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pro^{of}

Elementary Bodies

When we take a survey of the great Diversity of materials that seem to compose the different Bodies in nature we might be led to conclude that it would be impracticable to reduce them to any kind of order, & did they exist so the attempt would be fruitless, but I'm inclin'd to think that they are all composed of the same materials acted on by a difference of aggregation or that the most compound bodies we meet with may by various processes or by chymistry be reduced to a few elementary principles which are similar in all bodies however different they appear - The regularity & immutability with which the combination of the Elements have gone on since the earliest periods is a proof of it, the most lofty trees & tender plants are nourished by the same food & their parts the same properties as ever, & an animal the same in their nature, the same simplicity &

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it burnt all their cloths, but this might have happened from the great gravity of the acid which would sink it to the bottom of the water & the cloths dipped into it before mixture which might readily burn them & could easily have been prevented by agitation till the acid & water were perfectly united — Tho the mixture of salts & water of themselves will hardly separate yet there are several chymical processes for this purpose, one of which is evaporation to dryness this operation depends upon the power of heat to overcome the attraction of the water for the salt & to make the former fly off in vapour leaving the other dry behind it in the vessel used for this purpose under the form of a white spongy mass composed of particles whose figures are not easy to discern, but the method most commonly followed by those who prepare salts for sale is by crystallization which is performed by evaporating the water till a thin pellicle or crust like dust is form.

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or

be a very complicated figure something
line described by a point in the spoke
while the wheel is going over a round hilltop, whose
radius is 13 times that of the wheel. Tell therefore we
know the shape & position of this figure, you must
without hesitation agree with me when I say that it is
absurd to pretend to any knowledge, or to the acquisition
of any knowledge, of the powers by which she is agitated a
blind man may with equal reason pretend to discover
the sentiments which attend the mind of a speaker
without understanding the language in which he speaks.
farther let us consider the particular object of our
study. it is to investigate those powers of nature by
which the known phenomena are produced. From what
I lately delivered it appears that all our notions of
powers are taken from their effects. The effects or pheno-
mena are signs of the power, and therefore Lord Bacon
considerd them as the language of nature, informing us
of her laws. But this is not all, we have no notion of
the power differing from the effect. When Sir J. N.
has demonstrated that the power which retains the
Moon in her orbit is a centripital power, what does
he mean? nothing more than that the Moon tends

towards the Sun and a little more particularly to the subject
projection. in order to ascertain the form, and ^{steps} helps of
the Earth and explanation which is most intimately con-
nected with it and therefore best calculated for promoting our
knowledge.

The subject of our speculation is the sensible motion
and actions of bodies. By the actions we mean the produc-
tion of change in the situation of other bodies. This can
only be done by producing in them change of motion.
motion therefore is the principle subject of our specu-
lation.

A body in motion either wholly changes its place and
describes a figure various according to the nature of the
motion, or it only turns round its axis in which case
its various points describe circles having the axes in
their Centres or it does both.

In order therefore that our phenomenology may be
accurate, and a fit foundation for reasoning we
must understand the nature of the figure described.
In order to discover the forces by which the moon is
agitated in her orbit round the Earth, we must
know what are her motions, we must know the line
she describes. To a spectator on the Earth she
appears to describe an ellipse having the Earth
in one focus. But in the mean time the Earth is carried
round the Sun. Her real path therefore must

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towards the Earth, and were it not for her motion of projection, would approach it. we consider this approach as the Effect of a tendency, but when we come to think seriously, we have no notion of the tendency differing from the approach.

When Sir J. N. demonstrated that this tendency was $\propto \frac{1}{D^2}$ or that at half the distance it was four times as great, what does he mean? nothing more than that at half the distance the approach which she would make is four times greater than at the whole distance.

There is one case indeed in which we seem to know the cause independent of the effects, that is impulse, and from this opinion it is that Philosophers have always endeavoured to reduce the other phenomena of nature to this, and show them to be cases of impulse. Hence the Vortices of Descartes and the subtile fluids of other philosophers. But much labour might be spared, and much time saved which has been employed in jumbling contradictions, and reconciling inconsistencies. For when we have with much labour, and at the expence of much false reasoning shewed that our phenomenon is a case of impulse, we are little nearer a compleat explanation, for that power by which a body in motion produces motion and a certain determined degree of it in the body which it happens to strike, that power I say is known only by the effect, and we have no notion of the power differing from the effect itself. we must therefore not only say with Lord Bacon that the effects are the signs of their causes

and the phenomena the language of nature. But we must
add that with respect to us there is no difference between
the effect and the metaphysical cause, and that we
perceive the powers of nature not only by their effects
but in their effects.

What follows from the reasoning? does it not
inevitably follow that without a knowledge of the real motion
of bodies & their actions on each other, both as to direction and
quantity, we know nothing of the powers of nature, and
that our knowledge of the causes of all the sensible
motions & actions of bodies is little more than a knowledge
of the motions and actions themselves. all the differences
will be shown to be in this, that one change of motion may
be produced by different remote causes. Thus the motion
of a clock may be produced by a weight or a spring, that of
a mill by the pressure or by the impulse of water, or by
the impulse of wind. But in all these cases the immediate
metaphysical cause is the same, and known only in the
motion which it produces. Nay in the investigation of the
remote cause, and the decision to which of many the effect
belongs, is accomplished only by tracing thro' the imme-
diate cause each of which are known only in its effects.

What I have now delivered entitles me justly to say
that no knowledge of the powers of Nature can be acquired
but in the knowledge of the motion which they produce, and
that the accuracy of our knowledge, and its applicability
~~to the prosecution of the sciences~~ the purpose of life must ever

be in proportion to the accuracy of our knowledge of the motions themselves. I have farther made you sensible that these motions or changes of motions are so many figures or changes of figures. The conclusion I wanted to draw from the whole evidently follows. Viz. that it is in vain & illogical to expect any knowledge of the general laws of nature, and of the immediate causes of the phenomena, without some knowledge of the properties of figure, and the art of computation. That is without the assistance of Geometry & Arithmetic. It is ~~impossible~~ impossible to show the nature of that power which retains the planets in their orbits round the sun, and to demonstrate that at twice the distance it is but $\frac{1}{4}$ as strong except to him who knows the proportions of the parts of that ^{curve} ~~curve~~ which she describes. It is impossible to teach the theory of Gunnery to him who is ignorant of the properties of a curve whose abscissae are as the squares of its ordinates. But on the other hand it is to this circumstance, to the nature of the subject, continually involving or implying the properties of figure and number that we are indebted for that accuracy which is attained, and that progress which is made in general physic; an accuracy & progress which is to be met with in no other branch of the science of nature. It is owing to the generality & simplicity of the subject - It is always measurable may proper quantity all the changes which are produced by the sensible motion and action of bodies are capable of being doubled, tripled, halved, added subtracted and any how proportioned. This is true of every modification of motion, & may be

swifter, slower, more to the east, more to the west con-
tinued for a longer or a shorter time may be performed
by a larger or a smaller body, may overcome a greater
or a smaller obstacle. Each of these may be the object of our
search either as the cause of some actual appearance, or
as an effect to be produced. Now as this is true of all kinds
of Quantities indiscriminately, any kind of quantity may be
used for the general representative. The species of quantity
which is most convenient is extended quantity, the subject
of Geometry. For 1st this kind of quantity is employed in
almost all the subjects of our speculation. Motion im-
mediately involves it, for bodies move in lines straight
crooked, and variously posited. It is the obvious measure
of velocity, or more properly velocity is only a time
expressing a certain relation between the line run over
and the time employed: that velocity being called double
when the line described is double. It is the only means
of measuring the quantity of matter in a body, for this
depends on the Bulk & figure of the body and the distance
of its particles. Lastly it is the only measure of time we
can feel that one portion of duration ~~is~~ is greater
than another, but without some extended quantity,
such as the quantity of sand run out, or the quantity
of space passed over by the hand of the clock or shadow
of the dial we have no way of determining the proportion
of different parts of time.

2^d All the properties of numbers, the foundation of the
art of computation, have their analogons representation

in Geometry - a sum the sum of lines, a product the
rectangle of lines, a quotient the side of a rectangle.

Thus then, if we trace out the real Geometrical
quantities which occur in any physical phenomenon
and employ the proper Geometrical representations
for time and number, our investigation must acquire
all that accuracy which arises from the simplicity of
the subject, and which so eminently distinguishes
Geometry setting it above all other sciences.

I know that of late an opinion has been allowed to
gain ground that a complete knowledge of natural
Philosophy may be acquired without mathematics.
But this is the language of those who having ^{no} mathema-
tical knowledge themselves, cannot be admitted as compe-
tent judges. I appeal to fact - it is only in those parts
of the science which have been mathematically considered
that nat. philosophy can boast of having carried on her
investigations with certainty, success, and utility. Many
think themselves natural philosophers because they
are in the habit of making experiments in Electricity,
Magnetism, Chymistry &c. This is very laudable, and by
such labours the science will in proper hands, advance.
But I would desire you to remember that these gentle-
men are either natural historians, employed in collecting
facts, and perhaps arranging them in such a manner as
may enable the man of true science to investigate their
causes, or they are employed in Chymistry, Physiology, or
such other branches of the general study of nature where, as
yet, we contend ourselves with discovery of causes, and where
the immediate cause of the phenomena is out of the question.
When the Chymists made their collection of Chymical

laws of solution precipitation and so on, they were either natural historians, or contented with joining together events whose relation was remote, but when Sir Isaac N. attempted to investigate the immediate cause, and consider that power which caused the effervescence in a mixture of chalk and aquafortis he found himself obliged to proceed on the properties of quantity. when D^r Black pointed out a variety of double exchanges, and arranged them in a convenient order he was either a Natural historian or contented with a discovery of remote causes. But when he came to investigate the immediate cause of the double exchange, & assert the nature of the power which produces it, he is obliged to employ the property of number and figure. In short, Gentlemen, without a moderate share of Mathematical knowledge, you can expect nothing than a school-boys acquaintance with natural philosophy resembling those religionists who take up their opinion on the authority of their priests, and neither can give a reason for what they think they believe, nor apply it to any good purpose in life.

Without a moderate share of Mathematical knowledge you may read the flimsy and indeterminate writings of a Nollit or a Priestly, but you cannot profit by the truths delivered by a D'Sambert or a Newton.

To such of you therefore as wish to advance beyond the imperfect rudiments of general physics I would earnestly recommend the cultivation of mathematical

learning. I do not mean that you can't
philosophy to great advantage without being possessed of
Mathematical knowledge which is necessary for understand-
ing all the writings of Newton, Euler, Bernouillie and
such eminent philosophers. Newton was the inventor
of a new mathematics, and, fond of his invention, he has
shown its applicability to physics at great length.
Euler, Bernouillie and others seem rather to have
taken natural philosophy as a subject on which
they would employ their mathematical knowledge,
than to have considered mathematics as an instru-
ment for acquiring an acquaintance with the operations
and powers of nature. These and several others have
therefore amused themselves and displayed their math-
ematical knowledge and address in determining
what would be ~~necessary~~ the events were the power
of nature of such and such a kind or what powers would
be necessary for producing such and such phenomena.
But if we content ourselves with knowing what
powers nature really exerts and what are these circum-
stances which regulate the phenomena consequent
on the powers which really obtain a very moderate share
of mathematical knowledge is sufficient.
If it is not presuming, I would venture to say that,
among the infinite variety of powers which the author
of nature might have implanted in the works of his
hands he seems to have chosen those which were most
simple and best fitted for successfully employing the

van laws of Sers of his intillectual creatures. If you have learned therefore the elements of plane Geometry and the most obvious propositions of the Conic-sections, you are in a condition to study Natural Philosophy with profit and acquire such a knowledge of it you will be able to apply to the purposes of life, which must be considered as the great end of all our Study.

Thus I have at considerable length given you an account of the general subject aim of Natural Philosophy, as the science employed in investigating the causes and explaining the phenomena of nature exhibited in the material system. I have shown you what is the proper method of conducting ourselves in both of these tasks namely by a comprehensive and distinct history of the subject, and by a copious induction confirmed by experiment. I then took notice of an important distinction to be made among the phenomena of nature. In one class the changes were produced by means of sensible motions and actions in the other by such as are insensible, and only infered from the change, by analogy with the first. I then gave you my reasons for proposing to confine my attention to the first class, as most likely to make us acquainted with the immediate causes of the observed changes, and as affording us a probability of ever explaining the phenomena of the other kind by tracing out the intermediate causes and

~~Law~~ subordinate of natural phenomena leaving nothing unexamined but individual facts which cannot be the subject of a general course.

Were we sufficiently acquainted with the general powers of nature there would be no occasion for deviating from this plan. But this is not always the case and therefore in order to produce the more forcible convictions or your understanding, and at the same time make you acquainted with the inductive Logic, I shall begin each considerable article of the following course by a history or account of some characteristic phenomena which, obtaining thro' the whole Class of phenomena compared in that article may be supposed to be a consequence of the general law which distinguishes that Class. In order to discover this general law the phenomena will either be related as the subject of common and daily observation, or it will be exhibited to you in the way of an experiment. Where I can I shall show how this phenomena may be deduced from the properties of body which are yet more general. This will be a specimen of the Analysis which makes one great object of philosophy discussion.

Having thus established a law which extends over a certain class of bodies I shall then by its means explain all the chief subordinate phenomena thus given you a specimen of the theory.

In the last branch of our employment, if the general principle is well authenticated, and the consequences justly drawn, the demonstration or theory must be complete and the conviction inevitable. But as this process must be carried on by means of the abstract sciences, and the object presented by them to the mind is of a very refined nature, and is ~~to~~ with difficulty apprehended by the imagination with that degree of veracity which is necessary for enabling us to reason from it with clearness and steadiness, it is extremely proper to remedy this inconvenience, and to render the attention more easy, as well as the Idea more lively. This may be done by exhibiting to the Eye an experiment, which tho' only a single fact, yet gives the mind a sensible object of perception, which it can contemplate and remember much more steadily than if it was merely a creature of the imagination. I could by a proper description convey such a notion of this room that a person with some attention, could perfectly understand any narration which I should give of any occurrence in it. But a moments glance at the room would be infinitely better than the most accurate description.

I shall therefore accompany my lectures with a regular course of experiments chiefly with this view of giving you a sensible object of attention and thus illustrate my philosophical doctrines. But I must

not dignify this with the title of experimental philosophy.
Experimental Philos.^y is the investigation of the general
powers of nature by a copious induction of experiments or facts.
This is the illustration of known principles by means of one
experiment. Indeed in those parts of our subject, we are not yet fully
understood, I shall be obliged to exhibit experiments with the view
view, as representatives of a thousand others of the same kind made use of
in order to assert some general principles & we have not been able
to deduce from any yet more general.

I have just one thing more to say on this head. The value of any
character does not depend on what a man knows, but on what he can
do. Knowledge is terminated in itself alone is but an amusement - at
the same time it is the amusement must become a man, gentleman
and one who has the advantage of a liberal education. It must
however be classed among the Evacues of life I should think
the employment of an idle hour. But the science has a close
connection wth life, it mingles wth all the arts, in the foundation of
many, & contributes to the improvement of all. I shall ever look
on this therefore as our principle object, to point out to you the
practical uses of doctrines w^{ch} may be established from time to time. What
we have scientifically investigated a course, and established as a
property of matter, we now employ as a mean in order to produce
its proper effects as the end proposed by the artist. means consist in
the exertions of power, and in the view are called efficient causes
and their effects, considered as ends intentionally to be accomplished,
are called final causes ~