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CS modified
& sent to Lilley in Nov 48

More good stuff
in 4to notes
still to use

THE FUNCTION OF THE HISTORY OF SCIENCE.

The store of scientific knowledge is a general treasure-house from which all men may draw, and by which alone it is possible for them to better their material state. And yet - perhaps because of the wide spread of scientific ideas - we seldom remind ourselves that the development of the stock of scientific ideas, the heritage of all men, has always been the work of a very small band. Men capable of great scientific effort have always been rare, and for their effectual working an intellectual environment is needed that is wellnigh as rare as themselves. Surely the contemplation of the conditions under which such men have laboured and lived, the examination of their training and mental history, of the circumstances and manner of their development, must be of value to those who would follow

in their footsteps or prepare others to do so. Nor is the reverse side of the picture without its lesson. The study of those social and economic and philosophical conditions that fail to produce effective scientific fruits or that yield only bizarre or deformed products, can at least explain for us certain phases in the mental history of mankind. Thus the study of the scientific mood in its historical development needs little justification.

The scientific mood is perhaps one of the irreducible elements of the human spirit and cannot be defined, but we can say that it seeks especially those judgements to which - given an adequate apprehension - universal assent can be obtained. The scientific mood, in the degree to which it seeks universal assent, must demand independence of all other judgements that

influence mankind - judgments based on fashion or tradition or taste of passion or class or any of the hundred things in which men differ from one another, Science is thus of all studies the most truly humane, the most truly international. The man of science may, better than others, claim for himself that he is a citizen of the world and that he speaks a language that can be understood by all who call themselves men.

Modern science in contrast to the science of early civilization, including that of Greece, records not only conclusions but also the processes by which they have been reached. This gives hope of a permanence for the science of our age that has never before been attained. Hope of permanence lies

in the modern wide distribtution over the earth's surface of active centres of scientific research. And in the world wide distribtution of many thousands of books and journals concerned with scientific work.

The continuity of the development of scientific knowledge in historical times may be traced through six main phases, From the early valley-civilizations to the phase emerging in our own time, in which the scientific mood is becoming synthetic and historical investigation has become an urgent necessity. The need for historical survey following on the Synthesis of Science of the preceding centuries was realised by many of the pioneering minds of the eary XIX century. We recall Cuvier (circ. 1820), Comte who in 1833 suggested a Chair in the History of Science - Sarton has discussed the fate of the Chair

established in Paris, Baden Powell (1834)

Quetellet ( ) the pioneer of statistics

and De Morgan. Paul Tannery in a series of brillant works discussed the historical inter-relationship of philosophy and science; in 1837 came Whewell's History of the Inductive Sciences and in 1840 his Philosophy of the Inductive Sciences.

The XX century brought further developments to the subject. In Professor Partington's magnificent treatise we possess for the first time a searching, documented and completely marshalled survey of all that is known of the technology of the ancient Eastern civilizations.

Dr. Sarton of all living men has made the most sustained attempt to master the material for the

great theme of the development and product of the scientific mood throughout the ages. His work yields the necessary materials for an account of the science of classicial antiquity. It contains also the first attempt at a complete and ordered summary of the extremely important Oriental phase of the scientific mood when it dwelt almost wholly outside Europe. The passage of science and philosophy to the Hellenistic, Syriac and Hebrew nearer East in the early Christian centuries: the infiltration of Islam with scientific ideas, achieved by writers of Nestorian, Jewish, Pagan and Moslem affinities in the eight, ninth and tenth centuries; the flowering of Arabic science in the eleventh and twelth centuries and its later wilting; these processes provide Dr. Sarton's work with a grand series of chapters of the very highest interest and importance not only to the historian of science but also to the

historian of civilization itself.

The massive researches of Professor Thorndike which he has compressed into some 3,500 pages have succeeded in arranging for us for the first time the vast inchoate mass of manuscript material that bears on the scientific mood in Western Europe until the end of the seventeenth century.

There is a meaning in the fact that these three great synthetic attempts to trace the spirit of reason have been made by men one of whom is a product of British, one of Gallic and one of American culture. These three cultures are the main defence against the tribal disruption from which civilization has suffered repeatedly in the past and may well suffer again in the future. Against such disruption the disinterested

employment of reason is in the end the only effective weapon. Only through science can man know his world. Only by the aid of science can man truly know either his fellows or himself, Should science cease to be international, we may know of a surety that the end of civilization is at hand. It would be the Hippocratic sign of impending death.

Activity averting such dissolution was manifested in the early XX century by the steps taken in 1920 by the Carnegie Institute and by Harvard for the transplantation to a safer hemisphere of Dr. Sarton, his work, and the international journal Isis fathered by him. Then came the foundation in the U.S.A. of the international History of Science Society. In 1927 the vision of Aldo Mieli led to the foundation of the International Academy for the History of Science, whose first President

was Gino Loria, still in his tenth decade adding to the knowledge of the History of Mathematics. Fostered through good and evil days by the devotion of Aldo Mieli and of its Hon. Treasurer Helene Metzger, victim of Nazi savagery.

The Academy has formed an International Union, affiliated to the Internation Council of Scientific Unions, itself fostered by the yet wider embrace of the United Nations Educational, Scientific and Cultural Organsiation.

The title leads once more to consideration of the function of the History of Science. There is a striking analogy with the function of Humanism five hundred years ago. Both made small beginnings in a disturbed world. In the fifteenth century, scholastic philosophy was breaking down; the Universal Church

was ceasing to be universal; economic revolution was displacing the old values based on land ownership; Politically, feudalism was dissolving into the nation states; In Education, Logic was yielding to the humanistic stress on Language. In Philosophy. Theology, Economics, Politics, Education, great Discontinuities were temporarily healed by Humanism. Comparable discontinuities in our world may in the next generation be comparably bridged by the evolution of the New Humanism to the Historical Outlook which has itself broadened to survey the History of Civilization. The Scientific Age has recognised its need to know and to understand the History of Science.

Ēpit (2 Bryht proofs 383

The pioneers of the History of Science

The continuity of ~~scientific~~ the development of scientific knowledge in the ~~historic~~ time may be traced ~~After a survey of the field~~ through six main phases ~~of scientific~~ from ~~that of~~ the early ~~work known to us~~ ~~through history, that~~ valley-civilisations to the phase emerging in ~~Our~~ our own day ~~when the sci. mood~~ 27 31

and ~~mystic~~ GI ~~sci. mood began to be synthetic~~ 6

P7 l. 3 lines XIX century, such as 32

A survey of this work shows the most intimate relationship of Phil & sci

~~After~~ glancing at the conceptions of

Cuvier ( ) Comte ( ) Baden Powell ( )

Quetelet ( ) De Morgan 8 2 5

P7 Paul Tannery subject-Stil 515 ~~45 0~~ ~~520~~ ~~545~~ 40

~~P8 Professor Partington produced a searching ... ... of the technology ... civilisations ... His work is still by far ... isolation period of sci ... a remarkable feat from one engaged ... teaching~~ 5 18 45 60

58 6

~~Broght forward 586~~

~~P8 §2 His work [3 lines] contains the first 30~~
~~to bottom page 84~~

700

Broght forward 515

P8 §1 omitting [ending §4-5 with most work] or .... call it 4"

to mode of thought 55

∴ 530 left = foolscap and half 100

P9 Sexton Pt 3 lines 30

His work yields all to end page 100

P9

Jh No. 4 45

745

PTO

4

We have only 350 Bright forward 745

Pg 10 Surveying the

work of these three authors

9 10 lines left on P 9 100

P10 2 lines to treat 25

And yet ... seek

The story ... synthesis

~~watch[?] now 50~~

together 45

new 10 There is a meaning 1½ 115

to end page

860

240 left

EPITOME Bring to 3½ pages or 1100 words

e8 typed foolscap now 11 pages foolscap

The quarto will bring 2 more

At least 10 x 32 = 320 x 13 = 4160 to divide 4

use new page nos. 12

		lines	
1. §2-4	Scientific knowledge ... state	2½	25
	And yet to end par	16½	165
	last	7½	75
2§1	310	4½	45

~~Moreover there~~

Modern science, in contrast to the science of earlier civilisations including that of Greece, records not only conclusions but also the processes by which they have been reached. This gives hope 41

~~And there are certain grounds for the hope~~ of a ~~reform~~ ... attained. ~~Firstly there is~~ However ~~Moreover the~~ diffusion throughout the earths surface, of centres and the scientific research; and in the world-wide distribution of ~~..~~ many thousands of books & journals concerned with scientific work ~~which are diffused~~

mv §2

32

Safety lies too in the medium

38 3

INADEQUACY - not modesty true or false
LIFETIME

Address H.O.S. Soc. 4.5.48

After about CENTURY OF EFFORT
Early XIX several attempts
(a) CUVIER c. 1820
(b) COMTE c 1833 proposed chair of H of S
No fate. Sarton discusses.
(c) Baden Powell 1834 TANNERY QUETELET Inductive Scs 1837
(d) WHEWELL History of Philosophy of Inductive Scs 1840
many editions
(e) AUGUSTUS DE MORGAN. Penny Encyclopaedia
XX^th Cent. SARTONS dedication of himself 1913
ISIS
HARVARD & CARNEGIE 1920
HIST of Science SOC.
→ About same time department at U.C. DIVIDED
Post War. Full department in one Univ.
Several proposals / LACK OF TEACHERS
Seal of the ~~doc~~ subject as disciplined
LEARNED SOCIETY
For 300 years the existence of a learned Society has provided the HALLMARK of admission of a subject to the ORGANON of LEARNING
International ACTIVITY — UNESCO
Oslo 1929. MIELI
Paris 1925
London 1932 → LISBON 1935 — PRAGUE 38
Lausanne 1947 LAUSANNE
1950 BUCHAREST — LONDON
SCIENCE AND TECHNOLOGY LONDON ONLY
History & Philosophy
Combined under History

More general considerations. PROSPECTS
H&S analogies with Humanism
500 years ago. 15th cent

(1) Both made small beginnings in disturbed world
(2) Scholastic Philosophy was breaking down
(3) Universal Church ceasing to be Universal. Theology in hot dispute before Church divides
(4) Economic Revolution Mercantilism displacing the old values based on £ land rooted in Feudalism
(5) Political Feudalism → National State
(6) Education Medieval Rationalism Logic → humanistic stress on language

In Philosophy, Theology, Economics, Politics, Education GREAT DISCONTINUITIES (temporarily) healed by HUMANISM

Comparable discontinuities in our world may ~~be seen~~ in the next generation be comparably bridged by the ~~New~~ NEW HUMANISM → HISTORY
HISTORY OF CIVILISATION
SCIENTIFIC AGE → HIST. OF SCIENCE

Discontinuity. WHY. DISCOMFORT

Why are we distressed, afraid, interested in such discontinuities? Man is of his essence a social animal. Are not these feelings really reflections that his relations with his fellows are disturbed? I interpret that man seeks a common purpose. Dimly realised PURPOSE

I cannot see that any system of PHILOSOPHY or RELIGION has given any satisfying purpose. Such solutions as are offered are VERBAL

Nevertheless the desire for PURPOSE seems a special human attribute. Since we can see no purpose outside us in this vastly complex world, we must live at all, form our own purpose within ourselves

The argument from Paley's watch has failed for its very strength. We now see our whole universe including ourselves, as one great watch. Since we can discern no purpose for the great mechanism of which we form a part we must develop a purpose for our own little lives. If we can not, we & our civilisation must collapse.

We are made for the Glory of God
Man seeks to fulfil himself

All problems of existence are summed in the word purpose. It is only purpose that makes human life distinguishable as human. In their researches men of science try to divest themselves of any thought of the purpose in the things that they examine. In the degree to which they succeed they divest themselves also of their humanity. ~~But~~ Sooner or later they ~~must~~ come to express their observations in some causative sequence which is not far removed from the idea of purpose.

If the investigator be a biologist it will not be long before he falls into the trap ~~he cannot himself~~ He sets himself to describe values if trapped he soon, and will be talking in terms of purpose. He will say that The cell, the organ, the organism, the colony, does this or that for this or that end. He never gets far without invoking the language, at least, of purpose. And it goes deeper than mere language. He cannot rid himself of the idea.

The pride of the physicist is to live on Olympian heights far from the ~~human~~ voices in the plain below. But he too must sooner or later report on his findings. A Newton reports that the mechanics of the heavens are as those of ~~our~~ his own earth, a Clerk-Maxwell that light waves are electro magnetic phenomena. Such achievements we judge by the degree to which they bring ~~wat seem~~ to ~~superficially~~ (familiar) quite diverse things into some deeper relation to each other. Like the biologist, the physicist seeks ~~the~~ a deeper unity that must, as we all believe, underlies ~~the~~ surface diversity. Physics combines with biology for this express end. Are not the very terms biochemistry and biophysics a proclamation of this ?

Purpose and causation are ideas that are ~~very~~ near to each other. The scientific seeker is constantly blundering into a half concealed admission that there is either a purpose or a necessary ~~least a~~ causal chain in the sought. Whatever the philosophical difficulties of the idea of causation, science would become silent if forbidden to ~~imply~~ invoke it in her discourse. When we speak of nature we always, in some degree, ~~reflect our own~~ project our own minds into nature. For we are all prisoners in Plato's cave. The shadows of the things that we see dimly on our walls are either the shadows of our ~~own~~ thoughts or are blended with ~~them~~ the shadows of our own thoughts. Any purpose that we discern in nature we have in part, at least, read into her ~~from our own thoughts~~. But whether or not man be made for a purpose it is sure that he shapes himself for a purpose. If it were not so there would be no such thing as history. What then is man's purpose ? Could that be clearly answered life would become very simple. Men would unite spontaneously into one catholic body set on a clear end. Yet the tradition that we receive from the past, and the picture that our experience yields of the present is a vision of confused, struggling aspiring humanity. It is very far from ~~that~~ of an army of ordered units advancing as with one mind on a single objective, for we are men, not ants. Look at our history. Its scenes mostly fade one into the other though at times they suffer what seem sudden changes. These are called revolutions, but on careful examination they are ~~seen~~ turn out to be found rather to be like those transformations that the kaleidoscope reveals, new arrangements of the old pieces. The pieces in the kaleidoscope are man and men ~~are still~~ remain what they always were. These human pieces ~~They~~ merely

stand at new angles and with new relations to eachother, as do the fragments in the kaleidoscope.

Through all the changes of man's state and man's civilisation, there is something that persists. Continuity is ~~not~~ never wholly broken. The human spirit has remained essentially the same through the ages. Something more than mere memories ~~xx~~ come to us from those shattered hopes, those broken hearts, those triumphs that ~~ever~~ always end in defeat, that have marked the transition of each age into the next. We all recognize these permanent elements. We seek to embody them in our education ~~under~~ the embracing term ~~of~~ for them is civilisation or the "Humanities".

A fundamental element that the Humanities have to convey is the cultivation of the marvellous power of reason which ~~distinguishes~~ man and enables ~~him~~ man to survive when the beasts would perish and their purposes with them. Reason provides the permanent element in man's world, the essential atmosphere in which alone the mind can develop the scientific mood. The scientific mood - like the other great spiritual moods, the religious and the artistic - aspires to integrate the outer ~~with the inner~~ world. It seeks to integrate nature & the mind Science works to present the parts of the world as resolved into a whole under reason, with the order of man's mind as a reflection of ~~the~~ some universal order. Doubtless it is impossible to think of science as succeeding in her task. Neither her ~~end or~~ purpose nor her failure ~~to reach it~~ achieve are peculiar to her. What is peculiar to her is ~~her method~~ way of attempt the manner of her attempt. This necessarily develops with the

ages and is necessarily continuous in the senses in which the other great moods are not and perhaps cannot be. Science is not far from that Wisdom that is justified of all her children.

The scientific mood is one of the basic phenomena of the human spirit. It is the disposition of the natural man to seek out how things work. When, in order to do this, he tries to arrange things and their ways of working in some sort of connected order he ~~has reached~~ passed into the scientific mood. Knowledge of the distribution of the scientific mood in time as well as in place is an integral part of the record of civilised man. The history of science is ~~as~~ essential to history as a whole, just as science is ~~an~~ essential ~~part of~~ to the process by which man has become as we know him.

We should not nowadays think any historian worthy of the name who contented himself with a mere record of political and administrative events. But that was in substance the character of the older history. The kind of history that we know to-day, the attempt to lay hold of the great features of the life of the people and their relation to the general economic, social and political changes is not very old. In the year in which I was born appeared the first book to do that for England. It was the Short History of the English People by John Richard Green who was only 40 years my senior. Since the appearance of that great work attempts have been made to weave other aspects of human activity into the web of history. Art, literature, commerce, and, above

all, the so-called Industrial Revolution have all asserted their claims. It is quite remarkable, however, how resistant general historians have shown themselves to the admission of scientific factors. Even professedly economic and social historians have given but the scantiest attention to the scientific mood.

Of English writers on modern history the most distinguished is, by general consent, Sir George Trevelyan. In his England under Queen Anne of 18 years ago science is not mentioned. Newton masquerades in a role that may not be very familiar even to learned Newtonians. He appears in the full dress of a Whig politician. In Sir George's recent beautiful book English Social History, a Survey of Six Centuries science is given a walking-on part. The Royal Society is awarded a page and a half which is almost entirely taken up with the relations of religion and science. These of course were real, important and interesting, but they have little to do with science as a major intellectual activity. Science proper, science as a great movement of the human spirit comparable in its magnitude and influence to literature, art and religion, hardly appears at all. Nor do I know of any first class history that treats the Revival of Science as comparable in its influence to the Revival of Learning. In this omission the historians are palpably wrong. A moments reflexion, a glance at our world and a comparison of it with the historians' world of say 200 years ago

reveals their error at once. Ours is a scientific world. It is scientific not only in the sense that we have railways, electric light, penicillin, wireless and hybridized fruits, but scientific in the cultural contents of educated minds. It would be interesting to enquire why the historians all substantially ignore the cultural effects of the revival of science. Since they all commit a similar error may it not be that the fault is in us historians of science? We are assured on the highest authority that spiritually it is more healthy to consider our own sins that the sine of others. Let us see if we have any cause for self-reproach.

Buchman's followers. Public confession
I do not suggest turning our meetings → OXFORD GROUP
In our confession
I have treated SCIENTIFIC IDEAS
as though they exist in a vacuum
Little or no regard to CIVILISATION
H of S IN VACUO
Just what the general historian has done.
PECCAVI
Do better in next reincarnation

AN Error that I have not committed
I can therefore afford to be very severe on it
ERROR OF PURPOSELESSNESS
Accidental history. Scattered incidents.
Peculiarities of persons, incidents & periods

Journals of the H of S have far too many of ~~those~~ trivial contributions which clog the the literature. They make more difficult the tracing of ~~clear~~ relationships & of clear lines of evolution. The younger Historians of S have a wonderful opportunity, an outlook more hopeful than has ~~been~~ occurred to humanists since the ~~bright~~ dawn of the Revival of learning. The world is a hard explored field. It is theirs to lead humanist research. For the first time in history our world is emerging as a real Cosmos, a ~~feat ful~~-real place of Order. To integrate that into human history is our purpose. To keep research purposive is, I conceive, the highest function of a University & of a learned Society.

The last class included the mild alkalis

First two pages used. New 1
These may also prove useful.

of the East. Why do we study the History of Science?

That the store of scientific knowledge is a general treasure-house from which all men may draw, and by which alone it is possible for them to better their material state, has become a mere commonplace. And yet - perhaps because of the wide spread of scientific ideas - we seldom remind ourselves that the development of the stock of scientific ideas, the heritage of all men, has always been the work of a very small band. Men capable of great scientific effort have always been rare, and for their effectual working an intellectual environment is needed that is wellnigh as rare as themselves. Surely the contemplation of the conditions under which such men have laboured and lived, the examination of their training and mental history, of the circumstances and manner of their development, must be of value to those who would follow in their footsteps or prepare others to do so. Nor is the reverse side of the picture without its lesson. The study of those social and economic and philosophical conditions that fail to produce effective scientific fruits or that yield only bizarre or deformed products, can at least explain for us certain phases in the mental history of mankind. Thus the study of the scientific mood in its historical development needs little justification.

There is another direction from which the history of science may be approached. Many attempts have been made to define science but none has succeeded, for moods cannot be described in terms other than themselves. The scientific mood is perhaps one of the irreducible elements of the human spirit. But if we cannot define science, we may at least say of it that it seeks especially those judgements to which - given an adequate apprehension - universal assent can be obtained. The scientific mood, in the degree to which it seeks universal assent, must demand independence of all other judgements that influence mankind - judgments based on fashion or tradition or taste or passion or class or any of the hundred things in which men differ from one another. Science is

thus of all studies the most truly man-wide, the most truly humane, the most truly international. The man of science may, better than others, claim for himself that he is a citizen of the world and that he speaks a language than can be understood by all who call themselves men.

It is certainly true that in some countries and at some periods there has been a certain local and temporal stamp in the scientific material that has been produced. But these accidents concern the processes, the methods, the instruments employed by science rather than its aims or results. They do not affect the scientific mood itself. Nevertheless, among the processes and methods and instruments of the science of our age there are certain factors of an order that the world has not hitherto seen. And although he must be arrogant indeed and very ignorant of history who believes that, because of our nature and because we are who we are, therefore the guardianship of the scientific treasury will always remain with us, nevertheless these new factors give some hope of a permanence for the science of our age that has never before been attained. Among these new factors is the wide distribution over the earth's surface of active centres of scientific research. Another factor is the multiplication of scientific books, so that the destruction of one centre would not imply the disappearance of the knowledge there acquired. But a deeper hope of permanence is based on the peculiar nature of the scientific method of record in our time.

The importance of the method of record can be best brought out by comparing current sciences with some other form of science. That of the Greeks, being well known, is a useful example. Our science has developed a characteristic mode of expression in the so-called Journal. There are many thousands of scientific journals; they are issued periodically and consist of memoirs on very special and very narrow problems. Such articles or memoirs have a characteristic and almost constant structure which we may take as the

type of the modern scientific product and may briefly examine.

The author of a scientific memoir, having stated his problem, reviews the efforts made by others to solve it. He points out their errors or decides to accept their work and base his own upon it. Perhaps he distrusts their experiments or would like to reinterpret their results. Having surveyed their labours, he proceeds to detail his own experiments and observations. Finally he gives us his deductions from these. But it is important to note that he is never able to tell us of all his experiments and observations. If he did, scientific literature would be even more bulky than it already is, and science would quickly perish, suffocated under the dead weight of her own verbosity. The author in fact omits a great many of his mental processes. He tells us nothing of how he embarked on many different lines of work and abandoned them as unprofitable. He tells us nothing of the months or years spent in repeating the experience of others. He says not a word of how he acquired and improved his experimental skill and technical experience. He tells merely of the final line of work that has yielded results. But he does not tell all even of that. When he had after many trials at last discerned a profitable and feasible direction for his investigation, he reached after a time those conclusions which his final line of work has verified and rendered more exact. It is this final process of verification that he mainly describes, and it is the details of this that occupy the bulk of all that he has to say. Having described these verificatory experiments, he briefly summarizes his conclusions.

Now how do the scientific works of the Greeks compare with material such as that of the scientific memoir ? The corpus of Greek science is of course less in quantity than is our modern material, and it is often fragmentary in character. But it is not these deficiences which make comparison with our own science difficult.

The difficulty arises from the habit of the Greek writers of setting down only their conclusions. Their methods of work, even the verificatory observations and experiments, they have almost completely hidden from us, and those methods were almost as completely hidden from their immediate successors. It is as though we had a collection of the last few summarizing lines of a series of scientific articles. To grasp the actual nature of modern scientific methods from a scientific article is difficult enough, since not all the mental processes involved are recorded. In the case of Greek science the difficulty is far greater, for here we have only the conclusions with hardly any of the processes.

From this contrast between Greek science and modern science mathematics must be excluded, and for this there is a special reason. The defective Greek scientific method of record is practically inapplicable to mathematics. Mathematical results without mathematical processes would be an inanity. Greek mathematics, like everything else that has come down to us from antiquity, has, of course, suffered from the accidents of time; but the obscuring power of time is a mere light veil compared to the impenetrable curtain that the Greeks have themselves drawn over their other scientific works.

Thus it comes about that we can form a clear and consecutive picture of the nature and progress of Greek mathematics. But a corollary to the completeness of this mathematical record is a phenomenon in the history of mathematics that is shared by no other science. It is that for mathematics there are no Middle Ages. This does not mean that there was no period when mathematical knowledge was backward or arrested, or that mathematical progress was not at times very slow. The disturbances, political and economic, religious and philosophical, that followed the break-up of the Roman Empire, the long centuries of decay in the Near East, the many wars in India, that contributed to destroy the intellectual life of antiquity did, of course, equally destroy mathematical progress and mathematical thought. But the reason why we can say

that there were no Middle Ages for mathematics is that when and where civilization became settled, and when and where the Greek record became accessible, then and there it was possible for mathematical work to be taken up just where the Greeks had left it.

It has been said that the measure of the advance of a science is the degree to which its conclusions are susceptible of expression in mathematical form. But there is another and perhaps a deeper and more constant sense in which all sciences must borrow from mathematical method. It is in the record of processes. Of nothing is it more true than of science that the dead govern the living. By the degree to which our processes are clearly and succinctly recorded, by so much do we ensure the permanence of our work, by so much can we guarantee that our successors may begin where we leave off. From a consideration of the permanence of the scientific process we see that it can only be understood in the light of its history. In the historical development of the scientific mood we can perhaps distinguish six primary manifestations or phases, though further knowledge will doubtless increase their number. These phases are continuous in the sense that each derives by direct mental contact from its predecessor, even when the most typical products of one phase are separated by centuries from the most typical products of the next.

First, there is the phase of the early valley-civilizations of the East. This is shown at its best, or at least at its best known, in Babylonian science with its astronomical development of the seventh century B.C. Secondly, there is the phase of the classical culture which we recognize in its most typical form in the geometrical and biological development and cosmological speculations of the Greeks in the fith and fourth centuries B.C. Thirdly, there is the Oriental phase, expressed especially in the Arabic language by works on mathematics, chemistry, astronomy and optics in the tenth, eleventh and twelfth centuries of our era. Fourthly, there is the medieval phase, which is in essence a

New 6

a Mediterranean product, the result of the stimulus of the Oriental phase impinging in the twelfth and thirteenth centuries on a reviving Latin mentality. Its most characteristic products are the vast synthetic philosophies produced by highly original thinkers in the name of Aristotle in the thirteenth century. These medieval systems sought to resolve all the products of the human spirit - including those which we call scientific - into the formulas of Catholic Christianity. Fifthly, there is the modern phase, most typically developed perhaps in the seventeenth century, when men in Western Europe, educated by Renaissance art and humanism and utterly weary of theological and political disputation, turned to the details of nature, where the new instruments revealed a hitherto unconceived complexity, exactness and beauty. These details they came to classify under those more or less limited formulas which we nowadays call the "separate sciences." And in our own day we are entering a sixth phase in which the scientific mood is again becoming synthetic and for which historical investigation has become an urgent necessity.

Adequate surveys of these phases have only begun to appear of very recent years, and we are still without any comprehensive treatment of the last two. General historians have been reproached with excluding science from their narrative, and cultural historians have treated the scientific mood with hardly more consideration. But even an historian cannot be omniscient. He cannot consult all the sources, and he must often rely on others who have done so. Until a short time ago there were no major works of high authority on scientific history to which he could turn. Within the last few years, however, a whole series of fine efforts of scholarship, produced from first hand material, have gone very far to remove this opprobrium historicorum.

New p. 7 to follow old page 8(which is new page 6) (new p 7

The need for historical survey , following on the ~~XXXXX~~ of the preceeding centuries ~~XXXXX~~ Sybthesis of Science/was realised by many of the great pioneering minds of the early XIX century. We recall Cuvier (circ. 1820) ; Comte who ~~XXXpXXXXXXXXXXXXXXXX~~ in 1833 suggested a Chair in the History of Science - and Sarton has discussed the fate of the Chair established in Paris; then there was Baden Powell (1834) whose vision ;

;

Quetellet ( ) the pioneer of statistics ;

(run on) ~~XXXXXXXXXXXXXXXXXXXX~~ Paul Tannéry in a series of brilliant works discussed the historical inter-relationship of philosophy and science; in 1837 came Whewell's History of the Inductive Sciences and in 1840 his Philosophy of the Inductive Sciences. Both works ran into many editions. The comprehensive genius of Augustus de Morgan illuminated many aspects phases of the growth of scientific knowledge for the benefit of readers of the Penny Encyclopedia .

Then with the XX century came Gworge Sarton's dedication of ~~XXXXXX~~ his life to the ~~study-and-promotion-of-the~~ History of Science. In 1913 he became the father of Isis soon to be flanked by the ~~great-studies~~ extended studies in Osiris , and by the great volumes of the Introduction to the History of Science

The XX century brought further development of the subject.

Turn to old page 9, = new p. 8

In Professor Partington's extremely well arranged and learned treatise, which is mis-named with misleading modesty, we possess for the first time a searching, documented and completely marshalled survey of all that is known of the science, or, as he would probably prefer to call it, the technology of the ancient Eastern civilizations. Technology is the expression of the scientific mood before science has become a formal mode of thought. The arts and devices of civilized man are the products of experience. They are summarized by the word "Invention". And if Necessity be indeed the mother of that Invention which has raised man from the life that is nasty, brutish and short, then Experience is surely her father. We have in the researches of Professor Partington by far the ablest and completest presentation ~~x~~ to date of what may be called the "gestation period" of science. It is very remarkable that he should have been able to produce such a work while engaged in active scientific research and teaching.

Dr. Sarton of all living men has made the most sustained attempt to muster the material for the great theme of the development and product of the scientific mood throughout the ages. It is useless to attempt to summarize in a paragraph the two thousand pages of an " Introduction" projected on the grand scale of at least five times that range. His work, however, has proceeded far enough to yield all the necessary materials for an account of the science of classical antiquity. It contains also the first attempt at a complete and ordered summary of the extremely important Oriental phase of the scientific mood when ~~xxdwxlx~~ it dwelt almost wholly outside Europe. The passage of science and philosophy to the Hellenistic, Syriac and Hebrew nearer East in the early Christian centuries : the infiltration of Islam with scientific ideas, achieved by writers of Nestorian, Jewish, Pagan and Moslem affinities in the eighth, ninth and tenth centuries; the flowering of Arabic science in the eleventh and twelfth centuries and its later wilting;

these processes provide Dr. Sarton's work with a grand series of chapters of the very highest interest and importance not only to the historian of science but also to the historian of civilization itself.// Dr. Sarton has interpreted the word " science" with a fine generosity and much of his material, that, for instance, on historiography, lies far outside the range of the sciences as usually understood.

The massive researches of Professor Thorndike which he has compressed into some 3,500 pages have succeeded in arranging for us for the first time the vast incohate mass of manuscript material that bears on the scientific mood in Western Europe until the end of the ~~fifteenth~~ seventeenth century.// In many ways, Professor Thorndike's task has been the hardest of the three, for he has dealt with a period of which the documentary material is at once overwhelmingly copious, ill-arranged, legible with difficulty, confused and scattered. These facts make the very capable organization and admirable indexing of Dr. Thorndike's volumes particularly welcome. His main theme is an extension of that of Dr. Sarton, though it is earlier in date of publication. It is the incorporation of the legacy of Arabic science into that of medieval Europe. To some extent the two works overlap, although their methods are very different and in most ways they supplement each other. The later part of Professor Thorndike's investigations brings us in close touch with the dawn of modern science.

In surveying the enormous volumes produced by these three authors, certain reflections and inquiries inevitably present themselves. What a mass of labour and self-sacrifice such vast undertakings imply ! What organizing and administrative ability the love of learning draws to herself ! Of what courage and stubborn effort in the face of difficulty do these great works speak ! Scholarship on such a scale and thus conceived has in it something of the heroic. Works of this type can be produced only by men of high courage, inspired by a bold and determined purpose, and we come again to ask what is the

purpose for which men choose these steep and laborious and often thankless ways of life ? Such energy, such initiative, such ability, such patience could, if they would, find far rosier paths to treat, far greater renown to earn among men, than comes from the production of volumes which can appeal only to specialists and to them only for a generation or two, for it is of the nature of learning that it is soon replaced. And yet the answer is not far to seek, and is provided by these volumes the very meaning of which requires intepretation to readers who are not specialists. The stony paths of the steep ascent which these men have chosen lead to a common view-point. Their studies converge at the end to one great synthesis. Learning often seems dry-as-dist, purposeless, far from the ways of men. But there are great movements in learning that at times bring men together. One such movement is very much alive at this hour. It is the attempt to represent for us the secular adventures of that universal and eternal rational element in man that we lose too easily in history dealing with the revolutions of empires. The history of science is a vital issue of modern schoarship. It is science, and it is science alone, that can set forth that which is universal in mankind. In our world we see men divided in their ways of thought, into groups that are either national or universal. // There is a meaning in the fact that these three great synthetic attempts to trace the spirit of reason have been made by men ~~of~~ one of whom is a product of British, one of Gallic and one of American culture. These three cultures are the main defence against the tribal disruption from which civlization has suffered repeatedly in the past and may well suffer again in the future. Against such disruption the disinterested employment of reason is in the end ~~x~~ the only effective weapon. Only through science can man know his world. Only by the aid of science can man truly know either his fellows or himself. Should science cease to be international, we may know of a surety that the end of our civilization is at hand. It would be the Hippocratic sign of impending death . //

240 words

Activity averting such dissolution was manifested in the early XX century by the steps taken in 1920 by the Carnegie Institute and by Harvard ~~to preserve--the-~~ ensure ~~the-continuation-of-Dr-Sarton's-work-and-the-transplantation~~ of ~~the~~ Isis by the to a safer hemisphere for the transplantation/of Dr Sarton , his work, and the internationl journal Isis fathered by him , Then came the foundation in th USA of the international History of Science Society . In 1927 the vision/of Aldo Mieli ~~and--of-Helene-Metz~~ led to the foundation of the International Academy for the History of Science , whose first President was Gino Loria , still in his tenth decade adding to the knowledge of the History of Mathematics. Fostered through good and evil days by the devotion of Aldo Mieli and of its Hon. Treasurer Helene Metzger, victim of Nazi savagery . ~~The Academy has joined~~ now affiliated to the International Union.

122

The Academy has formed an International Union, affiliated to the International Council of Scientific Unions, itself fostered by the ~~all-embracing~~ yet wider embrace of the United Nations Educational, Scientific and Cultural Organisation.

80 words to present.

The title leads once more to consideration of the function of the History of Science.~~-With-all~~ There is a striking analogy with the function of Humanism five hundred years ago. Both made small beginnings in a disturbed world. In the fifteenth century, scholastic philosophy was btreaking down; the Universal Church was ceasing to be universal, ~~theology in hot dispute that was to lead to divided Churches;~~ economic revolution was ~~after discovery~~ displacing ~~Feudalism~~ the old values based on land , rooted ~~in Fudalism ;~~ Politically, feudalism was dissolving into the nation states; In Education, ~~the~~ ~~medieval~~ rationalism and lo

Logic was yielding to the humanistic stress on Language. In Philosophy, Theology, Economics, Politics, Education, great Discontinuities were temporarily healed by Humanism. Comparable discontinuities in our world may in the next generation be comparably bridged by the evolution of the New Humanism to the Historical Outlook which has itself Broadened to survey the Histort of Civilisation. The Scientific Age has recognised its need to know and to understand the History of Science.

Box. But Sor for Hist Sci

Answer attached

30.11.48

42,Lyndewode Road,
Cambridge.

27, November.1948.

My dear Singer,

Thank you very much for your version of your Presidential Address. It was a good deal longer that I had expected. But I thought that it would be a pity to have to cut it down. So I have taken the step of dropping the formal message which you gave me earlier and which was to have been the first item in the Bulletin. I hope you will not mind this.

There were one or two places at which I found it difficult to read your writing; so perhaps you would be good enough to read through the enclosed copy and point out any mistakes to me. At the foot of page 4 there is a place where you had obviously omitted some words in your script, and I have filled in the words "historian in general", as a good guess of what you meant. Is this correct?

I am enclosing two recent items of my own in the hopes that they may interest you.

With best wishes,

Yours sincerely,

Sam Pilley

Please thank Mrs. Singer for Re abstract of her Index on Pringle, which arrived safely

SC

Dr Charles Singer,
Kilmarth,
Par,
Cornwall.

Brit Soc Hist Sci ← file

20th November, 1948.

Dear Dr. Lilley,

You will have safely received the epitome of my husband's paper, posted yesterday. Here is Sir John Pringle and his Circle epitomised to 500 words as requested. I know that you allocate your space very exactly but if you have an extension from another contributor do not hesitate to shorten the enclosed.

With our best greetings,

Yours sincerely,

Dr. Lilley,

St. Johns College,
Cambridge.

Mrs. C. Singer.

30 November, 1948.

My dear Lilley,

Many thanks for your letter of November 27. which reaches me here today. I return my Presidential Address with such corrections as seem necessary. I think you are quite right to drop the formal message in the Bulletin.

Many thanks for your two articles which I look forward to reading.

With all good wishes in which Mrs. Singer joins,
believe me to be,
Yours sincerely,

Dr. S. Lilley,
42, Lyndewode,
Cambridge.

Charles Singer.

To Lilly by request
19 Nov 48

Sir John Pringle and his Circle.

Sir John Pringle (1707 - 1882) President of the Royal Society from 1772 to 1778 was typical of all that was best in eighteenth century cultured London society, and he foreshadows activities in the following centuries both in sense of public responsibility for the living and working conditions of the labouring population; and in his appreciation of the importance of public measures for the prevention rather than the cure of disease.

His view of medicine might almost be epitomised as cleanliness, to be achieved by purification of the air without and of the bloodstream within the patient. The first he would effect by Ventilation, the second by correct Diet. For the former, he would utilise the skill of the engineer. For the latter he recognised the need

of laboratory experiements, to ascertain the "septic" and "antiseptic" qualities inherent in various substances. His own experiments to this end were highly rated by his contemporaries. They were carried out on substances organic and inorganic. Pringle was not an innovator but his alert and benevolent mind was concerned to apply the creative activity of his contemporaries.

Born into a comfortable Scottish home with assured social position, Pringle received a good classical grounding at St. Andrews under a beloved relative, Francis Pringle. After medical study at Edinburgh and Leyden, he settled in Edinburgh and was soon combining the practice of medicine with a University professor in Philosophy. An introduction to the Earl of Starr

led to his appointment as physician to the British Army in the Low Countries and soon he was in charge of the hospital there. It was during this campaign and probably on Pringle's suggestion, that for the first time, the commanders on each side undertook not to molest the enemy's hospitals. Pringle's very careful observations and notes during the years of his Army service culminated in his great book Observations on Diseases of the Army in Camp and Garrison. This work attracted attention throughout Europe.

Meanwhile, soon after peace was declared Pringle left the Army and settled in practice in London where he had already been elected Fellow of the Royal Society. He was soon recognised as a leader in the Medical Profession. His influence was always used to promote justice and generosity toward his fellow men. His great contribution to

practical wellbeing was his observation that men contracted the same diseases in Army hospitals and in gaols! The disease was Typhus and Pringle's energetic advocacy of greater cleanliness and of Ventilation in these institutions led to reforms combating perhaps worse evils than diseases.

Pringle's presidency of the Royal Society was distinguished by brilliant historical discourses with which he introduced the recipients of the Society's Copley medal. The most distinguished medalist in his reign was Capt. James Cook, who no doubt owed to the advice of the great physician his achievement of a voyage of three years (1772 - 5) in distant waters without the loss of a single man from disease.

Pringle was intimate also with the brilliant circle of Non-Comformists who were contributing to scientific

knowledge in those years. A more extended account of Sir John Pringle and his circle will appear in part of the forthcoming number of the "Annals of Science).

Blue bag

FRO
7044.

43 Courtfield Rd
S.W.7

14/4

Dear Charles Singer.

Thanks. Do let me meet you both when in London. This would be a pleasure + really helpful to me. I am now remarried + wd bring One, my wife, + will you come here?

Am now whole time on scientific method i.e. my theory of one-way processes. Attached gives some idea of the approach.

Please let me know when in London

Yours ever
Lancelot Hogben

† Unitary Principle : "ϕ" Asymmetry decreases in isolable$^{\#}$ processes

(Axiom of general theory of one-way$^{\times}$ processes)

ϕ Lack of symmetry w.r.t. some spatial transformation (translation, rotation, etc)

\# i.e. capable of representation (causal description) without reference to its environment, or setting.

$\times$ one-way = moving "irreversibly" towards some end-state. (if left alone)

Examples

1) Entropy : Heat processes reduce differences of temp. (i.e. special type of asymmetry)

2) Many physical processes represent decrease of differences of some intensive magnitude (potential, etc)

3) All formative processes (in which spatial form is developed, i.e. clarified, perfected, or extended)

can be represented as decrease of asymmetry.

(nucleic formation, crystallization, etc)
protein molecule multiplication, etc.

i.e. One way processes move towards an equilibrium end-state characterized by some type of symmetry.

"Force" ≡ "Asymmetries"

† It is a generalization of entropy concept.

14/4/48

Dr Charles Singer.
with compliments &
affectionate greetings
from Lancelot Hogben.

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Vol. I

PROCEEDINGS OF THE CONGRESS

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ONE-WAY PROCESSES IN BIOLOGY

For a period the interest of the physiologist and biochemist was concentrated on reversible processes. The irreversible aspects of organic phenomena were treated as obvious and theoretically unimportant, mere by-products of the fundamental reversible physico-chemical processes. Morphologically all life is irreversible, but that was regarded as less interesting — possibly a result of the one-way flow of solar radiation. The aim of the exact biologist was to reduce the general irreversibility of life to reversible elementary processes, just as the evening out of temperature differences represented the inevitable degradation of the energy of such elementary processes.

The above formulation is based an a conversation with Prof. A. Mayerhof in 1929, and I think it gives a fair picture of a view which has been widely held in recent times. I wish to suggest that it is no longer adequate for biologists concerned with either fundamental structure or general laws.

Earlier it was legitimate for a thermodynamically-minded physiologist to neglect molecular structure and to treat the gross morphological aspects of the organism as a relatively unimportant secondary result of the perpetual degradation of solar energy. But today we are in possession of much information regarding not only the formation and structure of individual molecules, but also the relation of molecular structure to the structure of extended tissues. This means that the classical morphology of the total form of the mature organism must be regarded as one aspect of a wider organic morphology, including not only molecular and tissue structure but also the processes by which organic patterns are developed and sustained. From this broader point of view even the physiological homeostasis of the adult organism can be regarded as a special type of morphogenesis: the restoration, after disturbance, of a normal pattern of structural processes.

Within this structural approach the problem of reversibility and irreversibility acquires a new significance, and a clearer conception of "irreversibility" becomes necessary. The point is not that some given process cannot be reversed, but that left to itself it displays a characteristic trend or tendency, a directed property which carries it progressively *one way*, so that the process (while isolated) never returns identically to an earlier state. We can, for example, define a *one-way process* as *a finite process which, when isolated, never completes a cycle but continually approaches a characteristic end-state.*

It is not possible to discuss here the relation of this concept to the form of fundamental physical laws, but the concept can also be regarded

as *a rule for selecting limited processes which, for certain purposes, can be treated as isolable*, i.e. can be described without reference to their setting. This conception of one-way process, i.e. this method of isolating limited processes for separate consideration, in the more specific and constructive form suggested below, may be of value for the purposes of theoretical biology.

In any particular one-way process, as defined above, there is a characteristic *asymmetrical relation* (i.e. a relation incompatible with its converse; Russell) between the space-description of an earlier state and that of a later state. In other words, there is an ordered series of states which is correlated with the succession of time instants; the process goes one-way towards its end-state in the course of historical time. The asymmetrical relation which generates the serial order may, for example, be: *less than*, the differences of some physical magnitude at different points in a later state being always less than the differences in an earlier state. Obvious examples are differences of temperature, of potential, or of other intensity magnitudes, all of which decrease in the course of isolated processes. A less well known example is the decrease of spatial asymmetry (with respect to translations or rotations) in the course of the formation of symmetrical structures (molecules, crystals, fibres, etc.).

The *applied theory of one-way processes* is thus the study of the asymmetrical relations in natural phenomena, and it proves that the symmetrical relations of mathematical physics excluding entropy (e.g. equality, equations, conservation, cycles, reversibility) must necessarily constitute a special (logically degenerate) limiting case of the wider field of asymmetrical relations. Or in simpler language, both physics and biology may have need of a fundamental structural concept of a one-way process, because *one-way processes are of a more general character than reversible processes*, which represent merely ideal limiting cases that never actually occur. Physical and biological phenomena may therefore exist which cannot be described in terms of concepts based on symmetrical relations only (e.g. symmetry with respect to the substitution of $-t$ for $+t$, conservation principles, equations), but may have the essential character of one-way processes, and require to be represented in terms of *inequalities*. The statistical concept of entropy ($S_2 > S_1$) may have to be generalised to provide a structural concept of a one-way process.

Indeed certain organic processes, now of particular interest, do possess this one-way property. Autocatalytic synthesis, or the identical *multiplication* of specific molecular patterns, displays an irreducible one-way character. This is equally true of the process of differentiation, at least in certain phases of the developing embryo; but this may be an expression of differential synthesis, and so fall partly under the first example. A second, independent, example of irreducible one-way character is provided by all those processes which leave a residual *modification* of protein, so that subsequent processes are altered, usually with the result that the

original process is facilitated (i.e. simplified, stabilised, and re-inforced). Thus synthetic multiplicaton and adaptive modification are two fundamental examples of biological one-way processes, and no structural theory covering them is possible without a comprehensive structural concept of a one-way process.

Moreover these two classes of biological phenomena, the multiplication of structural units and the modification of extended protein systems, share a common formal characteristic: in both the process is autocatalytic, i.e. results in a pattern which facilitates the repetition of the process. The synthesised unit catalyses its own furher multiplication, and the modified protein facilitates the repetition of the process. Finally in both the process is formative, i.e. a spatial pattern is developed which itself tends to develop further by bringing about a repetition of the process by which it was formed.

This suggests that the advance towards a simple and yet comprehensive theoretical biology may be eased by the introduction of the concept of a *formative process* in which asymmetries tend to disappear and stable symmetrical patterns are developed and extended (subject to the existing conditions). The consideration of the relation of this conception to special physical and biological processes will be undertaken elsewhere. I wished only to call your attention to three points: (1) The importance of asymmetrical relations in biology. (2) The need of defining a precise concept of a structural (non-statistical) one-way process. (3) The possibility of using the concept of a formative process (decrease of spatial asymmetry in isolable processes) to clarify biological problems.