The principles of natural philosophy: with some remarks upon the fundamental principles of the Newtonian philosophy. In a introductory letter to Sir Hildebrand Jacob, Bart.

Contributors

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THE *PRINCIPLES* OF Natural Philosophy:

WITH SOME

REMARKS

UPON THE

FUNDAMENTAL PRINCIPLES OF THE *Newtonian* Philosophy;

IN AN

Introductory *LETTER*

TO

Sir HILDEBRAND JACOB, Bart.

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TO

Sir HILDEBRAND JACOB, Bar^t.

SIR,

AS you, with ſome other of my friends, did me the honour to publiſh the firſt Part of the following ſhort *Eſſays*, in the year 1748; I thought myſelf bound in gratitude to addreſs them to you, now they make their appearance in public together. My ſtudies, for ſome years before, having a conſiderable connexion with natural philoſophy, I had at leiſure hours drawn up the firſt Part, without any intention of making it public: but it happening to pleaſe you and ſome friends, whoſe judgement I truſted to more than my own, it was printed. From that time I began to conſider it as a regular

foundation for a Syſtem of phyſical principles; and in a year after drew up *the Principles of motion*, which have lain by me ever ſince. After ſtating ſome of the neceſſary properties and laws of matter and motion, the proſecution of the plan would require, in the ſame manner, to collect ſeparately the diſtinguiſhing properties of the different ſpecies of matter comprehended in the Syſtem of nature, ſo far as experience and reaſon can inſtruct us; and then to ſhew how they are mechanically adapted to co-operate in producing the beings and ſenſible modifications of matter in nature, particularly thoſe appearances, which philoſophers have reaſoned upon as occult and unmechanical, and yet regular and invariable.

It is ſomewhat aſtoniſhing, that the inquirers after phyſical truth ſhould obſerve and acknowledge mechaniſm in any part of nature, and not be led to inquire, whether it is not univerſally extended; eſpecially as all matter and motion muſt have the ſame abſolute invariable properties. If vapour riſes mechanically, why may not a ſtone deſcend by the ſame law? If fluids circulate in organiz'd

bodies

bodies by continued impulſe, why not a planet revolve by the ſame cauſe?

It may appear odd to throw the blame of the falſe ſyſtems of philoſophy, which have been lately invented, upon the abuſe of a branch of ſcience, which of all others is believed to give the fulleſt degree of evidence mankind is capable of receiving, namely, the Mathematics: and yet I ſuſpect it is too true. Mathematical evidence is a phraſe for the higheſt degree of certainty; and all other truths, the moſt important and intereſting not excepted, muſt be received in the mind with a weaker and obſcurer degree of perſuaſion, becauſe their proof is ſupported by an inferior or more fallible demonſtration. You are not ignorant, Sir, that this is the common boaſt of the mathematical philoſophers in praiſe of that ſcience. The inference is very obvious. In their mathematical reaſoning it follows, That the Deity can give his creatures no ſuch evidence for any truth he would have them receive, as they can attain of themſelves by lines and figures: therefore they are not, they cannot be abſolutely certain they are not impoſed upon.

Mathematics are a ſcience of great importance and uſe, and have it in their nature to be true, while apply'd to compare the relations of the figures of matter and motion: but the ſame reaſoning carried beyond theſe, becomes ſubtil abſurdity. I ſhall have occaſion hereafter to mention a remarkable inſtance of this, in reaſoning from the properties of a figure to the powers of motion; as they do, who pretend to explain the elliptical and parabolical motions of the planets and comets by the powers of centripetal force and projection.

A moſt remarkable abuſe of this ſcience preſents itſelf in the very Definitions which Mathematics ſet out with. Theſe are ſubſtituted for the elements of matter. A Point is that which hath no breadth, nor length, nor thickneſs; or which hath no extenſion. Now, Sir, can that, which hath no material properties, be the firſt principle of all material ſubſtances? Tho' you or I may think otherwiſe, I aſſure you, by two or three more ſuch mathematical Definitions it can. A Line is a range of ſuch points; a Surface is a range of ſuch lines; and a Solid is a compoſition of ſuch ſurfaces. Thus you ſee, Sir, as the ultimate judgement form'd

upon

upon mathematical evidence, defies the Creator's power to give any ſuch demonſtration of his own being or will; ſo what is laid down as the firſt principles of Mathematics, aboliſhes his creation, to make room for one formed upon ſuch elements.

I doubt not but many will reckon this a very ſtrained and invidious inference. But if I had looked upon theſe Definitions only as unmeaning ſubtilties in the ſpeculative part of Mathematics, I ſhould not have given you the trouble of this remark. But, whatever may be pleaded to the contrary, it is ſelf-evident, that theſe Definitions exactly coincide with, and are really the ground-work of our modern natural philoſophy. Could any one perſuade you, Sir, that the infinite diviſibility of matter has no connexion with the above non-entity, a mathematical Point? And we all know, how neceſſary the doctrine of infinite diviſibility is to the preſent ſyſtem of philoſophy. Have not the propagation of light, and many of the greateſt *phenomena* in nature, been explained by it? and are we not obliged to it, for that glorious mathematical Idea, the rarefying a grain

of

of ſand 'til it ſwells to the magnitude of a planet, or fills infinite ſpace?

It is no wonder, that theſe ſublime mathematical Ideas ſhould exalt the mind, beyond mathematical evidence, to all the pretended analogical conjectures, which theſe refined imaginations could deviſe, and which are received by many as the moſt undoubted truths—ſuch as, The ſcale of beings, The ſyſtems of comets, The ſupply of the ſolar fire, The plurality of ſyſtems, The conjectures built upon the thirteen ſtars of the firſt magnitude, twenty-ſix of the ſecond, *&c.* The galaxy, *&c. &c*: with many other expedients for repleniſhing infinite ſpace, eſtabliſhing a *plenum* of motions and revolutions, but a *vacuum* of matter where theſe motions are deſcribed, leſt they ſhould be incumbered in their career. What is amazing in all this is, That, tho' the modern philoſophical Creed be full of theſe uncertainties, yet many of the moſt unſhaken believers of it are ſo cautious, as to ſuſpend their aſſent to all divine truths, for want of mathematical demonſtration.

I ſhall always account it my happineſs, that I was not acquainted with the natural philoſophy

phy of the Schools, before I heard of another which bid as fair for truth; and that I had the privilege of making a choice, before I could be prejudiced in favour of any ſyſtem. I am not aſhamed at the ſame time to confeſs, that my education was ſuch, as made me however wiſh, that the philoſophy, which was aſſerted to be taught by Revelation, might be ſupported with evidence becoming the wiſdom and authority that unfolded it. I now am convinced, and even flatter myſelf, am able to demonſtrate that it is ſo.

The followers of the *Newtonian* ſyſtem do well to affect a contempt of every thing that may be oppoſed to their *Hypotheſis*. Doctrines, which are ſupported by popular reputation, ſave the partiſans of ſuch tenets a great deal of trouble and vexation, which might otherwiſe attend the diſcuſſion of knotty objections. I would chooſe neither to boaſt, nor inſult; but do think, that in all reaſon, they, who are not willing to give up that ſyſtem, ought to undertake a fair defence of it.

Mathematics have no concern in the diſpute. The controverſy is reducible to one ſingle point;

point; Is there a *vacuum*, or not? Let them either produce their proof of it; or diſprove the arguments we ſhall bring for a *plenum*. A *vacuum* is the *poſtulatum* which ſupports their whole fabric. *Sir* ISAAC NEWTON has no where proved it; yet it is evident, the three properties of matter, which are the Axioms or evident principles, in all his reaſonings upon motion, cannot be granted, unleſs a *vacuum* is firſt aſcertained.

His firſt Axiom is, That all bodies, once put in motion, have as conſtant a tendency to move, as they have to reſt before motion is impreſſed on them. It is true, this law needs no proof but experience of the fact. But where made *Sir* ISAAC the experiment? Not on this globe; becauſe the ſurface of it is ſo involved in air and light, that it was abſolutely impoſſible for him to try a projection *in vacuo*. Not among the planets, nor in the ſpaces between them; for he was never there, at leaſt not before he compiled his ſyſtem of philoſophy. Beſides we are pretty ſenſibly informed, that there is a continuation of luminous matter between us and all the orbs. But all the philoſophers of that claſs hold that fluid to be ſo rare,

rare, as to be of no account in affecting the motion of bodies: tho' unhappily for them, they cannot demonſtrate, that there is one of their mathematical points of ſpace, which it does not occupy; their ſenſes argue againſt them, and they themſelves allow it a wonderful rapidity of motion.

Is it not ſtrange then, Sir, that a Man ſhould take upon him to determine and eſtabliſh a law about the continuation of motion, without the continuation of the cauſe; never regarding an all-ſurrounding fluid, which neceſſarily muſt have ſome influence, both in promoting and overcoming all the motions he could ever make obſervation upon? To ſay nothing of the light, we are abſolutely certain, the air reſiſts motion; and by numberleſs experiments upon the air-pump, *Sir* ISAAC was, or might have been, as abſolutely certain, that air promoted it. He knew with what power the air preſſed upon his *vacuum*, and with what velocity it ruſhed into it: he knew alſo, that every moving body continually leaves a *vacuum* behind it, which the air muſt exert its power upon in the ſame manner. Nevertheleſs, he explains the *areas* which all projectiles deſcribe,

by the two laws of *vis inertiæ* and gravitation alone. If it ſhould be argued, that theſe two powers are only terms, which he uſed to include all the accidents that contribute to continue motion; then we ſay, whatever ſervice he has done mathematics, he has hurt natural philoſophy by his obſcure and fallacious terms.

A *vacuum* is no leſs neceſſary for aſcertaining his two other Axioms, than it is for the firſt. But the third not only depends upon his aſſumed *vacuum*, but is founded upon his great relative property of matter to matter, namely Gravitation. Can any thing be more inadvertent and deluſive, than to aſſume That as an abſolute law of matter, or primary Axiom, which is the conſequence of a ſecondary law, or of the relation of one parcel of matter to another? His Axiom is, that re-action is equal to action, or that one body, put into motion by another, deſtroys juſt as much motion in the firſt as it receives from it. Let us reflect a little what is the cauſe of this fact, aſſumed as an Axiom. Why does every body reſiſt the action of another upon it? It is its native power. How does this native power in bodies manifeſt

manifeſt itſelf? By their weight. What is the weight of a body? It is the force with which it is attracted towards the earth. So then this Axiom depends upon Gravitation, tho' it is aſſumed independent of it. But if it muſt be an Axiom, I would be curious to be informed, Whether a body would weigh or not (for reſiſtance is moſt certainly the ſame with weight) if the power of Gravitation were not acting in it: and if it did, I would be ſtill more curious to know, in what direction it would weigh.

Sir ISAAC has not even reduced his favorite principle of Gravitation to ſelf-conſiſtent laws. We are told, that this principle is of the ſame nature, and acts by the ſame laws, in all matter; that all attraction in bodies is mutual; that its power of action is in proportion to the quantity of matter contained in the bodies. But if that power of Gravitation be in every reſpect mutual between two bodies, then the degree of gravitation (which is known by the acceleration of the motion) muſt be in proportion to the quantity of matter in the ſmaller body, as well as that of the larger: that is, if the earth were left to the ſimple effect of

Gravitation or centripetal force, it would deſcend to the ſun, with a velocity proportioned to the power of attraction in the ſun and in the earth added together. Therefore a ſtone-weight of ſubſtance attracted by the ſun, would move only with a velocity proportioned to the ſimple power of the ſun's attraction, the ſtone weight's power being in proportion as nothing. But this is falſe in fact, for a feather gravitates as faſt towards the earth, as a 1000 tuns of the moſt ſolid ſubſtance. Now if the earth attracts according to its quantity of matter, why ſhould not a mountain of the ſubſtance of the earth, and every particle of it endowed with the ſame law, gravitate according to its quantity of matter, and deſcend faſter than a body which has not the 100,000 part of its ſubſtance?

If we reaſon upon this principle in the reverſe light, from what is matter of fact, it appears equally abſurd. If a ſmall body gravitates as faſt towards the earth as the largeſt does, then the quantity of matter makes no difference as to the power of Gravitation: but if a larger quantity of matter deſcending is not more ſtrongly precipitated

towards

towards the earth than a ſmaller; then the greater or leſſer quantity of matter contained in a planet cannot diſpoſe it to attract bodies more or leſs powerfully. For if there is no difference of velocity between the deſcent of the ſmalleſt and the largeſt body, gravitating toward the earth, then there can be no difference between the attracting powers of a ſmall body and the largeſt planet; if it be ſtill true, that this principle acts by the ſame laws in all matter. In ſhort, Sir, there is a myſtery of contradiction, obſcurity, and confuſion in this part of the *Newtonian* philoſophy, which is ſmoothed over by a kind of mathematical legerdemain.

Another law of the centripetal power is, That it decreaſes reciprocally in a duplicate proportion of the diſtance. That is, a body, double the diſtance that it now is from the centre of the earth's gravity, would gravitate or weigh four times leſs; at thrice the diſtance, nine times leſs. How eaſily may this law be traced into an abſurdity. For example, we muſt ſuppoſe, that it increaſes and decreaſes in the ſame *Ratio:* but if it increaſes in the ſame *Ratio*, how will reciprocal duplicate proportion

tion increaſe to infinity, when theſe diſtances come to be divided by yards, inches, and hair-breadths from the centre? In a hair's-breadth itſelf from the centre, it will increaſe millions of times, by that kind of mathematical menſuration, which makes a hair's-breadth admit of infinite diviſion.

What a jeſt is it then, SIR, for theſe gentlemen to pretend to calculate the denſities of planets, the quantities of matter contained in them, or their ſpecial powers of attraction, by ſuch laws! I know they will be very angry with us, for meaſuring the above law, by ſuch diviſions as their own refinements on Mathematics afford us; becauſe they think we laugh, and don't do it with the ſame gravity that they tell us, how much a pound weight would weigh upon the ſurface of the Sun, or *Jupiter*. But I hope we may laugh ſometimes with a ſerious meaning, as well as others be grave with a ridiculous one.

It is, in my opinion, a moſt neceſſary piece of true wiſdom for us, to know where our finite capacities are bounded. Infinite wiſdom has placed enough within the reach of our underſtanding;

ſtanding, which we ought to employ it upon. But we forſake that, and go in queſt of imaginary worlds and ſyſtems not of GOD's making; and frame laws for ruling the world we do know, which laws cannot be of GOD's compoſing, as they infer the greateſt abſurdities. It woud be juſt as modeſt for one of theſe philoſophers, to inform us what matter, or their attraction is, as to calculate by their rules, how many feet the moon would gravitate towards the earth in a minute.

Sir ISAAC NEWTON's friends alledge, from ſome of his Queries, and ſome cautions ſcattered in his *Principles*, that he had even ſome idea of that occult power, its being performed by the impulſes of a ſubtil fluid diſſeminated thro' his infinite ſpace, tho' he was too modeſt to be dogmatical about it. But tho' he had ſincerely meant ſo, it was only retiring a ſtep farther into the dark; and he might as well have plainly confeſſed his unmechanical power of attraction, as have attributed it to another unmechanical agent. For we muſt aſk, By what principle that ſubtil fluid acts? And the ultimate anſwer muſt be, The *vis inertiæ* and a *vacuum*. I am not inclined to judge of that great man's

man's ſecret reaſons for wavering about his principle of Gravitation: but if, by aſſuming ſome hints from the mechanical philoſophy, he deſigned to ſhew the world, that he even penetrated a little into the cauſes of theſe obſcure powers, he has not in fact advanced his character by it; for his Axioms throw him back again into his unmechanical *dilemma*. But it is not eaſy to gueſs what he intended by theſe ſeeming doubts; for in other parts of his Works, where he may be ſuppoſed to ſpeak his own ſenſe more peremptorily, he eſtabliſhes Gravitation as an univerſal property of all matter, his energetic fluid not excepted; and aſſerts it to be a principle, that acts not only by matter in *cumulo*, but eſſential to, and exerted by, every particle of it.

The greatneſs of *Sir* ISAAC NEWTON's character, and the palpable deficiency of former *Hypotheſes*, have been a blind to his followers. His character as a mathematician, and not his demonſtrations as a philoſopher, have been the confirmation of his phyſical principles. Whoever has ventured to differ from him, however weighty their objections may have been, have only incurred the character of conceit, obſtinacy,

obſtinacy or ignorance. The foreign philoſophers have ſuggeſted many objections and difficulties which deſerved the attention of the *Newtonians*; but theſe took the benefit of the character of infallibility, which opinions acquire when they become popular; and have anſwered them not a word.

While *Sir* ISAAC's diſcoveries have been thus adored, what contrary treatment have the diſcoveries and characters of his cotemporary Mr. HUTCHINSON met with! tho' it may be ſubmitted to NEWTON's moſt partial admirers, which of the two's doctrines (even ſuppoſing them equally juſt) are moſt important, and diſcover moſt of the natural philoſopher. What is properly *Sir* ISAAC NEWTON's in the preſent philoſophy, is his extending Gravitation to all matter, and by a moſt profound ſkill in Mathematics, forming rules for calculating the decreaſe of that power, by the increaſe of the diſtances of the attracting bodies from one another.

Mr. HUTCHINSON has laid down principles, which may enable any perſon to diſcover, how Gravitation is mechanically perform-

ed. This was what the *Newtonians* had not the remoteſt idea of; nor did they conceive any thing about it, in ſuch a manner as to give them any hopes of diſcovering the cauſe. He has diſcovered the certainty and the neceſſity of a *plenum*; a doctrine, which the *Newtonians* abhorred, as much as Nature (according to the ſchool-men) abhorred a *vacuum*. He has ſhewn how the ſolar fire is ſupported, without the aſſiſtance of a denſe atmoſphere, comets, or any ſuch expedients. He has explained what air is; and tho' he has not deſcended particularly to explain all the *phenomena* in nature, he has eſtabliſhed ſuch a material mechaniſm, as will account for all her operations, without having recourſe to occult powers and unmeaning terms. All theſe were more than ever the philoſophers expected to know.

Of this philoſophy Mr. HUTCHINSON had two proofs. The one was to demonſtrate it by experiments, and to reduce any neceſſary parts of it to geometrical proportions. As many of theſe had been made and calculated by preceding philoſophers, who could never inveſtigate the cauſes, he left theſe to be explained and applied, as a juſt idea of philoſophy ſhould direct:

rect: knowing that experiments particularly will always anſwer for themſelves, and cannot be preſſed into the ſervice of falſe maſters.

He therefore addreſſes himſelf to another proof, which was quite new, and which he carried on with a ſucceſs ſuitable to the nobleneſs of the deſign; a proof, for which he ought to be held in incomparably greater honor, than if he had, by the ſole dint of genius, produced the moſt refined and conſiſtent *hypotheſis* that human capacity could boaſt of: tho' perhaps it has gained him more enemies, than if he had been the moſt contemptible ſyſtem-compiler, that ever pretended to be a philoſopher. He proves, that we have in Revelation a diſcovery of the mechaniſm of Nature, given us by Him, whoſe knowledge of it muſt be infallible and indiſputable, becauſe He is the author and ſupporter of its being and ſtructure.

Tho' you are before-hand with me, SIR, in all I can ſay on the ſubject, you will excuſe my juſt glancing at the ſum of his proof; which I wiſh they who affect being his detractors would deliberately weigh and examine, before they pretend to reject and pre-

judice others againſt it. He ſhews, that the deſcriptions of natural things, and the words and expreſſions every where uſed by the inſpired writers when ſpeaking of them, are, when fairly examined, ſuitable to and founded upon the exact phyſical conſtruction of the ſyſtem *. He demonſtrates, that idolatry took its riſe from a miſapprehenſion of revealed natural philoſophy; and conſequently, that the names of the Pagan Deities, mentioned in the ſacred records, bear an expreſs analogy to the mechanical powers and operations of the ſyſtem. He proves, that their idolatrous typical ſervice of theſe Deities, was all a figurative exhibition of theſe material operations, but transferred by theſe idolaters and made powers and attributes of their falſe gods. He ſhews, that the Jewiſh typical oeconomy of worſhip, on the contrary (beſides its figurative exhibition of future events of infinite importance) was exactly calculated to reclaim all theſe Heathen miſapplications, and to inſtruct and confeſs that theſe powers belonged only to JEHOVAH; who had compoſed the mechaniſm of the world

* See *Letter to a Biſhop, concerning ſome important diſcoveries in Philoſophy and Theology:* printed in *Quarto* for HENRY WOODFALL, without Temple-bar, 1735. and in *Twelves*, 1747.

ſo

ſo as to exert them. With the ſame elegance and juſtneſs he diſcovers, that the miracles, wrought from time to time, were of ſuch a nature, and ſo ſuitably interpoſed, as to convince the idolatrous Heathens, and the wavering Jews (who were always apoſtatizing into their opinions) by controlling, reverſing, or rendering miraculouſly deſtructive the powers of nature, under all the different views they formed of the great operations which ſupported nature, and which they claſſed as different Deities, or different attributes of their Deities. For tho' all the ancient nations worſhipped the heavens, yet each nation pitched upon a particular view of their univerſal government of the world, and denominated their gods, temples, cities *&c.* accordingly: by which means each nation in a manner affected to appropriate their univerſal Deity to themſelves, ſtriving who ſhould engage moſt of his favour as a tutelar god and ſaviour. In this they affected to copy from the divine oeconomy: for tho' GOD was and is the common father and ſupporter of mankind, yet, for reaſons worthy of divine wiſdom, he aſſumed a particular care of, and exerted a ſyſtem of ſpecial providence for the Jewiſh

nation

nation and their progenitors. Upon the whole, he chains Revelation and Nature together, in a way never comprehended before; and eſtabliſhes a moſt glorious analogy between the powers and operations of nature and the ſyſtem of ſpiritual revealed truth, ſo important for man to receive and underſtand *. But this laſt belongs more eſpecially to his writings and character as a divine.

As a philoſopher, his diſcoveries (until they are diſproved at leaſt) intitle him to the character of one of the greateſt, and at the ſame time, moſt laborious genius's the world is acquainted with. They are likewiſe of that excellent nature, that they lay the foundation, and open the way for carrying on that ſyſtem of knowlege to greater perfection, than he himſelf either foreſaw, or could have imagined. I can with the greater freedom give him his due honor, as I don't hold his judgement infallible in many inſtances; and can without biaſs be ſenſible of what I think miſtakes in him. But in the main, his writ-

* See *Creation the ground-work of Revelation*; *Revelation the language of Nature*, &c.

ings,

ings, by way of eminence, above any human efforts I ever ſaw or heard of, deſerve the name of *Novum organum ſcientiarum*.

You'll readily agree with me, SIR, in thinking it worthy of a public remark, That of all the attacks which have been lately made upon him and his friends, not one of theſe oppoſers has ventured upon an examination of his philoſophy: but they have worked upon the critical part of his writings; where there was moſt room for cavil and evaſion, and which would tend moſt to prejudice thoſe, who were ſtrangers to him and his writings, with the ſeeming uncertainty and deceitfulneſs of his pretended diſcoveries.

I cannot imagine, how theſe gentlemen could be inſenſible of the unfairneſs and diſingenuity of this method. Suppoſe the critical evidence for this or that manner of tranſlating a Hebrew word had been equal on both ſides; yet his or his friends ſenſe, correſponding with the juſteſt idea of natural truth, was more than ſufficient to caſt the balance in their favor, with any perſon who did not think Revelation was written by too low and

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contemptible pens, to pay any regard to the phyſical juſtneſs of their ſtile.

You'll allow me alſo to remark, that in the age when the ideas of natural religion ran higheſt, and the arguments in defence of it were carried on, not with reaſon, but audacious inſolence and profaneneſs, and ſupported by pretenſions to unparallel'd diſcoveries in natural philoſophy, (while the contemptible *Scriptures* were ſuppoſed to be written, not for the wiſe and the learned, but *ad captum profani vulgi*) he has given the finiſhing ſtroke to that cauſe. In this light, I muſt be allowed to claſs along with him the inimitable Dr MANDEVIL; who has illuſtrated the ſcripture account of the ſtate of human nature, with as convincing demonſtration, as the other has the inſpired diſcoveries given us of natural philoſophy.

It is the great excellency of this philoſophy (tho' I'm afraid a very forbidding one with many) that it is inſeparably connected with Revelation; ſo that none can embrace the former, and reject the latter. Divine wiſdom, to the confounding of our mighty, penetrating,

ing, independent capacities, has ſo compounded the truths which admit of demonſtration with theſe which depend upon his own veracity and infallible teſtimony, that no adverſary can ſeparate them. They partake of one another's evidence in the fulleſt manner; they are woven into one another, ſo as to make one web; and they as faithfully correſpond, as the reflected image does to the object.

One of the ridiculous and monſtrous abuſes, which all preceding ſyſtems of philoſophy led into, has been the explaining Creation itſelf by the ſtanding laws which they imagined ruled Nature invariably, in its preſent diſpoſition. Tho' SIR ISAAC himſelf has not made this application of his Laws of matter and motion, yet his followers have fallen into the ſame abuſe. Our philoſophy lays an unſurmountable bar in the way of its being extended to ſuch imaginary and impious conjectures.

Every one, who has a juſt idea of the mechanical philoſophy, muſt readily determine, That matter could no more arrange itſelf into its preſent mechanical order, than it could

give being to itſelf; for its powers are the conſequence and not the cauſe of its compoſition. When conſtructed and put in motion with the full exerciſe of all its powers, it could not produce one organical body either vegetable or animal, nor generate the rudiments of them. It could not, from a mingled maſs of materials, have effected the ſeparation of fluid and more fixed parts, which we now enjoy on our globe; without which, it could not have reared organical bodies, and many other productions, when prepared for the influence of the machine. It cannot change its own courſe, neither fall into diſorder or waſte: without divine interpoſition, the frame of Nature muſt continue eternally; and without divine Revelation, we could never have known, that it did not exiſt from eternity. It is of obvious and neceſſary uſe, in giving a juſt direction to philoſophical reſearches, to know upon proper evidence, that there is a Creator; and to know what parts of the frame of Nature could not be originally the product of its powers, but were the elegant modifications of the Great Architect, in which the powers of Nature are to work out its various productions.

As to the following *Eſſays*, I ſhall ſay but little. Tho' the plan be new, I hope it will be univerſally approved, as it is certainly regular. The only way to attain the knowlege of any piece of mechaniſm and its powers, is to be acquainted with the diſtinct materials and members of which it is compoſed, and to underſtand their proper bearings and adjuſtments; without this, we ſhall be amuſed with myſteries, where there are none. The *Eſſays* have another property, which, I flatter myſelf, cannot fail to recommend them. They are ſhort; which is the beſt recommendation they can have, next to their being well executed. If they do not give ſatisfaction in this latter reſpect, it is not for want of inclination in the Author to ſatisfy his Readers. But if I have contributed to point out the way to a more juſt and general acquaintance with natural truth, I ſhall rejoice to be ſupplanted in the proſecution by ſome abler hand.

Tho' they are denominated *The principles and properties of matter and motion*, yet I am obliged to make ſeveral of theſe properties negative ones, in order to ſtrip the materials of the machine of thoſe falſe properties, which

do not inſeparably belong to it. An anatomiſt would not readily make it one of the properties of the bones of the leg, that they move the body; tho' they are for that uſe, when articulated, mounted with ligaments, muſcles and nerves. On the above-mention'd account, I have been led to reaſon a little under ſeveral heads, and to uſe a little more illuſtration than is uſual in writing Aphoriſms; which form I have endeavour'd to imitate, becauſe it favoured brevity moſt.

If this attempt, as far as it is brought, SIR, meet with your approbation, and that of ſome other gentlemen whoſe judgement and impartiality I confide in; I ſhall hope it will be better received by the Public, than I ſhould otherwiſe be vain enough to expect. I am, with reſpect, SIR,

Your obliged and moſt humble Servant,

Newton, Dec. 27, 1753.

A. WILSON.

NUMBER I.

THE PRINCIPLES AND PROPERTIES OF MATTER.

Αὐτος γαρ μοι ἐδωκεν των ὀντων γνωσιν ἀψευδη, εἰδεναι συστασιν κοσμου, και ἐνεργειαν στοιχειων.

WISDOM, &c. vii. 17.

NUMBER I.

THE

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THE philoſophers have been very curious and minute as to their inquiries into the mathematical laws and proportions of the motions of the larger bodies in this ſyſtem; which commonly go under the name of gravitation, attraction, projection, *&c.* But they ſeem to have been very unſucceſsful or defective, as to their diſcovering the natural or mechanical principles and cauſes of all motion in material ſubſtances. As local motion can belong only to material bodies,

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I am inclined to think it muſt be produced by material principles. The procedure of nature cannot be creating of new ſubſtances, but is a courſe of motions, revolutions, changes, alterations, and variations in matter already in being: ſo that this univerſal frame ſeems to be nothing but a complicated train of motions, abſolutely depending upon the immutable conſtituent properties of matter. In a word, the principles of matter and motion ſeem to be one and the ſame. Therefore it is hoped the following *Eſſay* to ſtate the firſt principles of natural philoſophy, will meet with a candid and open reception from the public in general, as it is no way abſtruſe; and from the ſearchers after phyſical truth in particular, as I hope they are agreeable to the profound ſimplicity of nature, and the mechanical juſtneſs of all her operations.

The univerſe appears to be one great machine, fitted and diſpoſed to perform all the operations which are carried on throughout the whole. No one part of it ſhould be conſidered as acting, without being acted upon; and no individual can be conſidered as an agent, without being a patient. It is unphiloſophical to ſay, matter in general, or any part of it, has eſſential or ſeparate properties, by which one part acts upon another: it is the eſſential property of no one wheel in any machine to move its fellow, tho' in conſequence of its being

being placed in the ſtation it is fitted for, it acts upon its fellow, becauſe it is acted upon.

Juſt ſo it is with the whole ſyſtem of nature. You cannot take up any parcel of matter and ſay of it, This has eſſential ſeparate properties, which impower it to be a natural agent. A philoſopher ought to conſider it as a concrete, with a certain diſpoſition of its parts, liable to be acted upon by the ſubtiler parts of the machine, which cannot be reſtrained from it by art. And it may as juſtly be alledged, that it is the eſſential property of animal ſubſtances to live, or of vegetables to ſpring, as it can be ſaid, that it is the eſſential property of the loadſtone to attract. Nothing therefore can be more conducive to the promoting a true acquaintance with the operations of nature, than to conſider what are, and what are not, the eſſential properties of the firſt principles of matter.

I. Firſt then, matter muſt be compoſed of firſt principles: and theſe may be called units or atoms of matter. Nothing to me appears more ſceptical in philoſophy, than to aſſume it for a firſt principle, that matter is infinitely diviſible: which is aſſerting in other Words, that matter has no beginning of ſubſtance; that there are no limits between matter and nothing. That there cannot be ſuch a thing as an unit of matter, is to

maintain, that matter has an infinite property. To ſay that any parcel of matter is finite, and at the ſame time that its component parts are infinite, is indeed philoſophy baffling itſelf, and maintaining contradictions. Time is made up of a perpetual ſucceſſion of years and days, and is meaſured by hours, and minutes, and moments: and it would be juſt ſuch a metaphyſical truth to tell us, one moment of time may by dividing be lengthened out into a thouſand ages; as it is a phyſical truth to aver, that a grain of ſand, by the infinite diviſibility of its matter, may be rarified and enlarged unto the bulk of a planet. Nothing can be more ſhocking to reaſon, or even to the ear, than *Eternal Time*; and infinite diviſibility, when examined, muſt be found juſt as abſurd. Concretes, in which form matter is made ſubject to our ſenſes, can no more be without ſuch firſt principles, than numbers in arithmetic can be compoſed without units.

II. Atoms muſt originally ſubſiſt in numbers, which cannot be diminiſhed or increaſed; it is equally impoſſible for many to become one, as it is for an unit to be multiplied: ſo that the original number of atoms is as invariable as their figures or ſizes. An atom may as ſoon be repreſſed into nothing, as two can be made to coaleſce into one unchangeable ſubſtance. Number is the fundamental

mental baſis of motion and changes in matter. An atom cannot act upon itſelf, nor communicate action, impreſſed intimately to its ſubſtance tho' never ſo large; but a concrete can and does impreſs its own inward parts, in a mechanical proportion to the power which acts upon its ſurface. Therefore it is in vain to ſay, that all atoms muſt have parts, tho' the component particles of all bodies are ſmall enough, and rigid enough, to reſiſt or elude all ſeparation by the agency of matter. If any body, tho' never ſo ſmall, has numerical parts, their coheſion muſt be mechanical; and nature can do nothing but what it can undo again, under certain circumſtances. To this purpoſe, *Sir* ISAAC NEWTON cloſes a fine inquiry into the nature, laws, and conſtitution of matter — "All theſe things conſidered, it "ſeems probable to me, that God in the begin-"ning created matter in ſolid, maſſive, hard, "impenetrable, moveable particles, incompara-"bly harder, than any of the porous bodies "compounded of them: nay ſo hard as never to "wear or break in pieces; no human power "being able to divide what God made one at the "creation. While theſe particles continue intire, "they may compoſe bodies of one and the ſame "nature and texture in all ages: but ſhould "they wear away, or break in pieces, the nature "of things depending on them would be chang-

" ed: water and earth, compoſed of old worn par-
" ticles and fragments of particles, would not be
" of the ſame nature now, as water and earth
" compoſed of intire particles at the beginning.
" And therefore, that nature may be laſting, the
" changes of corporeal things are to be placed
" only in the various ſeparations, and new
" aſſociations, and motions of theſe permanent
" particles." *

III. Such an atom or unit of matter muſt have dimenſion; it conſtitutes its own ſpace wherever it is, and occupies it. The idea of a ſolid and extenſion are inſeparable; but that of diviſion and a ſolid are irreconcileable. Solidity among concretes is only comparative and imperfect; but it is as great a contradiction in terms to apply diviſion to a proper ſolid, as it is to apply it to the ſpace of a body abſtractedly or mathematically conſidered, which is nothing. Tho' two things may be ſeparate one from another, yet one thing and nothing are equally indiviſible. Dimenſion in bodies has proportion, and may be conſidered leſs or more; and the extenſion of a larger body may be a proportion for ſeveral ſmaller bodies: but the idea of parts and diviſions has no connexion with extenſion; and as little with the matter

* NEWTON's *Optics*.

which

which occupies it, unleſs it is a concrete. Diviſion is an idea which properly belongs to number, which is a conſequence of the exiſtence of matter, and a different one from ſpace. There is therefore no connexion between matter having dimenſion, and its conſiſting of parts; or one body is not many in reſpect of another of the ſame kind, becauſe its ſubſtance is larger. To take an example from units of concretes, of which nature is compoſed in a ſecondary ſenſe; one egg may be larger than another egg; but tho' the one may be thrice as large as the other, yet the bigger is as much one as the leſſer, and cannot be ſuppoſed to be three. There is a great difference between thrice as much matter being contained in one individual, more than there is contained in another individual, and the larger one's being three individuals. Juſt ſo it is with reſpect to the firſt order of units, or the atoms of which all concretes muſt be compoſed. One atom may be ſeveral times larger than another atom, yet it is as much an unit as the other, and cannot be divided; tho' if any one pleaſe, he may conceive of its dimenſions, as having diſtinct room for a concrete of ſeveral ſmaller atoms; but even that gives the extenſion of the large atom no parts further, than by ſuppoſing a body with parts to occupy its place. Now becauſe the larger atom is ſeveral times more extended than the atoms of a concrete

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of its ſize, the one atom is not therefore many, becauſe the concrete is ſo. Therefore every atom or unit of matter has extenſion, which we may ſuppoſe to have menſurable proportion; but the atom itſelf is incapable of diviſion, becauſe

IV. An atom does not conſiſt of parts. It is not compoſed by one body's being applied to another body, which either art or nature can ſeparate, or which can be ſeparated even in imagination. There can be no incroaching on its ſubſtance, but by annihilation. Tho' we ſhould ſuppoſe two bodies equal in ſize, the one a concrete, the other an atom; becauſe the concrete may be diſſolved into a thouſand inconceivably ſmaller parts, yet that can give us no idea of the atom's conſiſting of as many parts ſtrictly applied to one another. It is an atom, has no coheſion of parts, becauſe it has no parts; however conſpicuous its dimenſions may be, yet it is one and unalterably the ſame. What gave being to it in that ſize and form can only alter it. But nature, or matter acting upon matter, combining, diſſolving, and changing the forms of things, cannot change an atom.

V. An unit of matter cannot be pervaded. Its ſubſtance is without parts, and ſo without pores or interſtices. It can be pervaded by no fluid, tho' never ſo ſubtil. It occupies its own ſpace or dimenſions,

ſions, and nothing elſe can he ſaid to be or exiſt where it is. Pores or interſtices belong only to concretes, or atoms forming a maſs by adhering to one another in any number. Such concretes as theſe muſt have interſtices between their atoms, and may be allowed to have theſe interſtices filled with a ſubtil fluid; or if there is any neceſſity for ſtill retaining the paradox, may have ſpace occupying them, as well as they occupying ſpace. But this cannot be the caſe of an unit: ſo far from it, that ſpace or dimenſion is an eſſential property of matter; and it is impoſſible to have any conception of the two ſeparately.

VI. Every unit, in conſequence of its former conſtituent properties, enjoys perfect ſolidity. Atoms of one ſhape and ſize cannot be heavier than one another. Weight, ſubſiding, aſcending, and parcels of matter taking different ſtations of one another, or weighing differently, are the effects of matter acting upon matter, and are performed according to the laws of different ſolidity, *&c.* Which ſubſiſt not among atoms, further than as to their different ſhapes and ſizes, by which another material agent may be applied to them in different proportions. But matter ſubſiſting in atoms, and acted upon by the agent which produces gravitation, would precipitate or ſubſide equally, becauſe in units there can be no difference of ſolidity. Atoms of the ſame figure

and

and ſize, or of different ſhapes and ſizes, muſt be to one another, as gold is to gold, and not as gold is to ſilver, or any other metals, which differ from one another in their ſpecific gravities.

VII. Such atoms muſt be abſolutely opaque. Pellucidity is oppoſite to perfect ſolidity, and ſuppoſes interſtices, and theſe in a certain direction. The tranſmiſſion of light in direct lines through the pores of concretes, is ſuch a ſingular conformation of its ſolid parts, and interſtices, as deſerves a ſeparate Treatiſe: but atoms have no pores, ſo nothing can penetrate their ſurface. And when reflexion of light is ſufficiently underſtood, it may be conſidered, whether atoms ſubſiſting as ſuch (that is, not adhering in forms) could in any quantity become viſible.

VIII. Atoms are abſolutely inert, and can neither conciliate motion to themſelves, nor continue in motion longer than they are impelled. They are abſolutely paſſive, and cannot be ſuppoſed to move one hair's breadth after the impelling force is reſtrained. To give matter an eternal power of changing its place, in conſequence of its being once diſquieted, to me appears moſt unphiloſophical.

IX. Units

IX. Units are at the ſame time capable of perfect mobility. For as they cannot move themſelves, or alter their place; ſo they have in themſelves not the leaſt reſiſtance to motion, or to be continually altering their ſtation while they are impelled. Therefore in our ſyſtem, the matter which ſubſiſts without any coheſion of its atoms muſt be by far the moſt active.

X. Atoms can have no elaſticity. They have no parts to recoil, and to reverberate upon their being impelled. That property of matter implies parts, interſtices; theſe interſtices repleniſhed with ſome active fluid, and a reſiſtance to motion: none of which atoms have.

XI. Atoms can have no attracting or impelling powers, *&c.* To ſuppoſe them to have ſuch, is to deſtroy another property, which by the philoſophers is aſcribed to matter; namely, the *vis inertiæ*. For if the firſt principles of matter attract one another, that is endowing them with a *vis motûs*, or a power of moving towards one another. If ſuch a thing there be as attraction, it muſt be either a material property, or a ſpiritual one. If it is a material one, an atom cannot be poſſeſſed of it. It cannot move itſelf. It conſiſts of no parts, therefore cannot detach ſubtiler parts to draw its fellows into contact. If it is a ſpiritual operation,

then it is no property of matter at all. And if the firſt principles of motion in matter be univerſally ſpiritual, then there is no need for mechanical agency in matter, or of ſecond cauſes. If we ſay, there is uſe for mechanical agency in nature; then it is very abſurd in philoſophers to fix unmechanical principles, until they are certain and can demonſtrate, that they have traced the utmoſt length that nature in a mechanical way can go. If attraction be a principle or radical property of matter; how is it, that it can be weakened, ſuſpended for a time, yea and quite deſtroyed? If it be a power determining matter to matter, and as real a property of matter as ſolidity, *&c.* how is it, that this property can be over-powered and deſtroyed by matter's acting mechanically upon matter; which muſt always be in a conſiſtency with and ſubſervience to its original properties? Yet in fact we ſee the force of fire can ſuſpend the ſtrongeſt attractions, as in the fuſion of gold; when that metal, which has ſuch ſtrong attraction of its parts, appears in the form of that metal, which has the leaſt and weakeſt of any, namely, quick-ſilver.

XII. Neither can the firſt atoms of matter poſſeſs a power of gravitation. That principle is yet more oppoſite than the former to a *vis inertiæ*; and the laws of gravitation and attraction ſeem even directly oppoſite to one another. In attraction, that

power

power is weak enough not to exert itſelf, but when the atoms of matter are in immediate contact with one another, or are at leaſt verging upon it; yet when they thus approach one another, they acquire an obſtinate coheſion. On the contrary, matter attracts matter in gravitation at infinite diſtances; and that paſſion increaſes their velocities, the nearer they approach one another: yet when they come into contact, notwithſtanding the rapidity with which they ruſh towards one another, they acquire no adheſion at all. One who would conſider theſe two diſpoſitions of matter (if ſuch there be) in a natural way, would think, that the one would naturally paſs into the other, and that they both proceed from the ſame inclination; ſo that gravitation would naturally end in that adheſion, which is the effect of attraction. But it is not ſo. From all we can underſtand of the units of which matter is compoſed, a maſs of them, lying together, unacted upon by a mechanical material agency, would neither attract, gravitate, nor take place of one another; as in our ſyſtem bodies of different gravities do.

XIII. Units may differ from one another in their ſize. This property it is, which lays the foundation for all the variety of forms and diverſity of ſubſtances, with their ſingular properties when thus combined, which are ſo uſeful in the

univerſe. This property, I ſay, is the ſource of all that variety, when joined with

XIV. The diverſity of figures in original atoms. Theſe two modify the other general properties of matter, ſo as units, combined according to their different ſizes and figures, preſent us with that profuſe and beneficial variety of ſubſtances, which we ſee in the creation. Without theſe, it will be difficult to account for them. Theſe leave ſmall hopes of the tranſmutation of metals, *&c.* eſpecially the more pure and ſimple ones. For if the units of gold, ſilver, or quick-ſilver be eſſentially different in their ſizes or figures, or in both of them; no art or mechanical agency can change the units of matter, becauſe all the properties of atoms are

XV. Unchangeable. To alter an eſſential property of any atom is to annihilate it, and ſo to diſannul its properties altogether. This is a firm baſis for mechanical agency. For if the ſubſtance of the firſt principles of matter were not permanent in its properties, but mutable upon external impreſſions; nature would go on uncertainly in her operations, and could not be uniform in her effects. Therefore we have no reaſon given us to apprehend, that matter has any primordial principles, which will yield to external

agencies.

agencies. An atom and all its properties are coeval, and muſt be of equal duration; becauſe an atom and its properties are the ſame. We can have no apprehenſion of matter, but that it is ſubſtance; and if we would define ſubſtance, we have no characteriſtic of it, but its properties. Therefore to give matter properties which can be diſſolved by any agency, beſides that by which it exiſts, is to leave us no certain principles as to matter at all. And hence we muſt neceſſarily conclude likewiſe, that

XVI. All the properties of matter are material, and not ſpiritual. If the contradicting the former diſannuls all certainty, as to matter itſelf; the denying of this would leave us in equal uncertainty as to its operations. To endue matter with properties which do not neceſſarily depend upon its being ſubſtance, is to poſſeſs it of a ſoul and ſpirit: and to ſubject ſoul, or theſe ſpiritual properties, to the laws of material mechaniſm, is abſurd. Nature proceeds mechanically, ſo far as we can trace it: and tho' our ſenſes are limited as to the *minutiæ* of that mechaniſm; yet we are certain that matter does exiſt in ſuch forms in the univerſe, as will aſſure us the mechaniſm may go on further than we can deſcribe. Matter is a mechanical, and ſo a neceſſary agent; this we ought to call nature. But a ſpirit is a voluntary,

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and ſo a free agent; and theſe ought not to be confounded. The philoſophy of occult qualities in matter, and of properties we have names for, but can form no ideas of, from the knowlege we have of ſubſtance, is certainly refined upon, by introducing the immediate agency of a firſt cauſe in all theſe caſes. This has lately been advanced by a great prelate and an ingenious philoſopher: and to be ſure it cannot be contradicted by any who maintain theſe uninveſtigable qualities of matter. But I cannot think it is doing any honour to the Deity, to make him a neceſſary agent in the courſe of nature, by impoſing theſe laws upon him, before we are certain whether material mechaniſm reaches unto them or not. Voluntary and neceſſary, are the diſtinguiſhing characters of the agency of ſpirit and matter: and to confound their operations, is exalting the one, and debaſing the other unduly.

XVII. All the properties of matter are natural, every one of them fit to act and to be acted upon in a mechanical way. They are ſuch as can all of them be adapted to the known principles of mechaniſm among artiſts. Latent qualities are deſtructive of that ſort of agency. Tho' matter is not infinitely diviſible, yet it is certain, its primordial atoms are indefinitely ſmall; ſo as the groſſeſt of them are far beyond the reach of our ſenſes, even

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with all the aſſiſtance which art can furniſh them. At the ſame time, our organs are ſo finely machined, as to be ſubject to the impreſſions of the ſmalleſt: from which ſeveral uſeful corollaries might be deduced. But becauſe the units of matter are ſo ſubtil as to elude our ſenſes; it does not therefore follow, that we can have no certain knowlege of them, or of their properties. From the knowlege of concretes we may certainly diſcover, what are the general unvariable properties of their conſtituent atoms. Every concrete enjoys two diſtinct kinds of properties: the firſt are ſuch as are inſeparable from it as matter, and theſe properties belong to every atom of which a concrete is compoſed; the ſecond are ſuch as are naturally produced from matter, being variouſly combined in concretes. Theſe are the natural, mechanical, or conſequential effects of the original properties of atoms adhering in various forms. Theſe cannot be however the original properties of matter, tho' the original properties, being all mechanical, naturally produce them. Therefore we ſhould obſerve the ſtricteſt caution, leſt we aſcribe the different properties, which matter acquires by being compoſed in different forms, unto the firſt atoms themſelves: for one may as juſtly conclude, that the units of which ivory are compoſed are white, as that they are elaſtic.

Theſe being the fundamental principles of matter; if we would underſtand the nature of its operations, we muſt proceed ſtep by ſtep, examining the different conditions in which it ſubſiſts in the world: what are the diſtinguiſhing characters of it in its different forms; how motion is produced and ſupported; what are the different circumſtances requiſite to produce, maintain, and direct the motions of bodies; what is done upon their ſurfaces; what is a doing within them, or what it is they are ſaid to do, conſidered as unorganized; what matter performs, and by what agents, in organized bodies; and how far its powers extend in ſenſitive ones. But what I have ſaid above is ſufficient for my preſent purpoſe; if it eſtabliſhes the neceſſary inſtruments for ſupporting and maintaining that inimitable ſeries of variety, which nature diſplays in her operations; which is amazing to all, and which it is the wiſdom of the true philoſopher to underſtand. All our inquiries are into the agencies of nature; but we can never comprehend them, unleſs we are acquainted with the principles which alone can produce them.

NUMBER II.

THE PRINCIPLES AND PROPERTIES OF MATERIAL MOTION.

Materiem ſuperabat opus. OVID. *Met.*

THE PRINCIPLES and PROPERTIES OF MATERIAL MOTION.

THE whole frame of nature is a compound of material ſubſtances and their motions. Matter without motion would be a lifeleſs barren maſs; and local motion without matter cannot be. Motion is the great and univerſal ſoul or principle of life in matter, the parent of all the forms or modes of being, into which matter is diverſified, and in which it acts. What I call modes of being are the different appearances and properties, which are not originally inherent in matter, abſtractly conſidered, without

any orderly motion produced upon it. The ſubſtance of an animal and a vegetable have the ſame abſolute material properties, defined N. I. which are inſeparable from both, and common to both: but the characteriſtics, which diſtinguiſh the one from the other, are their conditional properties, or the various products of differently modified motions, collecting, arranging, and ſupporting their ſubſtances in different modes of being.

That there is an univerſal principle of motion throughout the ſyſtem, is ſelf-evident. That it muſt have a continuing cauſe, is a neceſſary conſequence drawn from its exiſtence. Whether this cauſe be ſpiritual or material, needs be no queſtion; when we know, that matter moving can be the cauſe of motion in matter at reſt; and our comprehenſion has no intimation given it of any other natural cauſe, able to produce or preſerve ſuch motion. I ſhall therefore endeavour to ſtate, what muſt be ſome of the neceſſary univerſal properties and effects of motion, mechanically ſupported.

I. Local motion is eſſential to material action. As we can apply the idea of ſpace or place to matter only; ſo change of place can be aſcribed to nothing but matter. The action of intellectual powers ſeems to be quite of a different nature: for tho' in ſome ſenſe the human body may be called the determined

termined ſphere of the mind's activity; yet its actions require no change of place. On the contrary, it ſeems to have an unlimited power of conſtituting within itſelf a comprehenſion or conception of all the properties belonging to matter, or its actions. So that the mind, without being able directly to exert its influence upon matter, or to act as matter does, has as free and commanding an uſe of its properties, as the hand has of a ball. Here is an equal and wiſe partition, between the body and the mind, of the uſe of matter and its properties: the one is conſtantly either acting upon, or immediately affected by them; the other is conſtantly deriving the intimations of theſe accidents, and has the command of their images, but no action, that interferes with or can affect the material objects which yield them.

II. Tho' the abſolute properties of matter be eſſential to the being of matter; yet all the knowlege we can have of theſe properties is relative, and depends intirely upon the actions of matter. In other words, our ſenſes, which convey all the images we can have of matter, are ſupported and impreſſed by material action. Our knowlege of matter depends intirely upon the reflection its actions make upon our ſenſes; and as by looking into a glaſs, we know no more of an object than the glaſs repreſents; ſo we can know no more about matter,

matter, than its actions inform us of. The Creator has set a bar upon our attaining any more knowlege of nature, than is conveyed in that way. Infinite wisdom has conveyed sufficient knowlege to us, without the least glimmering light of the manner, in which creating power knows, passing along with it. The Creator intuitively and potentially knows what constitutes the essence of matter. We can only be informed, by its actions upon our senses, what are its material properties. So that it is one of the fundamental properties of motion, to reveal the existence of matter in all its modifications, to sensible and intelligent creatures.

III. As impulse is the only material cause of motion, which we know or can comprehend; we must determine it to be the cause of all motion, and continuance of motion in the material world. That is one certain and universally known cause, and neither the properties of matter, nor observation, afford us the knowlege of another. What divine power can do, or has done, is out of the question; I speak only of the power he has constituted to act in the frame of nature. It is one of the infinite differences between the human and divine mind, that the latter has the absolute power of what we find wisely denied the human mind, according to §. I.

IV. All

IV. All motion is relative. We determined number to be one of the eſſential properties of the material world. Now motion can only be abſolute, where an unit only exiſts. In which caſe, its ſuppoſed motion can admit of no menſuration; not even that of its own dimenſions: for multiplying its dimenſions to know the length of its motion, cannot be done, without being firſt poſſeſſed of the idea of plurality, which is acquired by matter's exiſting in number. As abſolute motion could not be mechanical, and could never have given the ideas of menſuration, diſtance, *&c.* ſo uſeful to creatures; ſo it would alſo have been abortive and inefficacious, which no motion or power of motion is. Suppoſe this whole ſyſtem ſhould be continually traverſing infinite ſpace; that is no motion to us: we feel no change, every thing continues juſt as it was, and no effect is produced by it. But with us the ideas of motion and change are inſeparable. Motion can be of no effect unleſs it be relative. Of what uſe relative to the ſyſtem, to which they once belonged, muſt the firſt rays of light be; which, according to the philoſophers, have for five or ſix thouſand years been travelling with vaſt rapidity into infinite ſpace? Motion being the univerſal principle of life in nature, would, without any further evidence, incline any unbiaſſed perſon to preſume, that no motion exiſted without producing

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ſome relative effects, ſubſervient to the ſupport of the frame of creation in general.

V. Tho' all motion be relative, it could not be ſo unleſs it were real. But as we have no names, except ſuch as are relative or comparative, to deſcribe it by; all we can ſay of it is, That matter in motion is continually ſhifting its ſtation, and occupying new room.

VI. As matter is not diviſible *in infinitum*, ſo neither can motion be ſo. There is a point or *minimum* in motion, as well as an atom of matter. The ſame way of arguing, which proves that a ſnail might out-run ACHILLES, or that two curves may be eternally approaching each other without a poſſibility of their ever coming into contact, will prove that two cannon balls at 50 paces diſtant from each other, and moving with the greateſt velocity directly towards one another, will never meet. The *minimums* of motion are as remote from our ſenſes, as the atoms of matter are. But as maſſive matter is the object of our ſenſes, and convinces us of the exiſtence of its inſenſible component parts; ſo the portions of motion, which are ſubject to our obſervation, convince us of the inſenſible diviſions which conſtitute it: and theſe inſenſible elements, I may call them, of motion are determined by the following propoſition.

VII. Mo-

VII. Motion has no ſenſible intermiſſion; yet it muſt be performed by real intermiſſions, that is, ſucceſſive impulſes and ſtops. This is the neceſſary conſequence of a ſucceſſion of impulſes being the cauſe of continued motion. Motion to the eye is like the edge of a poliſhed inſtrument, ſmooth to the naked ſenſe, but when more ſtrictly examined, ragged and ſerrated. This is more evidently demonſtrable in ſound, which, tho' it is perceived without any ſenſible remiſſion, is excited by diſtinct vibrations and percuſſions. In like manner, any body turned quickly round an *axis*, tho' extended from its centre by a pretty long *radius*, repreſents to appearance an uniform circumference, exiſting in every point at the ſame time.

This may poſſibly appear a very indirect way of deducing the mechaniſm of matter; but it certainly leads to a concluſion, which eſtabliſhes a primary fact in the organization of the ſyſtem. For if motion is continued by impulſe, there muſt be a conſtant ſucceſſion of impulſes: theſe impulſes cannot terminate in a mechanical origin, unleſs freſh matter be conſtantly brought into the direction of theſe impulſes. Therefore every new maſs of matter, deflected from a former into that new direction, muſt in that deflection or change of direction undergo a change; which,

tho' inſenſible, we can call by no other name than an intermiſſion. So that motion by continued impulſe neceſſarily infers a circulation of matter.

VIII. Time and length are two ideas inſeparable from all motion. Geometricians have been at great pains to aſcertain the proportions theſe bear to one another, in ſome particular kinds of regular motion. But theſe *Ratios* are not eſſential to all ſenſible motion, tho' they are eſtabliſhed as to ſome. This yields us a diſtinction, which may be of ſome uſe; namely, the difference between an eſſential relation and an eſtabliſhed one. Time and length are eſſentially related to motion; but their *Ratios* to one another is only eſtabliſhed. The earth might have rolled round its own *axis* in twelve hours, and round the ſun in half a year; but the double of theſe times is the eſtabliſhed courſe. The ſucceſſive durations of moving matter, in the ſucceſſive ſpaces the moving body occupies during its motion, is properly what is meant by the time and the length of a body's motion. Theſe are always ultimately related to the primary fountain of motion by impulſe, and their *minimums* are the ſame as thoſe in the two preceding ſections. Time is properly a ſucceſſion of durations, and theſe durations are ultimately the ſame with the *minimums* of motion. Infinite wiſdom and power, which contrived how to compact the inſenſibly-ſmall atoms of mat-

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ter into ſolid ſenſible bodies, has ſhewn the ſame ſkill in dividing duration, (tho' an indiviſible-like idea) by motion into inſenſible points.

Tho' time, in this light, be an obvious and neceſſary property of motion, and the ideas of the two are inſeparable in their natures; yet this abſtracted view could have been of no uſe to us, if infinite wiſdom, which knows how to convert the moſt obſcure principles into the moſt ſenſible benefit, had not exhibited in nature an eſtabliſhed ſenſible menſuration of time, fitted for all human uſes and applications. The public, in my opinion, is much obliged to the ingenious and learned *Mr.* KENNEDY for the éclairciſſement he has endeavoured to bring that matter to.

IX. All motion muſt neceſſarily be in ſome direction. Direction can be only of two kinds, either in a ſtraight line, or in a curve. Of the latter there is a great variety between a circle and an *hyperbola*: but the profoundeſt ſkill in geometry can never demonſtrate, that two ſimple powers, ſuch as projection and gravitation, can make any body move in any of theſe curves, ſave that of a circle. Philoſophers ſay, the power of gravity upon the ſurface of this earth cauſes a body to deſcend towards it, at the rate of about 16 feet in a ſecond of time. The power of gravity is about 23

times ſtronger upon the ſurface of the ſun; therefore the particles of light about the ſurface of the ſun, left to the ſun's attractive power, would precipitate towards it at the rate of 368 feet in a ſecond. The power then, with which they are projected into ſpace, muſt be that of 368 feet in a ſecond, added to the velocity with which they move outward. A power of projection, applied outward from the ſun's centre of gravity, juſt equal to 368 feet in a minute, would keep the particles of light ſuſpended, ſo as they could neither recede from, nor approach to, the ſun. That degree of power, applied in the direction of a tangent, would make them move round in a perfect circle; but that power, applied in any other proportion, either below or above 368 feet in a ſecond, and in any conceivable direction, could never bring the form of the curve they would deſcribe into any one of the ſections of a cone; but it muſt deſcribe a curve, either gradually bending more and more to the centre of gravity, or gradually extending and approaching more and more towards the direction of a ſtraight line. *Sir* ISAAC NEWTON himſelf has ſhewn, that if the centripetal power acts after a certain manner with the increaſe of diſtance, a body may deſcribe ſuch a curve line, that all the lines, drawn from the centre to the body, ſhall be equally inclined to that curve line the body moves in round its centre of gravity. Whatever force of projection is applied, above what is ſuffi-

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cient to cauſe a body to move in a perfect circle round its centre of gravity, muſt cauſe it to move in a ſpiral curve, regularly extending in proportion to the overplus of force, which would keep it always at an equal diſtance from its centre, and the gradual decreaſe of the centripetal power: no conceivable force and direction of projection can ever bring the orbit of a planet into an elliptical figure. I cannot apprehend any reaſoning more fallacious, than to argue from the properties of a figure to the *ratios* of powers; and to conclude, that, becauſe at that point of an elliptical arch, where a line drawn from the centre falls at a right angle upon the curve, the arch there begins to bend more toward the centre — therefore at certain points, the powers of gravitation and projection exchange an increaſe and decreaſe of their activity.

X. No mechanical motion can ſubſiſt without a *plenum*, wherever ſuch material motion ſubſiſts. This propoſition is ſo neceſſary a conſequence of motion's being carried on by impulſe, that it needs no other demonſtration.

XI. It follows alſo of conſequence, that the ſyſtem of material motion muſt be limited by boundaries. Without theſe, motion by impulſe muſt ceaſe, for it requires a *plenum*.

XII. Every

XII. Every body in motion muſt have the virtue both of a cauſe and of an effect. No body can move in a *plenum* without putting others in motion, and more than it can move without being impelled itſelf: but if there were no fixed limits to return and circulate the activity of the impulſes of matter upon matter, mobile bodies at the extremities could not obey the impulſes given them, by repeating them upon other bodies. It is not my buſineſs here, to obviate the things that may be ſaid to make the ſuppoſition of ſuch boundaries abſurd and monſtrous. I mention it here as a neceſſary condition of matter moving by impulſe; if any perſon will ſhew that it is not, I give it up.

XIII. There muſt be a centre of all mechanical motion, which muſt communicate impulſe and direction to all other motions. The centre of motion muſt be the ſame with the centre of the boundaries which confine and reflect motion. Such a common fountain is as neceſſary to mechanical motion, as a *plenum* or boundaries are.

XIV. The matter, which is originally concerned in carrying on all motion, and which acts to and from the common centre, muſt act in different conditional properties, but muſt conſiſt of the ſame kind of elementary principles. I purpoſe it ſhall be the ſubject of another *Number*, to examine, what

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are theſe conditions of matter, which qualify it for acting neceſſarily or mechanically, as it does in this ſyſtem. Therefore I take no further notice of it here, than as it is a neceſſary requiſite in mechanical motion. We have found above, that there muſt be a circulation or change of directions in ſuch motion. Now matter, in the ſame condition, cannot act regularly in oppoſite directions, becauſe it would have an equal tendency to both: but in different conditions it can have; and we ſhall in its proper place ſhew, it muſt have a *niſus* to oppoſite directions. Again, it could not change its direction, unleſs it change its properties, and be tranſmutable into the different conditions, which the oppoſite directions require. Therefore, that *congeries* of matter, which is the original fountain of motion, muſt have the ſame elementary properties, that is, muſt be homogeneous.

XV. Matter, from which all motion is originally derived, muſt be in a fluid ſtate. I mean by a fluid ſtate here, that ſuch matter has no coheſion between the particles which conſtitute its different conditional properties. This is ſo obviouſly neceſſary, that it needs no demonſtration.

XVI. Motion ought to be divided into ſenſible or apparent motion, and inſenſible or occult motion.

tion. The running of water, the deſcent of any weighty body called gravitation, the courſe of projectiles and other moving bodies, and the voluntary motions of animals, *&c.* are apparent motions. The propagation of light, the preſſure of the air, the action of the magnet, the power of electricity, are inſenſible motions, ſave by their effects.

XVII. All ſenſible motion muſt have inſenſible motion for its ultimate cauſe. When the magnet, or an electrical power, exerts its virtue on another body, we conclude there is a moving power, diſtinct from the body affected by it. When a perſon moves a member, we conclude it is produced by ſome inſenſible motion, communicated to that member, tho' we ourſelves are not conſcious of it.

XVIII. The three univerſal and inſeparable effects of motion upon all terreſtrial bodies, are coheſion, weight, and power.

XIX. Every body is not always in ſenſible motion, yet every body has at all times as much force acting upon it, as is equal to the moſt violent motion, it can be put into, without having its coheſion diſſolved. Any body, whirled round its own *axis*, with a degree of velocity ſtronger than the power of its coheſion, flies aſunder: a folding knife, moved round its *axis*, with a velocity ſuperior

perior to the force of the back-ſpring, will fly open; a drop of water, whenever it acquires a velocity in falling, greater than the degree of the coheſion of its particles, breaks into peices; and a cannon ball, moved with ſufficient quickneſs, would do the ſame. Hence we infer, that

XX. All motion in comparatively paſſive bodies (ſuch I call terreſtrial ſubſtances) tends toward the diſunion of their coheſion; and the force, which continues their motion, is a conſtant *niſus* to preſerve their adheſion. The latter part of this propoſition is no contradiction to the former; and the whole is a neceſſary conſequence of the preceding. A body moved out of its place would loſe its coheſion, if it were not inſtantaneouſly purſued by the power which ſupports its coheſion; and that power, acting upon it in the courſe of its motion, conſtantly puſhes it forward, 'til its force is overcome by a contrary force acting in the form of reſiſtance. Hence we conclude, that the power, which produces the motion, is the ſame with that which maintains the coheſion of bodies.

XXI. The weight of a body and its power are the ſame. A body moving upward or horizontally has no weight; but in its motion it acts with a power or force exactly the ſame as its weight, added to the quantity of its motion; and both theſe

are exactly proportioned to the force of its coheſion. A pound of lead in motion acts with a power as much ſuperior to a pound of ſpunge, in the ſame degree of motion, as the ſize of the former is ſmaller than the ſize of the latter: for it is the ſame quantity of force or power, reduced to a ſmaller compaſs, which produces neceſſarily a greater effect in the place of its action. This is a certain proof, that coheſion, power, and motion are the ſame; ſeeing they can be evidently analyzed into one another. It may be obſerved as a proof of the ſame, that two contiguous bodies have no power of action againſt one another, their force upon one another depends intirely upon the power of coheſion, acting in the form of ſenſible motion. We may further obſerve, that if there were not a conſtant effort of motion, acting upon every body, we could not put any body in motion. This if attended to needs little demonſtration.

XXII. All bodies, comparatively paſſive, mechanically move towards that part, where the greateſt effort of action is, if they are within that ſphere of action: which obviouſly accounts for the power acting upon ſuch bodies uniformly manifeſting itſelf in the form of weight, called gravity. That ſphere of action round any body, which gives it fixation, may properly be called its atmoſphere. The extent of that ſphere of action muſt be in pro-

portion

portion to the quantity of matter in the body compreſſed, and the degrees of compactneſs its component parts can be reduced to by the active power. That active power mechanically muſt reduce all large bodies, ſuch as this earth (which may be called the primary objects of its action) into an orbicular form; becauſe fixation cannot be accompliſhed unleſs the action be equal, or nearly ſo, on all ſides of the body. Now as both the extent of a body's atmoſphere, and the quantity of the power of that atmoſphere, are in proportion to the body acted upon; every detached part of that body placed any where within its atmoſphere, muſt be preſſed toward the place, where the action of the atmoſphere is primarily directed, with a velocity proportioned to the power of the atmoſphere in that primary direction.

XXIII. In all motion of detached bodies within the ſphere of an atmoſphere, there is a threefold reſiſtance conſtantly exerted, two of which are eſſential to all motion. The firſt, which is proper to ſmaller bodies moving within the atmoſphere of larger ones, is the conſtant preſſure upon them, towards that place where the greateſt effort of motion is. Secondly the reſiſtance they meet with from the fluid they move in. Thirdly, the reaction, which is conſtantly and mechani-

cally produced by the power, which forces all motion contrary to the two former reſiſtances. For the quantity of force applied in all motion is double the quantity of motion produced by it. This is demonſtrated by one moving elaſtic body ſtriking directly againſt another of the ſame kind; where we ſee the force, which moves the ſecond with nearly the velocity of the firſt, exerts its reſiſtance in the ſame proportion by ſtopping the motion of the firſt. So likewiſe two ſuch elaſtic bodies, moving in a ſtraight line with any given equal force againſt one another, upon percuſſion would be toſſed back again with the ſame velocity in the oppoſite directions. In a *plenum*, the fluid parts, which ſupport the fixation (according to §. XX.) and continue the motion of bodies, muſt ruſh in on all ſides behind the body, and act in the form of a wedge. Hence

XXIV. As reſiſtance is no principle of matter, it muſt be a principle inſeparable from motion. And as nothing can produce reſiſtance, ſave motions in contrary directions; ſo all motion in the more paſſive parts of matter, muſt be excited and continued, by two contrary motions in the more ſubtil and mobile parts of matter, which are always the primary cauſe of motion.

XXV. Theſe

XXV. Theſe two primary and univerſal motions, which ſubſiſt by each other, cannot be weakened nor increaſed: ſo that, tho' to our view more bodies may be in motion, and with greater velocity, at one time than at another, yet the univerſal quantity of motion muſt always be the ſame.

XXVI The effects of primary motion upon the more paſſive parts of matter are uniform, unvariable, and unchangeable: ſo that theſe effects muſt overcome the greateſt poſſible motion, art or accident can put bodies into. We can cauſe bodies to reſiſt and move in a direction contrary to their weight, and nothing appears weaker than the reſiſtance of the atmoſphere to progreſſion; yet any one of theſe is able in time to overcome the ſtrongeſt impulſes, which can be given bodies; yea it is able to break them in pieces, as we ſee by §. XIX.

Upon the whole, the ſtrongeſt preſumptions from analogy are in favour of the univerſal material mechaniſm of the operations of nature ſuch as the obvious properties of matter itſelf, N. I. the power of impulſe, its being the only ſenſible cauſe of motion, and the only intelligible one, if there ſubſiſts any other cauſe; the univerſal efficaciouſneſs of motion, which would be loſt in moſt moving bodies, if they were not every where

under

under the reciprocal conditions of cauſe and effect; and the imaginary, occult, and uncertain nature of any other ſuppoſed cauſe; for no *hypotheſis* of occult cauſes of motion has ever been framed, which is not clogged with contradictions ſo obvious, as to be unworthy of the name of a philoſophical principle.

Again, it appears by §. X. XI. XII. XIII. XIV. XV. That the very ſuppoſition of mechanical motion infers ſuch conditions of matter, as can and ſhall, I hope, be proved to ſubſiſt by indiſputable arguments, even ſuch as can be examined: for all other ſuppoſed principles of motion are the ſubject of conjecture, which is incapable of proof; and no reaſoning upon them can it its nature amount to more than a certain degree of probability; while every different *hypotheſis* points out the uncertainty of others. This ſpreads a veil of doubt and incredibility over all the doctrines of the imagination, which are not ſupported by ſuch ſufficient evidence as our underſtandings are capable of, and of conſequence demand. But if the above conditions of matter be the neceſſary conſequence of motion by continued impulſe; then the proof of their exiſtence is alſo the proof of that principle, which neceſſarily infers them.

The laſt evidence here aſſerted in favor of mechaniſm is, that all the *phenomena* in nature may be explained by it; and the three univerſal ſenſible properties of matter be reſolved into the power of motion, acting upon and by material ſubſtances. When the powers and properties of ſenſible bodies can be analyzed into motion and its effects, and when theſe powers can only diſcover themſelves by motion or a tendency to it; it muſt or ought to give ſatisfactory evidence, that motion is the direct cauſe of ſuch effects and appearances. Every one muſt be ſenſible, what a loſs it is to the increaſe of knowlege in the powers of nature, to have the fineſt and moſt curious productions of theſe powers reduced to unintelligible laws, and characterized by words for names which have no meaning, and which render the inventors of them no wiſer, after all their pains, than the moſt heedleſs and unattentive.

It follows in order, that we ſhould next proceed to examine the properties of celeſtial and terreſtrial matter in their different claſſes, with their proper conſtitutions and conſtructure. Theſe we muſt be acquainted with, previous to our underſtanding or being able to explain and account for the various productions and appearances which depend on them. Theſe, throughly underſtood, will lead us into darkeſt receſſes and laboratories of nature; but even a general knowlege of theſe principles, if it is only

only juſt and founded upon certain principles, will make our further inquiries ſatisfactory, ſo far as they reach. The degrees of penetration into theſe principles and their effects muſt diſtinguiſh each perſon's reach as a natural philoſopher, and not an acquaintance with a number of terms of art, depending upon memory and not capacity; and the knowlege of which flatters our vanity, without informing our judgement.

Upon an attentive ſurvey of the operations of nature, every perſon will conclude (as is expreſſed by the motto of this *Number*) that if the exiſtence of matter is wonderful, the beauty, variety, harmony and univerſally-mutual dependences of its operations, with their aſtoniſhing effects, is ſtill more ſo.

The END.

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