egyptian value for π as 3·16. It yet remains to be seen whether these determinations are based on general formulæ—as is believed to be the case by Prof. Struve—or whether they are empirically obtained. If the former, it will be necessary to rewrite the history of ancient science and with it much of ancient philosophy.

The rationalisation of the Greek intellect within a very few centuries has always appeared something of a miracle—an epiphany. On the other hand, an ancient and slowly disintegrating scientific tradition in Egypt or in the Near East would fit in well with what we know of the early history of Greek science. Whether such traditions existed is a question of fact which can only be solved by the Egyptologists or Assyriologists. In the meantime, the Rhind, the Edwin Smith, and the Moscow Papyri have made such a view less fantastic than would have appeared to be the case ten years ago.

[1] The more important works of the "Hippocratic Collection" are being edited by Mr. W. H. S. Jones and Dr. E. T. Withington for the Loeb Library. For a complete critical version we still depend on Emil Littré's "Œuvres complètes d'Hippocrate" in 10 volumes (Paris, 1839–61).

[2] C. N. Cochrane, "Thucydides and the Science of History" (Oxford University Press, 1929).

[3] An excellent summary of Greek mathematics has recently been prepared by Sir T. L. Heath, "A Manual of Greek Mathematics" (Oxford: The Clarendon Press, 1931).

[4] J. H. Breasted, "The Edwin Smith Surgical Papyrus", 2 vols. (University of Chicago Press, 1931).

[5] T. E. Peet, "The Rhind Mathematical Papyrus" (Liverpool, 1923). Another edition was produced for the Mathematical Association of America, 1927–29, by A. B. Chace, L. S. Bull, and H. P. Manning, with a bibliography of Egyptian and Babylonian Mathematics by R. C. Archibald.

[6] W. W. Struve, "Mathematischer Papyrus des Staatlichen Museums der schönen Künsten in Moskau" (Quellen und Studien zur Geschichte der Mathematik: Abt. A, Quellenband 1), Berlin, 1930.

[7] The Moscow Papyrus is discussed by Battiscombe Gunn and T. Eric Peet, "Four Geometrical Problems from the Moscow Mathematical Papyrus", *Journal of Egyptian Archæology*, 15, p. 167, Nov. 1929; and Kurt Vogel, "The Truncated Pyramid in Egyptian Mathematics", *Journal of Egyptian Archæology*, 16, p. 242, Nov. 1930. The work of Struve is critically reviewed by T. E. Peet in the *Journal of Egyptian Archæology*, 17, p. 154, May 1931.

Population Problems.

The second general assembly of the International Union for the Scientific Investigation of Population Problems met in the rooms of the Royal Society of Arts on Monday, June 15, the chair being taken by the president, Prof. Raymond Pearl. Delegates of ten nationalities were present.

During the opening session the president reviewed the work of the Union during the three years of its existence, and claimed, with reason, that the progress made could be regarded as gratifying. Fourteen countries already have National Committees, which function with varying degrees of intensity, whilst in still other countries (Czechoslovakia, Greece, Poland) National Committees are in process of organisation. There are three International Research Commissions receiving funds from the Union and dealing respectively with population and food supply, differential fertility, and the vital statistics of primitive races. In addition, grants have been made to many individuals for investigations which fall outside the scope of these Commissions. Sixty-four per cent

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By Dr. Charles Singer.

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It therefore behoves the historian of science to be very charitable, very forbearing, in all his judgments and presentations. He must not ask too much of previous ages, nor must he judge them by the standards of his own. He needs constantly to recall that he is dealing with work of erring and imperfect human beings, each of whom had, like himself, only a very partial view of truth. There is an unquenchable and irresistible tendency innate in the human mind to erect general laws or rules in explanation of the happenings of the world. That tendency is no less present in the historian of science than in the great minds whose work he records, and if he is to be judged at all by posterity, he can but echo the epitaph:

> Reader, thou that passest by,
> As thou art so once was I;
> As I am, so shalt thou be,
> Wherefore, reader, pray for me.

Time, still, like an ever-rolling stream, bears all its sons away. It is the stream itself and the spirit that dwells therein that the historian of science has to study.

Science, then, is a process that can be followed through the ages; it is not a mere passive body of knowledge. The sheer validity and success of the scientific process, as applied in our own time in western Europe and America, has given rise to popular misunderstanding as to the nature of science, and some misapplication of such terms as 'science' and 'scientific'. We hear of the *science* of some prize-fighter, and a book has been published on the "Science of the Sacraments". There is nothing in the laws of this or any other country which forbids its citizens from giving the words of their language such significance as they may choose, but the word *science* as employed in these connotations has no clear link with the great progressive method of acquiring knowledge with which the historian of science has to deal. The very form of the adjective from science might itself give pause to those who would force the word to cover such topics as the skill of the prize-fighter or a knowledge of the theory and practice of religious rites. The word *scientific* means, derivationally, *knowledge making*, and no body of doctrine which is not being progressively *made* can for long retain scientific attributes.

During the last two generations the evolutionary conception of Nature has become so general that it now pervades our thoughts on every aspect of living activity, nor can we understand an organic product until we know how it came to be what it is. Now, the efforts of the human mind are essentially such products. It has thus become generally recognised that to comprehend, for example, the constitution of a State or the teaching of a religion it is absolutely necessary to know its past. This is the true reaction of evolutionary doctrine on the study of history.

On the study of science itself, however, this reaction of evolutionary doctrine has been less generally recognised. Why this should be is perhaps not altogether clear. One reason may be that the triumphant and absorbing successes of the application of the scientific method have deflected attention from the process itself. Another reason, which is perhaps but a restatement of the former, is that the very rapid growth of the products of the scientific process in quite modern times has turned men's thoughts away from its more ancient achievements. Yet it is clear that if we would understand the process itself, we must examine its application in the past and watch its action under conditions different from those in which we ourselves live. Only thus can we hope to attain any real insight into the nature of the process and of the effect it has had on man's estate throughout the ages.

Among the criticisms that can be made of any attempt to trace the history of science, there is one

* Inaugural address delivered to the Second International Congress of the History of Science and Technology, by the president, on June 29, at the Royal Geographical Society.

that should be met at the outset. It has been said that the history of scientific activity presents a field so vast that it cannot be compassed at first hand by any single mind. The criticism is without validity. If pressed, it would not only prevent the writing of the history of science, but would also prevent the writing both of history and of science. Who, of his own knowledge, can compass the history of even a single country? Who, of his own knowledge, can deal with the animal kingdom, with the science of geometry, or with the structure of the earth? Yet this has not prevented, and should not prevent, the writing of histories of England and of Europe, of works on zoology, of treatises on mathematics, or of text-books of geology. The scope of such books in reference to the first-hand knowledge of their writers must be effectively infinite. The difficulty in writing them—as in reading them—is the difficulty in getting a philosophical grasp of the principles involved. In obtaining such grasp, first-hand knowledge is of primary importance. Yet this knowledge, applied in such a field, is but a means to an end, and the writer must be judged by his grasp of the principles he sets forth, rather than by the actual number of experiments he has made or experiences that he has undergone.

But to return to our question as to when science began. The question can as little be answered as the question, When does a man begin to grow old? "Before that I to be begun, I did begin to be undone." Anthropologists have detected germs of the scientific process in the lowest and rudest races of mankind. As soon as a child begins to observe, he begins to make generalisations. The savage sees the action of a living thing in the wind and the flow of the water. He generalises from his imperfect observation that movement means life. The baby calls every male "daddy"; his, too, is an elementary generalisation based on imperfect experience. Both ascriptions are imperfect attempts at deducing laws.

Here, however, we encounter a real gap in the historical narrative. We can see the scientific element in the baby's generalisation or in the savage's belief. Yet we cannot, with any confidence, trace them forward in a continuous stream to anything that we should call science in the current use of that term. How far, then, can we trace the matter the other way, ascending the stream of time? In this attempt the last decade has been particularly fruitful, and I shall venture to devote the remainder of my remarks to the special nature of this recent historical achievement. As is too often the case on the scientific front, the pioneers are more concerned with their own progress than with the relation of their advances to those of others. The onlooker truly sees most of the game, and perhaps it is not going too far to say that the game cannot be clearly seen except by the onlooker. This is the justification of the professed historian of science. Without him research in one department would rapidly lose touch with research in other departments. This is so with recent scientific history. Let us seek in the same spirit among the records of a far earlier scientific history.

As we trace the records of science back into the mists that shroud the dawn of history, we see its varied disciplines dwindling to two, namely, to medicine and mathematics. So far as complete works are concerned, the earliest of all scientific treatises that have come down to us are in the medical class. They are contained in the miscellaneous group of tracts known as the "Hippocratic Collection".

The "Hippocratic Collection" takes its name from the alleged 'father of medicine'. In a less critical age this mass of writings was all ascribed to Hippocrates, and there are some who still find it difficult to abandon the old paths. Nevertheless, there is no evidence, worthy of the name, that any part of any of these works was written by Hippocrates, nor indeed is there any real evidence that Hippocrates wrote anything. It is, however, certain that some works in the "Hippocratic Collection" were composed in the fifth century B.C., at which period their eponymous author was born. Sections of some of them may well date back to the sixth, and portions of them even to the seventh century. Moreover, it has long been recognised that these medical writings were an integral part of a far wider and more deeply based contemporary rational movement in philosophy.[1]

It has indeed been argued that the relations between the medical and historical writings of ancient Greece are closely paralleled by the relations between the evolutionary and historical writings of a generation or two ago. We might put it that Hippocrates was to Thucydides as Darwin was to Buckle or Lecky. A good case for the comparison has been made recently by Prof. Cochrane of Toronto.[2]

However this may be, it is evident that behind these earliest surviving scientific monuments of the fifth, sixth, and seventh pre-Christian centuries there must be a scientific tradition that was already ancient when the Greek world was still young. Of this more ancient rational tradition the mathematical fragments have been more successfully pieced together than the medical.[3] Thus we have details of the achievements of the followers of Pythagoras, and perhaps of Pythagoras himself, whose life occupied the greater part of the sixth century. Moreover, Thales, the sage of Miletus, of whose scientific achievements there can be no doubt, takes us yet further back and into the seventh century. He takes us, too, beyond Greece, for his mother was a Phœnician. He himself had travelled in Egypt. Phœnicia suggests contact with Mesopotamia and the ancient Sumerian civilisation. Recent discoveries in that region, notably those that deal with the treatment of metals, suggest a command of natural forces which demanded theoretical scientific knowledge. Yet it is to Egypt that the Greeks commonly ascribed the origin of their medical and mathematical knowledge.

Among the Greeks before Thales and the seventh century, our view of the rational spirit grows very dim. In the "Works and Days" of Hesiod, written in

ighth century B.C., we get some astronomical
Such knowledge, however, must have been non property in the Near East, and indeed ery early agricultural community. In the nce of an adequate calendar, some astronomical ledge is necessary for the elementary opera- in the field. Hesiod, it is true, has something r beyond farmers' astronomy, but in him we the independent scientific element at a well- irreducible minimum.

n we, then, trace the rational tradition among Greeks behind Hesiod and the eighth century? ink we can. In the Iliad of Homer we obtain pses, distant, it is true, of an independent nal medical system. The Iliad tells of a great of fighting, in the course of which no less than wounds are well described, and in many cases r treatment detailed. Now this treatment is ys on entirely rational grounds, and magical ents are conspicuous by their absence. This many other hints in the Iliad imply the prac- of scientific medicine by recognised practi- ers, without relation to folk-medicine. Thus, the aid of the Iliad, we may trace the scientific ition among the Greeks as far back as the ninth enth century. It is noteworthy that in the yssey the origin of medicines is ascribed to Egypt. n view of the consensus among the Greeks as to r debt to Egypt, all traces of the scientific spirit ealed in the Egyptian papyri are of peculiar rest. Yet the finds have been, till recently, raordinarily disappointing, and the contrast ween Greek science and Egyptian science is atly to the disadvantage of Egypt. For the in- iority of the Egyptian position as against the ek, due weight has not always been given to ferences in the records of the two civilisations.

First, we have to remember that the picture that form of Greek thought is derived from the rary remains of the Greek people. That there ve been irreparable losses to that literature is e, but the surviving part has come down to our e because it was read by the generations that me between the Greeks and ourselves, and it was d because, by each succeeding age, it was thought be worth reading. Greek literature, as we have is thus, in essence, a selection. It is far other- e with the Egyptian records. We have here erely what time has spared, and that old reaper s no more discretion with books than he has ith the lives of men. He spares what he will d as he will. What kind of literature should we pe to recover from the wreck of our own civilisa- on? Daily journalism and trade advertisements cupy many times more bulk, and therefore would ve a better chance of survival, than the works the philosophers and men of science.

Secondly, the remnants that have come down us from ancient Egypt have mostly been re- vered from tombs. They were the kind of things at the men of their day thought suitable to bury ith their dead. The commonest of all are, in fact, lls of the "Book of the Dead". If we had to ompare them with something in our own civilisa- ion, they would perhaps correspond to the inscriptions on tombstones, to hymn-books, and to prayers for special occasions. It is true that we have an admixture of other documents, but the proportional distribution of surviving Egyptian writings bears no relation to the proportional distribution of Egyptian interests.

Thirdly, it must be remembered that much surviving Greek literature is from the most vital period of Greek history. On the other hand, the overwhelming mass of Egyptian papyri are from the New or Middle Kingdom, whereas the Old Kingdom was the day of Egyptian power. The later scribes were content with copying earlier material. These later scribes were, moreover, commonly careless and not uncommonly incompetent, and, as it falls out, this was especially the case for the papyri that bear on scientific topics.

Bearing in mind these contrasts in the circumstances of Egyptian and Greek documents, let us turn to the surviving papyri of scientific content. These, like the earliest Greek scientific material, divide naturally into the medical and the mathematical. A number of documents fall into each of the two categories, but most of them are so debased or so trivial that we miss little if we take only the principal specimens. Of these there are two in each class that are of primary importance. In the medical class there is the long known Ebers Papyrus and the recently described Edwin Smith Papyrus. In the mathematical class there is the Rhind Papyrus and the very recently described Moscow Papyrus. These four contain practically all that is known of Egyptian medicine—other than that of a purely magical character—and most that is known of Egyptian mathematics.

The Papyrus Ebers, known for seventy years, is still not completely intelligible. It presents many linguistic difficulties, chief among them being the names of drugs. It is of the New Kingdom, and is generally dated as of the sixteenth century B.C. It is in the main a collection of remedies for various named conditions which are sometimes briefly described. Its general intellectual level is about comparable to an English family receipt book of the seventeenth century, of which several have been published. There is no definite physiological, pathological, or pharmaceutical theory, but there is also little that one can call superstition. The book is taken up with a list of traditional treatments of a more or less disgusting character. That sections are taken from a much older work is evident from a few isolated paragraphs in it that are devoted to anatomy. These are so confused as to be unintelligible, but it is obvious that the scribe is trying to abstract an older and more scientific document.

During the last few months Prof. Breasted, of Chicago, has presented us with his edition of an Egyptian medical document of a somewhat different order.[4] The Edwin Smith Papyrus has had a romantic history, having been originally discovered about the same time, and perhaps in the same tomb, as the Ebers. A series of remarkable circumstances left it in private libraries and unknown to scholars until a few years ago.

In general form the Edwin Smith Papyrus is not unlike the Ebers, in date somewhat similar or a little earlier, and its scribe no less careless and incompetent. He was, however, engaged in copying a document of greater scientific value, and probably of greater antiquity than that which was occupying the scribe of the Ebers Papyrus, for there can be little doubt that the original source of the Edwin Smith Papyrus was of the Old Empire. Moreover, the Edwin Smith Papyrus deals with surgical conditions, and especially injuries, while the Ebers is occupied with diseases. Injuries and their treatment lend themselves to clearer descriptions than do the diseases. We thus have in the Edwin Smith Papyrus a document of high value for comparison with certain works of the "Hippocratic Collection" of about twelve centuries later. Without discussion of details it may be said that through the mist of scribal ignorance and misunderstanding we can see in the Edwin Smith Papyrus an author who not only recorded actual case histories, but was seized at times of the spirit of science; that is to say, he records in order to learn something of the workings of the body as distinct from any attempt to treat his patient. Some of his observations, such as that injuries to the brain on one side result in paralysis of the other side of the body, are repeated in the "Hippocratic Collection", and do, in fact, throw light on the nature of physiological mechanism. The Edwin Smith Papyrus—or at least that part of it which survives—is devoted to injuries about the head. It gives us a glimpse—alas! that it should be so dim—of a lost and more ancient scientific literature to which such magnificent treatises as the "Wounds of the Head" and "Fractures and Dislocations" of the "Hippocratic Collection" may well have been related.

For Egyptian mathematics the most important document is the Rhind Papyrus, which was finely edited a few years ago by Prof. T. E. Peet, of Liverpool.[5] Its age is about that of the Edwin Smith Papyrus, though it is copied from an original of the nineteenth century B.C. It professes to be a 'guide for calculation'. Apart from simple rules for giving the areas of figures enclosed by right lines, we have the measure of a circle from which an estimate of π as 3·16 can be deduced, and a calculation with reference to the proportions of pyramids. In this last a certain relation which, as the Papyrus says, "makes the nature of the figure", is deduced from the side of the square base and vertical height or *per-em-us* as the Papyrus calls it. The word *per-em-us* is doubtless the source of the Greek word *pyramis* and our *pyramid*. The problem clearly links up with the mathematical triumph of Thales in deducing the height of a pyramid from its shadow.

The last scientific document of Egyptian origin to be considered is the Moscow Papyrus, which was only published in full by Prof. Struve a few months ago.[6] It is of the Middle Kingdom and thus older than the others. It contains the determination of the volume of a truncated pyramid and the area of a hemisphere.[7] Both are correct, the latter on the basis of the Egyptian value for π as 3·16. It yet remains to be seen whether these determinations are based on general formulæ—as is believed to be the case by Prof. Struve—or whether they are empirically obtained. If the former, it will be necessary to rewrite the history of ancient science and with it much of ancient philosophy. The rationalisation of the Greek intellect within a very few centuries has always appeared something of a miracle—an epiphany. On the other hand, an ancient and slowly disintegrating scientific tradition in Egypt or in the Near East would fit in well with what we know of the early history of Greek science. Whether such traditions existed is a question of fact which can only be solved by the Egyptologists or Assyriologists. In the meantime, the Rhind, the Edwin Smith, and the Moscow Papyri have made such a view less fantastic than would have appeared to be the case ten years ago.

[1] The more important works of the "Hippocratic Collection" are being edited by Mr. W. H. S. Jones and Dr. E. T. Withington for the Loeb Library. For a complete critical version we still depend on Emil Littré's "Œuvres complètes d'Hippocrate" in 10 volumes (Paris, 1839–61).

[2] C. N. Cochrane, "Thucydides and the Science of History" (Oxford University Press, 1929).

[3] An excellent summary of Greek mathematics has recently been prepared by Sir T. L. Heath, "A Manual of Greek Mathematics" (Oxford: The Clarendon Press, 1931).

[4] J. H. Breasted, "The Edwin Smith Surgical Papyrus", 2 vols. (University of Chicago Press, 1931).

[5] T. E. Peet, "The Rhind Mathematical Papyrus" (Liverpool, 1923). Another edition was produced for the Mathematical Association of America, 1927–29, by A. B. Chace, L. S. Bull, and H. P. Manning, with a bibliography of Egyptian and Babylonian Mathematics by R. C. Archibald.

[6] W. W. Struve, "Mathematischer Papyrus des Staatlichen Museums der schönen Künsten in Moskau" (Quellen und Studien zur Geschichte der Mathematik; Abt. A, Quellenband 1), Berlin, 1930.

[7] The Moscow Papyrus is discussed by Battiscombe Gunn and T. Eric Peet, "Four Geometrical Problems from the Moscow Mathematical Papyrus", *Journal of Egyptian Archæology*, 15, p. 167, Nov. 1929; and Kurt Vogel, "The Truncated Pyramid in Egyptian Mathematics", *Journal of Egyptian Archæology*, 16, p. 242, Nov. 1930. The work of Struve is critically reviewed by T. E. Peet in the *Journal of Egyptian Archæology*, 17, p. 154, May 1931.

Population Problems.

THE second general assembly of the International Union for the Scientific Investigation of Population Problems met in the rooms of the Royal Society of Arts on Monday, June 15, the chair being taken by the president, Prof. Raymond Pearl. Delegates of ten nationalities were present.

During the opening session the president reviewed the work of the Union during the three years of its existence, and claimed, with reason, that the progress made could be regarded as gratifying. Fourteen countries already have National Committees, which function with varying degrees of intensity, whilst in still other countries (Czechoslovakia, Greece, Poland) National Committees are in process of organisation. There are three International Research Commissions receiving funds from the Union and dealing respectively with population and food supply, differential fertility, and the vital statistics of primitive races. In addition, grants have been made to many individuals for investigations which fall outside the scope of these Commissions. Sixty-four per cent

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high temperature on the properties of the insulating material. The object of the investigation is to determine the current carrying capacity of standard cables of various types and sizes under different conditions of laying, both for alternating and direct current.

For work in connexion with the testing of fuses, the laboratory facilities have been extended to cover the latest specification of the British Engineering Standards Association for domestic fuses up to 250 volts and 100 amperes. The specification requires that the tests be made at 260 volts and at suitable short circuit currents up to a maximum of 6500 amperes. With the new equipment, the short circuit is made from a distance by means of a solenoid controlled switch, the cut-out being observed through a wired glass panel in the door of the test enclosure. An auxiliary circuit incorporating a neon lamp indicates whether iron-clad cut-outs show any tendency to arc to their cases.

In the Wireless Division a new type of dynatron oscillator has been developed by the use of the negative resistance characteristic of the screen grid valve. By coupling the anode to the control grid through a small capacity and including a resistance of the order of a megohm in the filament-control grid circuit, higher frequencies than are possible with normal dynatron circuits have been obtained. The exhibit shown can be used for the generation of oscillations of wave-length as small as 6 metres.

The same principle can be applied to the problem of selective amplification. With the usual triode valve the presence of the positive shunt resistance of the valve decreases the selectivity of the tuning circuit through damping. If the negative resistance characteristic of the screen grid valve be utilised, the selectivity of the amplifying stage can be made greater than that of the tuned circuit alone. A demonstration of this was given by means of a circuit incorporating a valve of this type.

The investigation on behalf of the Radio Research Board in connexion with the development of transmitting and receiving apparatus for very short wave-lengths has been continued, and equipment capable of transmitting and receiving oscillations of wave-length as small as 1·5 metres was shown. The apparatus has been used for the study of the propagation characteristics of very short waves.

The apparatus for testing the performance characteristics of wireless receivers has now been extended to cover the shortest wave-lengths in commercial use. Improved apparatus has been installed capable of carrying out comprehensive tests at wave-lengths from 7 metres to 2000 metres. The tests comprise over-all sensitivity, radio-frequency, selectivity, and fidelity in the reproduction of radio-frequencies. The last-named test is carried out by the use of an input modulation free from harmonics. Any harmonics present in the output constitute a measure of the distortion produced.

In the High Voltage Building, equipment for the measurement of the dielectric loss of high voltage porcelain insulators was exhibited. Demonstrations were given of flashover tests to determine the maximum voltage withstood by a 132-kilovolt porcelain insulator string.

In the Photometry Division an investigation was in progress in connexion with the light-diffusing properties of diffusing glassware. These properties are governed by the size and concentration of the particles, and apparatus has been developed in the division for the measurement of these two quantities by the use of a powerful microscope. Half-silvered interferometer plates are fitted to the fixed and movable stages of this instrument, enabling the movement of the latter to be obtained directly in terms of light wave-lengths. The diameter of a particle can be determined by observation of the interference fringe system, as the particle is made to traverse a fixed cross wire, or alternatively by attaching the cross wire to a travelling microscope, the scale of which can be calibrated by means of the interferometer. To determine the concentration, the field is limited by an aperture of known diameter. The microscope is focused through the particles by a slow-motion device, the distance traversed being measured by a second interferometer.

The fundamental work on glare has been extended to cover the glare effect of coloured light sources with white and coloured backgrounds. Practical application has also been made of the results already obtained with normal light sources by the design of an instrument for the determination of the glare effect due to an actual lighting system. Two measurements of the brightness difference threshold, one with the glare sources exposed to the observer's eyes, and the other with the glare sources screened, give a ratio which is a measure of the glare effect.

In the William Froude Laboratory a model of a single-screw vessel was being tested to compare its behaviour in shoal and deep water. There are reasons for supposing that there is a scale effect leading to differences between the model and the full-sized ship. The model under test was equipped with its own inboard motor and propeller and apparatus for determining its resistance through the water. A model twin-screw vessel fitted with its own propelling and recording gear and utilised for research work on the backing qualities of propellers was exhibited. The tests are designed to show the thrust capacities of propellers of various shapes and diameters to destroy and reverse the motion of the model.

The International Congress of the History of Science and Technology.

THE Second International Congress of the History of Science and Technology, which assembled in London on June 29–July 4, has achieved a notable success, thanks to the untiring efforts of its distinguished president, Dr. Charles Singer, and the executive committee, and thanks also to the active interest it has aroused among scientific workers and historians throughout the world. The Congress, which was really the first of its kind, originated with the Comité International d'Histoire des Sciences, which was founded at Oslo on Aug. 17, 1928. It has, however, been fortunate in enlisting the co-operation of the Comité International des Sciences Historiques, of the American History of Science Society, and the Newcomen Society for the Study of the History of Engineering and Technology, of London. It has thus been possible to show, in its widest extent, the important part played by the sciences in historical and technical research. The papers and discussions of the Congress, and the large attendance of official representatives, who came not only from most of the universities of Great Britain and the Empire, but also from the Continent, North and South America, Asia, and Africa, bear witness to this fact.

At the inaugural session of the Congress, which was opened by the President of the Board of Education, the Right Hon. H. B. Lees-Smith, M.P., in the Great Hall of the Royal Geographical Society, Dr. C. Singer read some paragraphs of his inspiring presidential address on "The Beginnings of Science", which was published in full in NATURE of July 4. He emphasised the dynamic rôle of science, which is best illustrated by its history, and pleaded for the introduction into school-teaching of the broad lines of scientific history.

The work of the Congress itself was divided into four main sections, which met most fittingly in the lecture hall of the Science Museum. The first section, with Prof. G. Loria (Genoa) as chairman, dealt with "The Sciences as an Integral Part of General Historical Study". In his opening paper, Prof. G. N. Clark (Oxford) showed the complexity of the relations between the history of science and general history, and claimed that science has more truly a history than have other human activities, owing to the fact that the history of science is distinguished by more definite achievements and a more orderly development. This point was further emphasised by Sir William Dampier-Whetham (Cambridge), who proposed that the teaching of history should follow the natural order of its development, moving onward from primitive emotions to law, economics, and science. In support of these views, Dr. T. Greenwood (London) maintained in his paper that even the development of mathematics is a necessary constituent of both philosophy and technology, and illustrated the point that a critical history of mathematics should help in getting a deeper knowledge of the various philosophical systems which, in turn, provide the fundamental causes of the periodical and progressive changes in the mental and material outlook of the human race. Some stimulating remarks were made in this connexion by Prof. A. V. Hill (London), who submitted that if history is to deal with human greatness, with things which have given man control of himself and his surroundings, that have relieved him of superstition, ignorance, ill-health, and incompetence in the face of natural forces, then the great figures of science and their discoveries deserve a more worthy place even in children's history-books. For after all, the forces that move us are forces of our own making, which cannot be of less importance than the results they produce.

To this individualistic interpretation of history and to the paramountcy of the history of science, the representatives of the U.S.S.R. took exception, and proposed instead a communistic explanation of scientific development, in which the integrative work of the masses is exalted at the expense of the glorification of genius. Prof. B. Zawadovsky (Moscow), for example, does not conceive history as the history of personality, but rather as the process of development of mankind conforming to certain laws, as a social whole in all the multiformity of its class structure. From this angle, the history of science begins only from the moment when we discern the particular conditions of material culture and the economic requirements of production which determine the direction of the interests of the scientific workers concerned, and the readiness of society to utilise their discoveries. In seconding this opinion, Prof. E. Colman (Moscow) was able to illustrate the influence of the spiritual atmosphere of his time on Darwin himself by means of a letter written by the great naturalist to Karl Marx, in which Darwin admits having refrained from writing on religion in order to avoid surprising his contemporaries and his relatives, although he was all the same an advocate of free thought on all subjects. Prof. M. Rubenstein (Moscow) shared the views of his colleagues, suggesting that history has not been made by great men, but by the economic and social forces of which they have been the expression. It might be said here that the attitude of the Soviet delegates can scarcely explain any history, however stimulating their message and their endeavours to put it into practice in their own educational institutions.

The second section of the Congress, with Prof. W. H. Welch (United States) in the chair, discussed the important problem of "The Teaching of the History of Science". M. Aldo Mieli, the active permanent secretary of the Comité International d'Histoire des Sciences and editor of *Archeion*, told the Congress how this body is directing an inquiry into the teaching of scientific history, which will be completed in time for the Congress of History to be held at Warsaw in 1933. Going into the heart of the debate, Prof. A. E. Heath (Swansea) tried to show that our social and cultural disharmonies are largely due to our failure to acclimatise ourselves to modern cosmologies; and proposed, as a solution of this difficulty, the creation of a scientific history more in accord with the facts of the modern world. On the other hand, in advocating the development of special courses in the history of science in secondary schools and colleges, Prof. F. S. Marvin (University of Cairo) outlined, in his paper, the advantages to be gained by introducing the historical side into scientific work: such a method would present science as a growing thing; it would show the link with the other aspects of our knowledge; it would present the mass of scientific facts in a more human form; and finally it would illustrate the collective work of the human mind, building up an increasingly coherent framework of the universe. One may add, too, that the history of science can suggest new lines of research, and thus lead to unexpected discoveries.

Prof. A. Wolf (London) outlined the teaching of the history of science in the University of London, which owes so much to his own efforts, pointing out as one of the difficulties of the organisation of such courses the existing hostility towards new subjects, which are wrongly imagined by many to be side lines to something else. Prof. P. Diepgen (Berlin), Prof. H. Dannemann (Bonn), Prof. Q. Vetter (Prague), Prof. M. Stephanides (Athens), and Prof. D. E. Smith (United States) gave some interesting details about the teaching of the history of science in their respective countries; while Prof. Laignel-Lavastine, the new holder of the chair of the History of Medicine in the University of Paris, expressed the feeling of the whole Congress when he urged the necessity of university chairs of the history of science in the principal universities of the world.

The third section of the Congress was devoted to the "Historical and Contemporary Inter-relationship of the Physical and Biological Sciences", and was presided over by Prof. W. Ritter (United States). It developed into a lively debate between 'organicists', represented by Prof. J. S. Haldane, Prof. D'Arcy Thompson, Dr. E. S. Russell, and Mr. L. L. Whyte, and the 'mechanists', represented by Dr. J. Needham, Dr. J. H. Woodger, Prof. L. Hogben, and Prof. Baas-Becking (Holland). The case for organicism was put forward forcibly by Prof. J. S. Haldane (Oxford), who claimed the independence of biology from physics, while admitting that the advances of physics during the present century have made it much easier to realise the true relations between these sciences. The discovery that atoms are not mere inert elastic bodies but centres of intense specific and persistent internal activity, and that on this internal activity their physical and chemical properties depend, has upset the physical conceptions which we inherited from Galileo and Newton. Atoms seem now as if they had properties similar to those which the vitalists attributed to living organisms. Yet, on the other hand,

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biology deals with parts and events which are manifestations of the co-ordinated whole which we call the life of the organism. Hence, it looks as if, while we shall retain the old physical and mathematical conceptions for practical purposes, the more fundamental physical and mathematical conceptions are assuming characters similar to those of biology. This fundamental attitude was further explained by Mr. L. L. Whyte, who showed how the study of the structure of material bodies and of radiation is beginning to influence biology. The adequate description of ordered structures, which was impossible by classical methods, is now expressed by 'quantum conditions' which refer to systems as a whole, each part having in it definite positions and motions. Thus the conflict between the analytical methods of classical physics and the organic concepts of biology is thinned down to such a point that it may be hoped to see the study of biology leading ultimately to the discovery of exact biological laws defining the structural characteristics of living systems.

Dr. Needham's cry for an increase in the use of the style of physics in biology, and Dr. Russell's slogan, 'Back to Aristotle', alike strengthened the resistance of the mechanists, who, like Prof. L. Hogben (London), emphasise that there was never a time when biologists entertained more confidence in the usefulness of classical physico-chemical methods as instruments for arriving at predictable conclusions about how organisms behave. The ecclesiastical origins of modern culture and the contemporary social unrest were quoted as causes for the public distrust of the mechanist conception of life, at a time when the materialistic tradition appears to be entrenched in the laboratory more strongly than ever before. Dr. J. H. Woodger (London) went a step further by proposing to apply to the study of biological questions, not only physical methods, but also an appropriate notation of mathematical logic derived from the method of Russell and Whitehead. He was thus led to predict a gradual displacement of the notion of 'stuff' by that of 'system'; so that the notion of 'protoplasm' or 'living matter' would have to go the way of 'hereditary substance', when the scientific worker will learn to think of cells more in term of systems, and less in terms of stuff. A mechanist conception of biology seemed to linger also in the mind of Prof. A. Joffe (Moscow), though he admitted that physicists have to use biological methods for the finest measurements. He quoted the experiments of Prof. Gurtwitsch, who claims to have discovered 'biological rays', in support of the closer relationship between physics and biology, which will lead in time, he hoped, to the disappearance of the 'mysterious' vitalistic conceptions.

The fourth section of the Congress, presided over by Sir Henry Lyons, Director of the Science Museum, dealt with "The Interdependence of Pure and Applied Science". Sir Napier Shaw, Prof. C. H. Desch, Prof. F. G. Donnan, Dr. G. Windred, Mr. R. V. Vernon, Dr. Marie Stopes, and Prof. W. Mitkewich illustrated the various aspects of the problem, and seemed to agree that a study of scientific history makes it evident that there can be no independence between pure research and experiment on one hand, and the practical application of scientific principles on the other hand. Further, it appears that the present tendency of intense specialisation makes the progress of science more than ever dependent upon the co-ordination of pure and applied science.

At a meeting of the Committee on July 5, the following were elected members of the International Council for the period 1931–34: Prof. Karl Sudhoff, of Leipzig (*President*); Prof. Gino Loria (Genoa), Dr. Charles Singer (London), Prof. Paul Diepgen (Berlin), Prof. Julian Ribera (Madrid), Prof. George Sarton (Harvard); Mme. Hélène Metzger, of Paris (*Treasurer*), and M. Aldo Mieli, of Paris (*Secretary*). The next Congress will be held in Berlin in 1934.

Such was the general trend of the labours of the Second International Congress of the History of Science and Technology. As Dr. Singer has long been claiming, the history of science can take its place not only among the departments of high scholarship, but also as an integral part of training and discipline in the general study of history. Science cannot assume her just position in education until the educator himself recognises the part that science has taken in shaping the social and intellectual environment in which we live. If the scientific process come to be recognised as a great part of our great inheritance, the Congress will have gone a good way towards achieving its objective.

THOMAS GREENWOOD.

The British Australian New Zealand Antarctic Research Expedition.

THE second cruise of the *Discovery*, under the title of the British Australian New Zealand Antarctic Research Expedition, ended on March 27 with the arrival of the ship and party at Melbourne. The health of Sir Douglas Mawson and his men has been excellent, and they have added greatly to our scientific knowledge of the Antarctic continent.

It has been definitely established that the coast-line is continuous through a great arc from Cape Adare to Enderby Land, which is nowhere far removed from the Antarctic Circle. New land totalling 16° of longitude has been discovered, and further detailed charting has been carried out of the 13° discovered on the first cruise last year. The field work extended through one-third of the circuit of the Antarctic region, beginning at the new 180th meridian and ranging west to long. 60° E. Additional features have been added to the coast lines of Adelie Land and Wilkes Land. It has been shown that there is no land in the latitudes assigned for North's Highland, Totten's Highland, or Budd's Land. The name Banzare Land (from the initials of the Expedition's title) has been given to a stretch of territory running from a well-defined cape near the juncture of the 66th parallel and the 127th meridian. It is proposed to maintain the title Sabrina Land for an area observed from the aeroplane between the 115th and 116th meridians at about the 66th parallel. At the end of Wilkes Land is an ice land about 1300 ft. high, which has been charted as Bowman Iceland, in honour of the Director of the American Geological Society. Princess Elizabeth Land is a newly discovered region commencing at the 80th meridian on the 76th parallel and extending south and west in a great sweep to Cape Amery. All the salient features of the MacRobertson Land coast have been charted and named. It is a most interesting region, diversified with mountains, peaks, and islands.

Apart from the geographical work, an immense mass of scientific data has been accumulated by the Expedition. Considerable delineation of the sea floor has been possible with an echo sounder, and many examinations of vertical marine stations were carried out. Daily nettings for marine life and

There is also a chapter on the modern functional-analytic way of looking at Fourier Analysis and its applications to prime number theory. He also uses Stieltje's integrals on occasion to analyze what is happening. The book is not an exhaustive survey on the thousands of papers that have been written on the zeta function and prime number theory but rather follows several lines of papers directly flowing from Riemann's work.

KARL MARX. MATHEMATISCHE MANUSKRIPTE. Edited, with an introduction and commentary, by Wolfgang Endemann. Kronberg Taunus, BRD (Spriptor Verlag). 1974. 178 p.

KARL MARX. MANOSCRITTI MATEMATICI. Translated and edited by Francesco Matarrese and Augusto Ponzio. Bari, Italy (Dedalo Libri). 1975. 184 p. 3,000 lire.

Reviewed by H. C. Kennedy
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At the burial of Karl Marx, 17 March 1883, Friedrich Engels noted that Marx had worked in many fields and "in each, even in that of mathematics, he made independent discoveries" (Marx/Engels, *Werke*, vol. 19, p. 336). That Engels singled out mathematics for special mention was no accident; Marx was often occupied with mathematics in his later years, although he never published his mathematical writings. Nor was Engels able to carry out the intention he expressed in 1885 of doing so. Then interest in this aspect of Marx' studies seems to have languished until 1933 when, on the occasion of the 50th anniversary of Marx' death, two brief articles, dating from 1881, dealing with "the concept of the derived function" and "the differential", along with some additional material, were published in Moscow in Russian translation. After that, perhaps the first outside the Soviet Union to call attention to the interest of Marx' ideas in mathematics was D. J. Struik ("Marx and Mathematics", *Science and Society* 1948, *12*, 181-196). Struik had access to the original German text of the Russian publication and gave English translations of several pertinent passages. But Marx' mathematical manuscripts were not published in their original German until the complete--some 1000 pages of manuscript are in the Institute of Marxism-Leninism--Moscow edition of 1968. This also includes a preface and other material by the editor, S. A. Yanovskaya, along with a Russian translation of all the manuscripts. The book is divided into two sections: the first contains the essentially original writings of Marx, including the two articles mentioned above. (Only these two were left by Marx in a complete state, and even then were not as such intended for publication). The second, larger section includes summaries of books Marx studied, excerpts from them along with his commentary, etc. The first volume under review here includes only the German text of the first section of the Moscow edition; the second volume is an Italian translation of the same German text.

When Marx left the Gymnasium in Trier in 1835 his graduation certificate included the statement: "He has a good knowledge of mathematics"--presumably a comment of his mathematics teacher, Johann Steininger (1792-1874). Nevertheless the next evidence of further occupation with mathematics came only in 1858. In a letter to Engels of 11 January, he wrote (Marx/Engels, *Werke*, vol. 29, p. 256): "In working out economic principles I have been so damned delayed by mistakes in computation that out of despair I have begun again a quick review of algebra. Arithmetic was always foreign to me. By the algebraic detour I am shooting rapidly ahead again."

By 1863 he was well into his study of calculus, writing Engels on 6 July (Marx/Engels, *Werke*, vol. 30, p. 362): "In my free time I do differential and integral calculus. Apropos! I have a surplus of books on it and will send you one, if you want to get hold of this subject."

The books Marx had were English and French textbooks of the period and were based on the work of 17th and 18th century mathematicians. He early worked his way through Sauri's *Cours complet de mathématiques* (Paris 1778) and then the 1827 English translation (*An elementary treatise on the differential and integral calculus*) of the widely read work by Jean-Louis Boucharlat (1775-1848). Among other books in Marx' library and used by him were texts by John Hind (1796-1866) and S. F. Lacroix (1765-1843). Marx was not current with the latest developments in mathematics on the Continent and seems to have been unaware of Cauchy's foundational work in the calculus. His original interest in mathematics was in its application to political economy, but he was soon drawn to the foundational questions of the calculus, since "here, as everwhere, it is important to tear off from science its veil of secrecy" (p. 130 of the German edition under review).

In the first article "On the concept of the derived function" Marx develops his concept of the derivative in a dialectical way. He begins with the differentiation of the simple function $y = ax$. If x increases to x_1, then y increases to y_1, so that $y_1 - y = a(x_1 - x)$. Now let x_1 go to x. Then the last equation becomes $0 = 0$. "First making the change and then removing it leads literally to *nothing*. The entire difficulty in understanding the differentiation operation (as in that of any *negation of the negation whatever*) lies precisely in seeing *how* it differs from such a simple procedure and therefore leads to true results" (p. 51). In this example the ratio of the differences is such that $(y_1 - y)/(x_1 - x) = a$ or $\Delta y/\Delta x = a$. Now letting x_1 go to x we have $0/0 = a$. Here, since all trace of the origin and significance of this expression has been erased, we substitute dy/dx, so that $dy/dx = a$. "The closely held consolatio of some rationalizing mathematicians, that *dy* and *dx* are in fact only infinitely small and [their ratio] only approaches *0/0*, is a chimera, as will more closely be shown in article II" (p. 53).

In the second article "On the differential", after discussing several examples, Marx concludes: "Wherever *dx* stands, its change of position leaves the ratio of *dy* to it untouched. Thus $dy = f'(x)dx$ appears to be another form of $dy/dx = f'(x)$ and is always replaceable by the latter" (p. 68). Further, the differential that arose from an algebraic operation may be taken as the independent starting point for further operations. Thus: "We have a double right to treat the differential $dy = f'(x)dx$ as a symbolic operational equation" (p. 69).

A. N. Kolmogorov comments (in "Matematika", *Bolshaya Sovetskaya Entsiklopediya*, 2nd ed., 1954, vol. 26, p. 478): "In an especially detailed way K. Marx worked through the question of the content of the concept of the differential. The concept proposed by him, of the differential as an 'operational symbol', anticipated an idea that was revived only in the 20th century, and his interpretation of the differential as the principal [linear] part of an increment completely corresponds to what is stated in modern textbooks and was absent from the texts studied by K. Marx (the works of mathematicians on the foundations of analysis, beginning with the work of the French mathematician A. Cauchy, remained unknown to K. Marx)."

K. A. Rybnikov further notes (in "Matematicheskie Rukopisi Marksa", *Bolshaya Sovetskaya Entsiklopediya*, 2nd ed., 1954, vol. 26, p. 497): "The concept of the differential as an operational symbol, first discovered by K. Marx, along with the distinction of the two concepts of the differential acquires, as the Soviet mathematician V. I. Glivenko has shown, a particular significance in the contemporary generalizations of the concept of the differential in functional analysis."

Marx was, of course, also interested in the historical development of the calculus, and he distinguished three periods: (1) the "mystical differential calculus" of Newton and Leibniz, (2) the "rational differential calculus" of Euler and D'Alembert, and (3) the "purely algebraic differential calculus" of Lagrange. In the first period he found no mathematical foundation for the operations of the calculus, referring to the suppression of higher order differentials, for example, as "sleight of hand", but he valued the historical significance of the new discoveries. He summed up the period: "Thus: they themselves believed in the mysterious character of the newly discovered calculus, that yielded true (and moreover, particularly in the geometrical application, astonishing) results by a positively false mathematical procedure. They were thus self-mystified, valued the new discovery all the higher, enraged the crowd of old orthodox mathematicians all the more, and thus called forth the cry of opposition, that even in the lay world has an echo and is necessary in

order to pave the way for something new" (p. 119).

In the "rational" period, D'Alembert is able to correct the procedure of the "mystics" so that, for example, "they are therefore now removed without sleight of hand" (p. 121), and thus: "D'Alembert had, by stripping off the mystical garb from the differential calculus, made an enormous progress" (p. 122). But Marx still found much that was superfluous in D'Alembert's procedure, since the differential coefficient was presented by the binomial theorem and "is found already as second term of the development in a series" (p. 123). Marx' advice to "throw out the useless baggage" (p. 123) was followed (or rather, anticipated) by Lagrange, who represents the "purely algebraic" period. The manuscripts in the volumes under review also include a consideration of Taylor's and Maclaurin's theorems.

The new German edition, while not quite the "deutsche Erstveröffentlichung" its cover claims, must be welcomed, since the 1968 Moscow edition is not readily available, but the unscholarly editing is regrettable. The main part of the book, the manuscripts of Marx, is photocopied from the Moscow edition, although this is not stated, and the German footnotes of the Soviet editor are simply left *as if they were* by the present editor. On the other hand he has erased all but three of the 98 references to notes in Russian. Of course the three remaining (on pages 53, 98, and 137) simply lead to Nowhere. He has added several notes of his own, but these are not nearly as helpful to the reader. In fact, the *content* of the notes in the Moscow edition seems to be entirely ignored. Is this merely because the present editor cannot read Russian? There is also added a sequence of numerals and right angles in the left margins of several pages. They have no obvious connection with the text and are nowhere explained.

This edition has its own 'introduction' and 'commentary'; the reader may safely skip them--indeed he is advised to do so. They contain much that is superfluous, irrelevant, and/or nonsense. For example (p. 158): "This rough form of argument, that Marx rather vaguely understands as a dialectical procedure, i.e. the transition of $f(x)$ through $F(x_1,x)$ to $F(x,x)$, has an amazing similarity to the diagonal process of Cantor, that is applied in set theory and logic in connection with the general foundational problems of mathematics."

A good introduction for the German reader would be the article "Karl Marx' 'Mathematische Manuskripte'" by S. A. Yanovsk: (*Sowjetwissenschaft. Gesellschaftswissenschaftliche Beiträge*, 1969, Heft 1, pages 20-35). This article is cited by our editor in his introduction, although he does not make clear that this is a German translation of the preface to the Moscow edition. Those who read Russian, but do not have access to the Moscow edition, could read the article by K. A. Rybnikov. (Rybnikov wrote his doctoral dissertation on the mathematical manuscripts of Marx.) Those who read English can do no better than read the excellent article by Struik. Finally, the list price of this slim paperback is 12.80 DM, but in an ironic confirmation of Marx' theory of capitalist exploitation, the price was raised almost as soon as the catalog listing it was published.

Translation is a difficult job, and translation of a work that was not intended for publication is doubly difficult. The Italian translation is very readable and the printing is good. I noted only a few mistakes: 'descrescenti' (p. 161) instead of the correct 'crescenti', 'contraibile' (p. 172), presumably a typographical error for 'contrattile', a reference (on. p. 84) to a blank page, and the somewhat garbled sentence (p. 138): "si credeva nel carattere misterioso del tipo di calcolo recentemente scoperto, che forniva risultati veri (e in tal modo specialmente anche risultati sorprendenti) nella applicazione geometrica con un procedimento matematico effettivamente errato." This should read: si credeva nel carattere misterioso del tipo di calcolo recentemente scoperto, che forniva risultati veri (e in tal modo specialmente nella applicazione geometrica anche risultati sorprendenti) con un procedimento matematico effettivamente errato. The proofreader was not a mathematician, however: fifteen equations have mistakes in them, and we see once again the danger of Newton's 'dot' notation. Already in the German text at least one dot has disappeared. In the Italian edition six more dots have disappeared, although two of these departed quantities come back in Leibnizian form (du, dz) to haunt page 114, where they have no connection with the text.

Each of the translator-editors wrote an introduction. The one by Matarrese is marked by vague generalities and inexact particulars. For example, after mentioning the calculation of the position and orbit of planets and comets, Matarrese continues (p. 13): "D. Harley (1656-1742) sulla base di questo tipo di calcoli stabilì che le comete apparse nel 1531, 1607 e 1628 facevano parte della stessa cometa e che nel 1679 sarebbe riapparsa: la previsione trovò una conferma nella realtà." Now, the date '1628' for the correct '1682' can be explained as a typesetter's error; 'D. Harley' for 'E. Harley' is a bit more difficult to explain; '1679' for '1758' is inexplicable. Ponzio's introduction, on the other hand, is much better and should help the reader in understanding the point of the mathematical manuscripts of Marx. That point was stated by Friedrich Engels in his *Anti-Dühring* (3rd ed., Foreign Languages Publishing House, Moscow 1962, p. 185): "Elementary mathematics, the mathematics of constant quantities, moves within the confines of formal logic, at any rate on the whole; the mathematics of variables, whose most important part is the infinitesimal calculus, is in essence nothing other than the application of dialectics to mathematical relations."

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KARL MARX AND THE FOUNDATIONS OF DIFFERENTIAL CALCULUS

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SUMMARIES

The publication of the mathematical manuscripts of Karl Marx, suggested by Engels in 1885, announced in 1932 and completed in 1968, brought new awareness of his many-sided talent. A sketch of the history is followed by discussion of Marx's concept of the derivative and the differential, and assessment of the originality and value of his achievement in this field.

Die von Engels im Jahre 1885 vorgeschlagene, in 1932 angekündigte und in 1968 vollendete Veröffentlichung der mathematischen Manuskripte von Karl Marx brachte ein tieferes Verständnis für seine vielseitigen Talente. Einer Skizze deren Geschichte folgt eine Erklärung seiner Ideen über den Begriff der Ableitung und des Differentials, sowie eine Würdigung der Originalität und des Wertes seiner Leistungen auf diesem Gebiet.

Публикация математических рукописей К. Маркса, предложенная Энгельсом еще в 1885 г., объявлянная к печати в 1932 г. и законченная в 1968 г., вызвала новое осознание многосторонности таланта Маркса. В докладе, кроме наброска истории этих рукописей, предлагается изложение понятий производной функции и дифференциала разработанные Марксом и оценка оригинальности его мысли и достижений в этой области.

I

In his preface to the 2nd edition (1885) of his *Anti-Dühring* Friedrich Engels expressed the desire to publish "the extremely important mathematical manuscripts left by Marx" [MEW 20, 13; Engels 1939, 17] [1] together with the results of his own research in science. This was not done, however, and so the "independent discoveries" of Marx, mentioned by Engels in the graveside ceremony at Highgate Cemetery [MEW 19, 336], remained unpublished for fifty years after Marx' death.

The existence of some 1000 pages of mathematical manuscripts of Marx in the Marx-Engels Institute in Moscow was announced in 1931 by E. Kolman at the International Congress of the History of Science and Technology, London [Kolman 1931]. An extensive excerpt from Marx' mathematical manuscripts was published in 1933 in Russian translation [Marx 1933] along with an analysis of it by S. A. Yanovskaya [1933]. This publication was announced at the International Congress of Mathematicians, Zürich 1932, by E. Kolman, one of the editors of the journal in which it appeared, although his sanguine prediction that "the complete mathematical writings of Marx, under the editorial direction of Professor Yanovskaya, will shortly [demnächst] appear in the works of the Marx-Engels-Lenin Institute (Moscow)" [Kolman 1932] did not come true until 1968 [Marx 1968]. That edition was, in fact, prepared under the direction of S. A. Yanovskaya, although she died two years before its final appearance.

During this period, interest in the mathematical writings of Marx was mainly confined to the Soviet Union, where, for example, an extensive monograph on the subject was published by L. P. Gokieli [Gokieli 1947]. Perhaps the first outside the Soviet Union to give an analysis of Marx' mathematical writings was D. J. Struik [1948]. He had access to the original German text of the Russian publication of 1933 and gave English translations of several pertinent passages [2].

In the 1950's work on the manuscripts continued under the direction of S. A. Yanovskaya, especially by K. A. Rybnikov, who investigated the mathematical sources at Marx' disposal. In addition to writing his doctoral dissertation on Marx' mathematics, Rybnikov also contributed an article on this subject to the 2nd edition of the Great Soviet Encyclopedia [Rybnikov 1954]. (This article has been omitted from the 3rd edition.)

But the manuscripts were not published in their original language--mainly German--until 1968, when the long awaited (nearly) complete text appeared along with a complete translation into Russian [Marx 1968]. This edition contained a preface that was immediately translated into German [Yanovskaya 1969] as well as numerous notes and commentaries. For the few articles that were in [Marx 1933] a new translation into Russian was made and the translation on the whole is, as far as I can tell, excellent,

although one egregious error should be pointed out. At one point Marx remarks that Boucharlat "wants some hocus pocus", which has been translated as "nuzhdaetsya v kakom-nibud fokuse" [wants some kind of focus]" [Marx 1968, 263]. To this the editor can only plaintively note: "The question of precisely what focus in Boucharlat Marx has in view here presents a certain difficulty" [Marx 1968, 617] [3].

With the publication of [Marx 1968] interest in Marx' mathematical writings spread more rapidly outside the Soviet Union. Already in 1969 an article on Marx' foundation of differential calculus appeared in the German Democratic Republic [Miller 1969]. (This article probably covers some of the same ground as mine. I have not seen it.) An Italian translation of the first article in [Marx 1968] appeared along with a commentary [Marx 1972 and Lombardo Radice 1972], and in 1974 the original German of the first part of [Marx 1968] was published in the Federal Republic of Germany [Marx 1974]. This part, headed "Differential calculus, its nature and history", contains the original and self-contained articles of Marx on the subject. The second, and longer, part is headed "Description of the mathematical manuscripts", a rather misleading title, since it consists mainly of actual writings of Marx and not a mere description of them. An Italian translation of 'Part One' appeared the following year [Marx 1975], prompting further discussion of Marx' mathematical writings (for example, [Bottazzini 1975].) An English translation of the mathematical writings of Marx is expected to be included in the *Collected Works of Marx and Engels* the publication of which began in 1975 and will include some fifty volumes.

II

Although Marx' Gymnasium certificate said that he had "a good knowledge of mathematics," there is no evidence of further occupation with mathematics for 23 years. Then Marx wrote Engels on 11 January 1858: "During the elaboration of the economic principles I have been so damed delayed by computational errors that out of despair I undertook again a quick scanning of the algebra. Arithmetic was always alien to me. Via the algebraic detour, however, I catch up quickly" [MEW 29, 256]. Marx' new interest in mathematics continued and he wrote Engels on 23 November 1860: "Writing articles is almost out of the question for me. The only activity by which I can keep the necessary quietness of mind is mathematics" [MEW 30, 113]. By 1863 he was well into his study of calculus, writing Engels on 6 July: "In my spare time I do differential and integral calculus. Apropos! I have plenty of books on it and I will send you one if you like to tackle that field. I consider it almost necessary for your military studies. It is also a much easier part of starting point the theorem of ... Taylor, which in fact is the most general, most comprehensive theorem and at the same time an operational formula of differential calculus, namely that which expresses y_1 or $f(x + h)$ by a development in a series with symbolic differential coefficients" [Marx 1968, 178]. Marx sees Lagrange as "furnishing the truly rational basis of differential calculus" [Marx 1968, 285]. He sums up his judgement of Lagrange's merit in two points:

"(1) The great merit of Lagrange is not only the founding of Taylor's Theorem and differential calculus in general by a purely algebraic analysis, but in particular to have introduced the concept of derived function that all those who have come after him have more or less used without mentioning it. But he was not content with this. He gives the purely algebraic development of all possible functions of $x + h$, in ascending whole positive powers of h and christens them with the names of differential calculus. All the ease and short cuts that differential calculus itself allows (Taylor's Theorem etc.) are thereby forfeited and very often replaced by operations of a much more lengthy and complicated nature.

"(2) So far as it is a question of pure analysis, Lagrange is in fact free of everything that appears to him as metaphysical transcendence in Newton's fluxions, Leibniz' infinitesimals of various orders, the limiting value theory of vanished quantities, the use of $0/0$ $(=dy/dx)$ as symbol for the differential coefficient, etc. This still does not hinder him, in the application of his theory and curves, etc., from constantly using one or the other of these 'metaphysical' notions" [Marx 1968, 202].

III

Marx was not in the mainstream of mathematics and to the end he seems to have been unaware of the advances being made by continental mathematicians in the foundations of differential calculus, including the work of Cauchy. The most mathematical of his acquaintances was Samuel Moore, who, as it turned out, was unable to appreciate the originality of Marx' work, although he was co-translator, with Edward Aveling, of the English translation of the first volume of Marx' *Capital*. Marx was self-taught, and for this he used textbooks based on the work of mathematicians of the 17th and 18th centuries.

He began his study of differential calculus with the *Cours complet de mathématiques* (Paris 1778) of the Abbé Sauri and later worked his way through the 1828 English translation (*An elementary treatise on the differential and integral calculus*) of the widely read work of Jean Louis Boucharlat (1775-1848). The book of Sauri presented the infinitesimal method of Leibniz. (Marx immediately compared this with Newton's method.) Boucharlat's work was a mixture of the ideas of D'Alembert and

Lagrange. Marx also read Euler and MacLaurin, as well as textbooks by Lacroix, John Hind (1796-1866), George Hemming (1821-1905), and others.

IV

Marx' article "On the concept of the derived function" begins with the very simple example $y = ax$, for which: "if x increases to x_1, $y_1 = ax_1$ and $y_1 - y = a(x_1 - x)$. Let the *differential operation* now take place, i.e. let x_1 decrease to x, so that $x_1 = x$; $x_1 - x = 0$, then $a(x_1 - x) = a\cdot 0 = 0$. Further, since y simply went to y_1, because x went to x_1, now likewise $y_1 = y$; $y_1 - y = 0$. Therefore $y_1 - y = a(x_1 - x)$ becomes $0 = 0$.

"First making the differentiation and then removing it leads literally to *nothing*. The entire difficulty in understanding the differential operation (as in that of any *negation of the negation* whatever) lies precisely in seeing *how* it differs from such a simple procedure and so leads to true results" [Marx 1968, 28].

He then proceeds to divide $y_1 - y = a(x_1 - x)$ by $x_1 - x$ to obtain $(y_1 - y)/(x_1 - x) = a$. He comments:

"Since a is a constant, no change in it can occur, and so neither can it occur on the reduced *right side* of the equation. Under such circumstances the *differential process* takes place on the left side

$$(y_1 - y)/(x_1 - x) \text{ or } \Delta y / \Delta x$$

and this is a characteristic of such simple functions as ax.

"If in the denominator of this ratio x_1 decreases, then it approaches x; the limit of its decrease is reached as soon as it becomes x. With this the difference is such that $x_1 - x = x - x = 0$, and hence also $y_1 - y = y - y = 0$. We thus obtain $0/0 = a$.

"Since in the expression $0/0$ every trace of its origin and its meaning has been wiped out, we replace it by dy/dx, in which the finite differences $x_1 - x$ or Δx and $y_1 - y$ or Δy appear symbolized as *removed* or *vanished* differences, or $\Delta y/\Delta x$ is changed into dy/dx. Therefore $dy/dx = a$.

"The closely held consolation of some rationalizing mathematicians, that the quantities dy and dx are in fact only infinitely small and [their ratio] only approaches $0/0$, is a chimera, ..." [Marx 1968, 30-32].

Two things stand out in this presentation of Marx. One is his total rejection of the concept of the derivative as a ratio 'summations of indefinitely small magnitudes' which Herr Dühring himself declares are the highest operations of mathematics, and in ordinary language are known as the differential and integral calculus. How are these forms of calculus used? In a given problem, for example, I have two variable magnitudes *x* and *y*, neither of which can vary without the other also varying in a relation determined by the conditions of the case. I differentiate *x* and *y*, i.e. I take *x* and *y* as so infinitely small that in comparison with any real magnitude, however small, they disappear, so that nothing is left of *x* and *y* but their reciprocal relation without any, so to speak, material basis, a quantitative relation in which there is no quantity. Therefore, *dy/dx*, the relation between the differentials of *x* and *y*, is equal to *0/0* as the expression of *y/x*" [MEW 20, 128; Engels 1939, 150-151].

Unlike Marx, Engels was prepared to accept mathematics as he found it. He continues: "I only mention in passing that this relation between two magnitudes which have disappeared, caught at the moment of their disappearance, is a contradiction; it cannot disturb us any more than it has disturbed the whole of mathematics for almost two hundred years. And yet what have I done but negate *x* and *y*, though not in such a say that I need not bother about them any more, not in the way that metaphysics negates, but in the way that corresponds with the facts of the case? In place of *x* and *y*, therefore, I have their negation, *dx* and *dy* in the formulae of equations before me. I continue then to operate with these formulae, treating *dx* and *dy* as magnitudes which are real, though subject to certain exceptional laws, and at a certain *point I negate the negation*, i.e., I integrate the differential formula, and in place of *dx* and *dy* again get the real magnitudes *x* and *y*, and am not then where I was at the beginning, but by using this method I have solved the problem on which ordinary geometry and algebra might perhaps have broken their teeth in vain" [MEW 20, 128; Engels 1939, 151].

Thus, while Engels was willing to accept the view of *dy/dx* as a ratio of infinitely small quantities, for Marx the differentiation was completed only when Δx and Δy became zero. Marx would probably have been amused by Berkeley's jibe at Newton's fluxions as "ghosts of departed quantities." He certainly would have appreciated the verses in Samuel Butler's mock romance *Hudibras*, first published in 1663, from which (according to Wolfgang Breidert [private communication]) Berkeley's expression was derived: "He could reduce all things to Acts/ And knew their Natures by Abstracts,/ Where Entity and Quiddity,/ The Ghosts of defunct Bodies, flie" [Butler 1967, 5].

But after reading Marx' exposition, Engels was immediately converted to his viewpoint, as we have seen from his letter of 18 August 1881. Engels continued in that letter to set forth the view of Marx: "When we say that in $y = f(x)$ the *x* and *y* are variable, then this is, as long as we do not move on, a contention without all further consequences, and *x* and *y* still are, pro tempore, constants in fact. Only when they really change, that is *inside the function*, do they become variables in fact. Only in that case is it possible for the relation--not of both quantities as such, but of their variability--which still is hidden in the original equation, to reveal itself. The first derivative $\Delta y/\Delta x$ shows this relation as it occurs in the course of the real change, that is in every *given* change; the final derivative *dy/dx* shows it in its generality, pure. Hence we can come from *dy/dx* to every $\Delta y/\Delta x$, while this itself $(\Delta y/\Delta x)$ only covers the special case. However, to pass from the special case to the general relationship the special case has to be liquidated as such [als solcher aufgehoben werden]. Hence, after the function has passed through the process from *x* to x_1 with all the consequences, x_1 can be quietly allowed to become *x* again, it is no longer the old *x*, which was only variable in name, it has passed through *real change*, and the *result* of the change remains, even if we liquidate it again itself [auch wenn wir sie selbst wieder aufheben]" [MEW 35, 24].

VI

Engels' letter continues: "We see here at last clearly, what many mathematicians have claimed for a long time, without being able to present rational reasons for it, that the differential *quotient* is the original, the differentials are derived" [MEW 35, 24]. This agrees with what Marx wrote in his article "On the differential": "In *0/0* the numerator is inseparable from the denominator, but why? Because only unseparated do both express a relation, in this case the ratio

$$(y_1 - y)/(x_1 - x) = [f(x_1) - f(x)]/(x_1 - x)$$

which has been reduced to its minimum, where the numerator has become *0*, because the denominator has. Separated both are *0*, lose thereby their symbolic meaning, their sense.

"But as soon as $x_1 - x = 0$ has gained in *dx* a form that it unchangeably displays as a vanished difference of the independent variable *x*, thus also *dy* as vanished difference of the function of *x* or the dependent *y*, the separation of the denominator from the numerator becomes an entirely allowable operation. Wherever *dx* now stands, such a change of position leaves the relation of *dy* to it untouched. Thus $dy = f'(x)dx$ appears to us as another form of $dy/dx = f'(x)$ and is always replaceable by the latter" [Marx 1968, 62].

That is, the differentials *dx* and *dy* have their meaning from the symbol *dy/dx*. But Marx must still take into account the fact that in practice differentials are used in the

17043

calculation of derivatives. This he does by seeing them as symbols of operations to be carried out. "We know from this now a priori that if $y = f(x)$ and $dy = df(x)$, that if the differential operation signified by $df(x)$ is carried out, the result: $dy = f'(x)dx$, and that out of this finally comes: $dy/dx = f'(x)$.

"But also, only from the moment in which the differential functions as starting point for the calculation is the reversal of the algebraic differentiation method completed, and hence the differential calculus appears as a separate, specific way of reckoning with variable quantities" [Marx 1968, 64].

This last quotation shows two aspects of Marx' view of the differential and the derivative that have been pointed out by D. J. Struik: "his insistence on the operational character of the differential and on his search for the exact moment where the calculus springs from the underlying algebra as a new doctrine" [Struik 1948, 196]. The originality of Marx' view of the differential as an operational symbol was pointed out shortly after the publication of [Marx 1933]. K. A. Rybnikov has noted: "Already on the basis of the then published material V. I. Glivenko showed that Marx was the first to work out the concept of the differential as an operational symbol; later Fréchet extended the concept to functional analysis" [Rybnikov 1955, 197]. (Both Struik and Rybnikov refer to [Glivenko 1934]; I have not seen this article.)

The second idea of Marx mentioned by Struik shows up in what Marx called "the reversal of the method [Umschlag der Methode]." Consider the example: $y = x^3$. In order to find its derivative we let x increase to x_1, so that y increases to y_1, and write: $y_1 - y = x_1^3 - x^3$. Then dividing by $x_1 - x$ we have: $(y_1 - y)/(x_1 - x) = x_1^2 + x_1x + x^2$. We now let x_1 return to its minimum value x, so that *on the right side* we have $3x^2$, which is algebraic in Marx' sense that no differential symbols appear there, i.e. a real process has taken place that results in the derivative of the original function. But *on the left side* we have $0/0$ or dy/dx, i.e. operational symbols. Thus Marx distinguishes the two sides of the equation $dy/dx = 3x^2$: the left is the symbolic and the right is the algebraic. Viewing a mathematically variable magnitude as a reflection of a varying natural magnitude, we may investigate it by the 'algebraic' differentiation process that takes place on the right side of the equation. But this process is reflected symbolically on the left side of the equation and may in turn be investigated by the development of a calculus of those symbols. Thus the initiative, so to speak, passes from the right side of the equation to the left--in a "reversal of the method."

This reversal is seen already in a rudimentary form in Marx' simplest example: $y = x$. Here the preliminary derivative is $\Delta y/\Delta x = 1$ and since 1 is constant, no further development can take place on the right side of the equation. Marx comments: "From the outset, as soon as we obtain [$\Delta y/\Delta x = 1$] we are forced to operate further on the left side, because the right is occupied by the constant 1. And with this, the *reversal in the method*, that throws the initiative from the right side to the left, appears in its nature [von Haus aus] once and for all proven, in fact the first word of the algebraic method itself" [Marx 1968, 68].

This idea is seen more clearly in Marx' investigation of $y = uz$, where u and z are each functions of x. Letting x increase to x_1, so that u increases to u_1, z to z_1, and y to y_1, we obtain, after dividing by $x_1 - x$:

$$\Delta y/\Delta x = z_1(\Delta u/\Delta x) + u(\Delta z/\Delta x).$$

Now, following the algebraic method, we let x_1 decrease to x or Δx to zero, to obtain $dy/dx = z(du/dx) + u(dz/dx)$. Here the right side is no longer algebraic, it contains symbolic differential coefficients. No 'real' functions have been operated on. In the earlier example, dy/dx was the symbolic equivalent of a derived function $3x^2$ and here the dy/dx plays the same role, but what of du/dx and dz/dx? They do not stand opposite any derived function whose double [Doppelgänger] they would be. Marx writes: "They have one-sidedly come into the world, shadow figures without bodies to cast them, symbolic differential coefficients without real differential coefficients, i.e. without corresponding equivalent 'derivatives'. The symbolic differential coefficient has become an *independent starting point*, whose real equivalent has first to be found. The initiative has been moved from the right hand pole, the algebraic, to the left hand one, the symbolic. With this, however, the differential calculus appears also as a specific kind of computation, operating already independently on its own territory. Its starting points du/dx, dz/dx are mathematical quantities which belong exclusively to this calculus and characterize it. And this reversal of the method resulted here from the algebraic differentiation of uz. The algebraic method changes automatically into its opposite, the differential method" [Marx 1968, 54-56]. This is what Struik meant by Marx' "search for the exact moment where the calculus springs from the underlying algebra as a new doctrine."

VII

While Marx' analysis of the derivative and differential had no immediate effect on the historical development of mathematics, Engels' claim that Marx made "independent discoveries"

17044

is certainly justified. It is interesting to note that Marx' operational definition of the differential anticipated 20th century developments in mathematics, and there is another aspect of the differential, that seems to have been seen by Marx, that has become a standard part of modern textbooks--the concept of the differential as the principal part of an increment. Yanovskaya writes: "This concept, which plays an essential role in mathematical analysis and especially in its applications, was introduced by Euler ..." [Marx 1968, 579] and "we have every reason to consider that Marx had at his disposal also a concept equivalent to the concept of the *differential* as *principal part of the increment of a function* (as with Euler ...)" [Marx 1968, 29].

But Marx' interest in differential calculus was perhaps primarily philosophical; certainly it was no mere pastime that brought him "quietness of mind." Indeed, Lombardo Radice has concluded: "More generally, there is no doubt that Marx gave so much attention and so much effort of thought in the last years of his life to the foundations of differential calculus because he found in it a decisive argument against a metaphysical interpretation of the dialectical law of the negation of the negation" [Lombardo Radice 1972, 275]. As Marx himself wrote: "here as everywhere it is important to strip the veil of secrecy from science" [Marx 1968, 192].

As we approach the 100th anniversary of Marx' death it is still true what Yanovskaya wrote at the time of the 50th anniversary: "Modern mathematics also defines the derivative in fact by means of a certain dialectical process, consisting at first of the positing of a finite difference, and then its 'removal', but which it carries out not in the form of a return to the equating of x_1 to x or Δx to zero, but in the form of a 'passage to the limit of Δx to zero" [Yanovskaya 1933, 97]. Nor can the recent justification of infinitesimals with the introduction of non-standard analysis by Abraham Robinson (or even the reintroduction of infinitesimals into the classroom [Keisler 1976]) take away the value of Marx' critique. Yanovskaya's prediction that "the publication by the Marx-Engels-Lenin Institute of the mathematical works of Marx will have for our mathematician-Marxists no less significance than the *Dialectics of Nature* for all the natural science front generally" [Yanovskaya 1933, 110] may have been a bit sanguine, but surely they "will always remain in the field of vision of mathematicians" [Gokieli 1947, 111]. Marx did not give us just another example of his philosophical approach. Rather, "the difficult task of the foundation of differential calculus became for K. Marx the touchstone [probnym kamnem] of the application of the method of materialistic dialectics to mathematics" [Rybnikov 1954, 496].

NOTES

1. The double reference here and later refers first to the original and then to the translation that I have used here. MEW = *Marx Engels Werke*.
2. I have used several of Struik's translations in this article.
3. All translations from Russian are mine.

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