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THE PLACE OF SCIENCE IN A LIBERAL EDUCATION

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Science, to the ordinary reader of newspapers, is represented by a

varying selection of sensational triumphs, such as wireless telegraphy

and aeroplanes, radio-activity and the marvels of modern alchemy. It is

not of this aspect of science that I wish to speak. Science, in this

aspect, consists of detached up-to-date fragments, interesting only

until they are replaced by something newer and more up-to-date,

displaying nothing of the systems of patiently constructed knowledge

out of which, almost as a casual incident, have come the practically

useful results which interest the man in the street. The increased

command over the forces of nature which is derived from science is

undoubtedly an amply sufficient reason for encouraging scientific

research, but this reason has been so often urged and is so easily

appreciated that other reasons, to my mind quite as important, are apt

to be overlooked. It is with these other reasons, especially with the

intrinsic value of a scientific habit of mind in forming our outlook

on the world, that I shall be concerned in what follows.

The instance of wireless telegraphy will serve to illustrate the

difference between the two points of view. Almost all the serious

intellectual labour required for the possibility of this invention is

due to three men--Faraday, Maxwell, and Hertz. In alternating layers

of experiment and theory these three men built up the modern theory of

electromagnetism, and demonstrated the identity of light with

electromagnetic waves. The system which they discovered is one of

profound intellectual interest, bringing together and unifying an

endless variety of apparently detached phenomena, and displaying a

cumulative mental power which cannot but afford delight to every

generous spirit. The mechanical details which remained to be adjusted

in order to utilise their discoveries for a practical system of

telegraphy demanded, no doubt, very considerable ingenuity, but had

not that broad sweep and that universality which could give them

intrinsic interest as an object of disinterested contemplation.

From the point of view of training the mind, of giving that

well-informed, impersonal outlook which constitutes culture in the

good sense of this much-misused word, it seems to be generally held

indisputable that a literary education is superior to one based on

science. Even the warmest advocates of science are apt to rest their

claims on the contention that culture ought to be sacrificed to

utility. Those men of science who respect culture, when they associate

with men learned in the classics, are apt to admit, not merely

politely, but sincerely, a certain inferiority on their side,

compensated doubtless by the services which science renders to

humanity, but none the less real. And so long as this attitude exists

among men of science, it tends to verify itself: the intrinsically

valuable aspects of science tend to be sacrificed to the merely

useful, and little attempt is made to preserve that leisurely,

systematic survey by which the finer quality of mind is formed and

nourished.

But even if there be, in present fact, any such inferiority as is

supposed in the educational value of science, this is, I believe, not

the fault of science itself, but the fault of the spirit in which

science is taught. If its full possibilities were realised by those

who teach it, I believe that its capacity of producing those habits of

mind which constitute the highest mental excellence would be at least

as great as that of literature, and more particularly of Greek and

Latin literature. In saying this I have no wish whatever to disparage

a classical education. I have not myself enjoyed its benefits, and my

knowledge of Greek and Latin authors is derived almost wholly from

translations. But I am firmly persuaded that the Greeks fully deserve

all the admiration that is bestowed upon them, and that it is a very

great and serious loss to be unacquainted with their writings. It is

not by attacking them, but by drawing attention to neglected

excellences in science, that I wish to conduct my argument.

One defect, however, does seem inherent in a purely classical

education--namely, a too exclusive emphasis on the past. By the study

of what is absolutely ended and can never be renewed, a habit of

criticism towards the present and the future is engendered. The

qualities in which the present excels are qualities to which the study

of the past does not direct attention, and to which, therefore, the

student of Greek civilisation may easily become blind. In what is new

and growing there is apt to be something crude, insolent, even a

little vulgar, which is shocking to the man of sensitive taste;

quivering from the rough contact, he retires to the trim gardens of a

polished past, forgetting that they were reclaimed from the wilderness

by men as rough and earth-soiled as those from whom he shrinks in his

own day. The habit of being unable to recognise merit until it is

dead is too apt to be the result of a purely bookish life, and a

culture based wholly on the past will seldom be able to pierce through

everyday surroundings to the essential splendour of contemporary

things, or to the hope of still greater splendour in the future.

"My eyes saw not the men of old;

And now their age away has rolled.

I weep--to think I shall not see

The heroes of posterity."

So says the Chinese poet; but such impartiality is rare in the more

pugnacious atmosphere of the West, where the champions of past and

future fight a never-ending battle, instead of combining to seek out

the merits of both.

This consideration, which militates not only against the exclusive

study of the classics, but against every form of culture which has

become static, traditional, and academic, leads inevitably to the

fundamental question: What is the true end of education? But before

attempting to answer this question it will be well to define the sense

in which we are to use the word "education." For this purpose I shall

distinguish the sense in which I mean to use it from two others, both

perfectly legitimate, the one broader and the other narrower than the

sense in which I mean to use the word.

In the broader sense, education will include not only what we learn

through instruction, but all that we learn through personal

experience--the formation of character through the education of life.

Of this aspect of education, vitally important as it is, I will say

nothing, since its consideration would introduce topics quite foreign

to the question with which we are concerned.

In the narrower sense, education may be confined to instruction, the

imparting of definite information on various subjects, because such

information, in and for itself, is useful in daily life. Elementary

education--reading, writing, and arithmetic--is almost wholly of this

kind. But instruction, necessary as it is, does not \_per se\_

constitute education in the sense in which I wish to consider it.

Education, in the sense in which I mean it, may be defined as \_the

formation, by means of instruction, of certain mental habits and a

certain outlook on life and the world\_. It remains to ask ourselves,

what mental habits, and what sort of outlook, can be hoped for as the

result of instruction? When we have answered this question we can

attempt to decide what science has to contribute to the formation of

the habits and outlook which we desire.

Our whole life is built about a certain number--not a very small

number--of primary instincts and impulses. Only what is in some way

connected with these instincts and impulses appears to us desirable or

important; there is no faculty, whether "reason" or "virtue" or

whatever it may be called, that can take our active life and our hopes

and fears outside the region controlled by these first movers of all

desire. Each of them is like a queen-bee, aided by a hive of workers

gathering honey; but when the queen is gone the workers languish and

die, and the cells remain empty of their expected sweetness. So with

each primary impulse in civilised man: it is surrounded and protected

by a busy swarm of attendant derivative desires, which store up in its

service whatever honey the surrounding world affords. But if the

queen-impulse dies, the death-dealing influence, though retarded a

little by habit, spreads slowly through all the subsidiary impulses,

and a whole tract of life becomes inexplicably colourless. What was

formerly full of zest, and so obviously worth doing that it raised no

questions, has now grown dreary and purposeless: with a sense of

disillusion we inquire the meaning of life, and decide, perhaps, that

all is vanity. The search for an outside meaning that can \_compel\_ an

inner response must always be disappointed: all "meaning" must be at

bottom related to our primary desires, and when they are extinct no

miracle can restore to the world the value which they reflected upon

it.

The purpose of education, therefore, cannot be to create any primary

impulse which is lacking in the uneducated; the purpose can only be to

enlarge the scope of those that human nature provides, by increasing

the number and variety of attendant thoughts, and by showing where the

most permanent satisfaction is to be found. Under the impulse of a

Calvinistic horror of the "natural man," this obvious truth has been

too often misconceived in the training of the young; "nature" has been

falsely regarded as excluding all that is best in what is natural, and

the endeavour to teach virtue has led to the production of stunted and

contorted hypocrites instead of full-grown human beings. From such

mistakes in education a better psychology or a kinder heart is

beginning to preserve the present generation; we need, therefore,

waste no more words on the theory that the purpose of education is to

thwart or eradicate nature.

But although nature must supply the initial force of desire, nature is

not, in the civilised man, the spasmodic, fragmentary, and yet violent

set of impulses that it is in the savage. Each impulse has its

constitutional ministry of thought and knowledge and reflection,

through which possible conflicts of impulses are foreseen, and

temporary impulses are controlled by the unifying impulse which may be

called wisdom. In this way education destroys the crudity of

instinct, and increases through knowledge the wealth and variety of

the individual's contacts with the outside world, making him no longer

an isolated fighting unit, but a citizen of the universe, embracing

distant countries, remote regions of space, and vast stretches of past

and future within the circle of his interests. It is this simultaneous

softening in the insistence of desire and enlargement of its scope

that is the chief moral end of education.

Closely connected with this moral end is the more purely intellectual

aim of education, the endeavour to make us see and imagine the world

in an objective manner, as far as possible as it is in itself, and not

merely through the distorting medium of personal desire. The complete

attainment of such an objective view is no doubt an ideal,

indefinitely approachable, but not actually and fully realisable.

Education, considered as a process of forming our mental habits and

our outlook on the world, is to be judged successful in proportion as

its outcome approximates to this ideal; in proportion, that is to say,

as it gives us a true view of our place in society, of the relation of

the whole human society to its non-human environment, and of the

nature of the non-human world as it is in itself apart from our

desires and interests. If this standard is admitted, we can return to

the consideration of science, inquiring how far science contributes to

such an aim, and whether it is in any respect superior to its rivals

in educational practice.

II

Two opposite and at first sight conflicting merits belong to science

as against literature and art. The one, which is not inherently

necessary, but is certainly true at the present day, is hopefulness

as to the future of human achievement, and in particular as to the

useful work that may be accomplished by any intelligent student. This

merit and the cheerful outlook which it engenders prevent what might

otherwise be the depressing effect of another aspect of science, to my

mind also a merit, and perhaps its greatest merit--I mean the

irrelevance of human passions and of the whole subjective apparatus

where scientific truth is concerned. Each of these reasons for

preferring the study of science requires some amplification. Let us

begin with the first.

In the study of literature or art our attention is perpetually riveted

upon the past: the men of Greece or of the Renaissance did better than

any men do now; the triumphs of former ages, so far from facilitating

fresh triumphs in our own age, actually increase the difficulty of

fresh triumphs by rendering originality harder of attainment; not only

is artistic achievement not cumulative, but it seems even to depend

upon a certain freshness and \_naïveté\_ of impulse and vision which

civilisation tends to destroy. Hence comes, to those who have been

nourished on the literary and artistic productions of former ages, a

certain peevishness and undue fastidiousness towards the present, from

which there seems no escape except into the deliberate vandalism which

ignores tradition and in the search after originality achieves only

the eccentric. But in such vandalism there is none of the simplicity

and spontaneity out of which great art springs: theory is still the

canker in its core, and insincerity destroys the advantages of a

merely pretended ignorance.

The despair thus arising from an education which suggests no

pre-eminent mental activity except that of artistic creation is wholly

absent from an education which gives the knowledge of scientific

method. The discovery of scientific method, except in pure

mathematics, is a thing of yesterday; speaking broadly, we may say

that it dates from Galileo. Yet already it has transformed the world,

and its success proceeds with ever-accelerating velocity. In science

men have discovered an activity of the very highest value in which

they are no longer, as in art, dependent for progress upon the

appearance of continually greater genius, for in science the

successors stand upon the shoulders of their predecessors; where one

man of supreme genius has invented a method, a thousand lesser men can

apply it. No transcendent ability is required in order to make useful

discoveries in science; the edifice of science needs its masons,

bricklayers, and common labourers as well as its foremen,

master-builders, and architects. In art nothing worth doing can be

done without genius; in science even a very moderate capacity can

contribute to a supreme achievement.

In science the man of real genius is the man who invents a new method.

The notable discoveries are often made by his successors, who can

apply the method with fresh vigour, unimpaired by the previous labour

of perfecting it; but the mental calibre of the thought required for

their work, however brilliant, is not so great as that required by the

first inventor of the method. There are in science immense numbers of

different methods, appropriate to different classes of problems; but

over and above them all, there is something not easily definable,

which may be called \_the\_ method of science. It was formerly customary

to identify this with the inductive method, and to associate it with

the name of Bacon. But the true inductive method was not discovered by

Bacon, and the true method of science is something which includes

deduction as much as induction, logic and mathematics as much as

botany and geology. I shall not attempt the difficult task of stating

what the scientific method is, but I will try to indicate the temper

of mind out of which the scientific method grows, which is the second

of the two merits that were mentioned above as belonging to a

scientific education.

The kernel of the scientific outlook is a thing so simple, so obvious,

so seemingly trivial, that the mention of it may almost excite

derision. The kernel of the scientific outlook is the refusal to

regard our own desires, tastes, and interests as affording a key to

the understanding of the world. Stated thus baldly, this may seem no

more than a trite truism. But to remember it consistently in matters

arousing our passionate partisanship is by no means easy, especially

where the available evidence is uncertain and inconclusive. A few

illustrations will make this clear.

Aristotle, I understand, considered that the stars must move in

circles because the circle is the most perfect curve. In the absence

of evidence to the contrary, he allowed himself to decide a question

of fact by an appeal to æsthetico-moral considerations. In such a case

it is at once obvious to us that this appeal was unjustifiable. We

know now how to ascertain as a fact the way in which the heavenly

bodies move, and we know that they do not move in circles, or even in

accurate ellipses, or in any other kind of simply describable curve.

This may be painful to a certain hankering after simplicity of pattern

in the universe, but we know that in astronomy such feelings are

irrelevant. Easy as this knowledge seems now, we owe it to the courage

and insight of the first inventors of scientific method, and more

especially of Galileo.

We may take as another illustration Malthus's doctrine of population.

This illustration is all the better for the fact that his actual

doctrine is now known to be largely erroneous. It is not his

conclusions that are valuable, but the temper and method of his

inquiry. As everyone knows, it was to him that Darwin owed an

essential part of his theory of natural selection, and this was only

possible because Malthus's outlook was truly scientific. His great

merit lies in considering man not as the object of praise or blame,

but as a part of nature, a thing with a certain characteristic

behaviour from which certain consequences must follow. If the

behaviour is not quite what Malthus supposed, if the consequences are

not quite what he inferred, that may falsify his conclusions, but does

not impair the value of his method. The objections which were made

when his doctrine was new--that it was horrible and depressing, that

people ought not to act as he said they did, and so on--were all such

as implied an unscientific attitude of mind; as against all of them,

his calm determination to treat man as a natural phenomenon marks an

important advance over the reformers of the eighteenth century and the

Revolution.

Under the influence of Darwinism the scientific attitude towards man

has now become fairly common, and is to some people quite natural,

though to most it is still a difficult and artificial intellectual

contortion. There is however, one study which is as yet almost wholly

untouched by the scientific spirit--I mean the study of philosophy.

Philosophers and the public imagine that the scientific spirit must

pervade pages that bristle with allusions to ions, germ-plasms, and

the eyes of shell-fish. But as the devil can quote Scripture, so the

philosopher can quote science. The scientific spirit is not an affair

of quotation, of externally acquired information, any more than

manners are an affair of the etiquette-book. The scientific attitude

of mind involves a sweeping away of all other desires in the interests

of the desire to know--it involves suppression of hopes and fears,

loves and hates, and the whole subjective emotional life, until we

become subdued to the material, able to see it frankly, without

preconceptions, without bias, without any wish except to see it as it

is, and without any belief that what it is must be determined by some

relation, positive or negative, to what we should like it to be, or to

what we can easily imagine it to be.

Now in philosophy this attitude of mind has not as yet been achieved.

A certain self-absorption, not personal, but human, has marked almost

all attempts to conceive the universe as a whole. Mind, or some aspect

of it--thought or will or sentience--has been regarded as the pattern

after which the universe is to be conceived, for no better reason, at

bottom, than that such a universe would not seem strange, and would

give us the cosy feeling that every place is like home. To conceive

the universe as essentially progressive or essentially deteriorating,

for example, is to give to our hopes and fears a cosmic importance

which \_may\_, of course, be justified, but which we have as yet no

reason to suppose justified. Until we have learnt to think of it in

ethically neutral terms, we have not arrived at a scientific attitude

in philosophy; and until we have arrived at such an attitude, it is

hardly to be hoped that philosophy will achieve any solid results.

I have spoken so far largely of the negative aspect of the scientific

spirit, but it is from the positive aspect that its value is derived.

The instinct of constructiveness, which is one of the chief incentives

to artistic creation, can find in scientific systems a satisfaction

more massive than any epic poem. Disinterested curiosity, which is the

source of almost all intellectual effort, finds with astonished

delight that science can unveil secrets which might well have seemed

for ever undiscoverable. The desire for a larger life and wider

interests, for an escape from private circumstances, and even from the

whole recurring human cycle of birth and death, is fulfilled by the

impersonal cosmic outlook of science as by nothing else. To all these

must be added, as contributing to the happiness of the man of science,

the admiration of splendid achievement, and the consciousness of

inestimable utility to the human race. A life devoted to science is

therefore a happy life, and its happiness is derived from the very

best sources that are open to dwellers on this troubled and passionate

planet.