

LETTERS

OF

EULER

ON DIFFERENT SUBJECTS

IN

NATURAL PHILOSOPHY.

ADDRESSED TO

A GERMAN PRINCESS.

WITH

NOTES, AND A LIFE OF EULER,  
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# CONTENTS

OF THE

## SECOND VOLUME.

LETTER	PAGE
I. CONTINUATION of the Subject, and of Mistakes in the Knowledge of Truth	1
II. First Class of known Truths. Conviction that Things exist externally, corresponding to the Ideas represented by the Senses. Objection of the Pyrrhonists. Reply.	4
III. Another Objection of the Pyrrhonists against the Certainty of Truths perceived by the senses. Reply; and Precautions for attaining assurance of sensible Truths	7
IV. Of demonstrative, physical, and particularly of moral Certainty	10
V. Remarks that the Senses contribute to the increase of knowledge; and Precautions for acquiring the certainty of Historical Truths	14
VII. Whether the Essence of Bodies be known by us	17
VIII. The true Notion of Extension	20
VIII. Divisibility of Extension <i>in infinitum</i>	23
IX. Whether this Divisibility <i>in infinitum</i> takes Place in existing Bodies?	27
X. Of Monads	30
XI. Reflections on Divisibility <i>in infinitum</i> , and on Monads	33
XII. Reply to the Objections of the Monadists to Divisibility <i>in infinitum</i>	37
XIII. Principle of the <i>sufficient Reason</i> , the strongest Support of the Monadists	39
XIV. Another Argument of the Monadists, derived from the Principle of the <i>sufficient Reason</i> . Absurdities resulting from it	43

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LETTER		
XXXIX.	The Possibility of preventing and of averting the Effects of Thunder	122
XL.	On the celebrated Problem of the Longitude; General Description of the Earth, of its Axis, its two Poles, and the Equator	126
XLI.	Of the Magnitude of the Earth; of Meridians, and the shortest Road from Place to Place	129
XLII.	Of Latitude, and its Influence on the Seasons and the Length of the day	133
XLIII.	Of Parallels, of the First Meridian, and of Longitude	137
XLIV.	Choice of the first Meridian	140
XLV.	Method of determining the Latitude, or the Elevation of the Pole	144
XLVI.	Knowledge of the Longitude, from a Calculation of the Direction, and of the Space passed through	148
XLVII.	Continuation. Defects of this Method	151
XLVIII.	Second Method of determining the Longitude, by means of an exact Time-Piece	154
XLIX.	Continuation, and farther Elucidations	158
L.	Eclipses of the Moon, a third Method of finding the Longitude	161
LI.	Observation of the Eclipses of the Satellites of Jupiter; a fourth Method of finding the Longitude	165
LII.	The Motion of the Moon, a fifth Method	168
LIII.	Advantages of this last Method: its Degree of Precision	172
LIV.	On the Mariner's Compass, and the Properties of the Magnetic Needle	175
LV.	Declination of the Compass, and Manner of observing it	179
LVI.	Difference in the Declination of the Compass at the same Place	182
LVII.	Chart of Declinations; Method of employing it for the Discovery of the Longitude	186
LVIII.	Why does the Magnetic Needle affect, in every Place of the Earth, a certain Direc-	

PAGE	
46	XV. Reflections on the System of Monads
49	XVI. Continuation
52	XVII. Conclusion of Reflections on this System
55	XVIII. Elucidation respecting the Nature of Colours
59	XIX. Reflections on the Analogy between Colours and Sounds
62	XX. Continuation
65	XXI. How opaque Bodies are rendered visible
67	XXII. The Wonders of the Human Voice
71	XXIII. A Summary of the principal Phenomena of Electricity
74	XXIV. The true Principle of Nature, on which are founded all the Phenomena of Electricity
77	XXV. Continuation. Different Nature of Bodies relatively to Electricity
80	XXVI. On the same Subject
84	XXVII. Of positive and negative Electricity. Explanation of the Phenomenon of Attraction
87	XXVIII. On the same Subject
90	XXIX. On the electric Atmosphere
94	XXX. Communication of Electricity to a Bar of Iron, by Means of a Globe of Glass
97	XXXI. Electrification of Men and Animals
100	XXXII. Distinctive Character of the two Species of Electricity
103	XXXIII. How the same Globe of Glass may furnish at once the two Species of Electricity
106	XXXIV. The Leyden Experiment
109	XXXV. Reflections on the Cause and Nature of Electricity, and on other Means proper to produce it
113	XXXVI. Nature of Thunder: Explanations of the ancient Philosophers, and of <i>Descartes</i> : Resemblance of the Phenomena of Thunder to those of Electricity
116	XXXVII. Explanation of the Phenomena of Lightning and Thunder
119	XXXVIII. Continuation

LETTER	PAGE
LXXXIV.	Effect of Convex Lenses - 247
LXXXV.	The same Subject: Distance of the Focus of Convex Lenses - 250
LXXXVI.	Distance of the Image of Objects - 254
LXXXVII.	Magnitude of Images - 257
LXXXVIII.	Burning-Glasses - 260
LXXXIX.	The Camera Obscura - 264
LXXXX.	Reflections on the Representation in the Camera Obscura - 268
LXXXXI.	Of the Magic Lantern, and Solar Microscope - 271
LXXXXII.	Use and Effect of a simple Convex Lens - 274
LXXXXIII.	Use and Effect of a Concave Lens - 277
LXXXXIV.	Of apparent Magnitude, of the Visual Angle, and of Microscopes in general - 281
LXXXXV.	Estimation of the Magnitude of Objects viewed through the Microscope - 284
LXXXXVI.	Fundamental Proposition for the construction of simple Microscopes. Plan of some simple Microscopes - 288
LXXXXVII.	Limits and Defects of the simple Microscope - 291
LXXXXVIII.	On Telescopes, and their Effect - 294
LXXXXIX.	Of Pocket-Glasses - 297
XC.	On the magnifying power of Pocket-Glasses - 301
XCI.	Defects of Pocket-Glasses. Of the apparent Field - 305
XCII.	Determination of the apparent Field for Pocket-Glasses - 308
XCIII.	Astronomical Telescopes, and their magnifying Power - 312
XCV.	Of the apparent Field, and the Place of the Eye - 314
XCV.	Determination of the magnifying Power of Astronomical Telescopes, and the construction of a Telescope which shall magnify objects a given number of times - 318
XCVI.	Degree of Clearness - 322

LETTER	PAGE
LIX.	Elucidations respecting the Cause and Variation of the Declination of Magnetic Needles - 193
LX.	Inclination or Dip of Magnetic Needles - 197
LXI.	True Magnetic Direction; subtle Matter which produces the Magnetic Power - 201
LXII.	Nature of the Magnetic Matter, and of its rapid Current. Magnetic Canals - 205
LXIII.	Magnetic Vortex. Action of Magnets upon each other - 208
LXIV.	Nature of Iron and Steel. Method of communicating to them the Magnetic Force - 211
LXV.	Action of Loadstones on Iron. Phenomena observable on placing pieces of Iron near a Loadstone - 216
LXVI.	Arming of Loadstones - 219
LXVII.	Action and Force of armed Loadstones - 223
LXVIII.	The Method of communicating to Steel the Magnetic Force, and of magnetizing Needles for the Compass: the <i>Simple Touch</i> , its Defects; means of remedying these - 226
LXIX.	On the <i>Double Touch</i> . Means of preserving the Magnetic Matter in magnetized Bars - 230
LXX.	The Method of communicating to Bars of Steel a very great Magnetic Force, by means of other Bars which have it in a very inferior degree - 234
LXXI.	Construction of artificial Magnets in the form of a Horse-shoe - 237
LXXII.	On Dioptries; Instruments which that Science supplies: of Telescopes and Microscopes. Different Figures given to Glasses or Lenses - 241
LXXIII.	Difference of Lenses with respect to the curve of their surfaces. Distribution of Lenses into three classes - 244

LETTER	PAGE
CXII.	An attempt toward the true Explanation of this Phenomenon: the Moon appears more distant when in the Horizon than when at a great Elevation - 376
CXIII.	The Heavens appear under the Form of an Arch flattened toward the Zenith - 379
CXIV.	Reason assigned for the Faintness of the Light of Heavenly Bodies in the Horizon - 383
CXV.	Illusion respecting the Distance of Objects, and the Diminution of Lustre - 386
CXVI.	On the Azure Colour of the Heavens - 388
CXVII.	What the Appearance would be were the Air perfectly transparent - 392
CXVIII.	Refraction of Rays of Light in the Atmosphere, and its Effects. Of the Twilight. Of the apparent rising and setting of the Heavenly Bodies - 395
CXIX.	The Stars appear at a greater Elevation than they are. Table of Refractions - 398

LETTER	PAGE
XCVII.	Aperture of Object-Glasses - 325
XCVIII.	On Distinctness in the Expression: On the Space of Diffusion occasioned by the Aperture of Object-Glasses, and considered as the first Source of Distinctness in the Representation of Lenses, and other Means of lessening the space of Diffusion, till it is reduced to nothing - 333
XCIX.	Diminution of the Aperture of Lenses, and other Means of lessening the space of Diffusion, till it is reduced to nothing - 337
C.	Of Compound Object-glasses - 340
CI.	Formation of Simple Object-glasses as to Distinctness - 344
CII.	Second-Source of Defect by the Telescope. Diff- of Representation by the Telescope. Different Refrangibility of Rays - 348
CIIL.	Means of remedying this Defect by Compound Object-glasses - 351
CIV.	Other Means more practicable - 354
CV.	Recapitulation of the Qualities of a good Telescope - 357
CVI.	Terrestrial Telescopes with four Lenses - 361
CVII.	Arrangement of Lenses in Terrestrial Telescopes - 361
CVIII.	Precautions to be observed in the construction of Telescopes. Necessity of blackening the inside of Tubes. Diaphragms - 364
CIX.	In what manner Telescopes represent the Moon, the Planets, the Sun, and the fixed Stars. Why these last appear smaller through the Telescope than to the naked Eye. Calculation of the Distance of their fixed Stars, from a Comparison of their apparent Magnitude with that of the Sun - 367
CX.	Why do the Moon and the Sun appear greater at rising and setting, than at a certain elevation? Difficulties attending the Solution of this Phenomenon - 370
CXI.	Reflections on the Question respecting the Moon's apparent Magnitude: Progress toward a Solution of the Difficulty. Absurd Explanation - 373

# LETTERS

ON

DIFFERENT SUBJECTS

IN

## NATURAL PHILOSOPHY.

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LETTER I.—CONTINUATION OF THE SUBJECT, AND  
OF MISTAKES IN THE KNOWLEDGE OF TRUTH.

THE three classes of truths which I have now unfolded, are the only sources of all our knowledge; all being derived from our own experience, from reasoning, or from the report of others.

It is not easy to determine which of these three sources contributes most to the increase of knowledge. Adam and Eve must have derived theirs chiefly from the two first; God, however, revealed many things to them, the knowledge of which is to be referred to the third source, as neither their own experience, nor their powers of reasoning, could have conducted them so far.

Without recurring to a period so remote, we are sufficiently convinced, that if we were determined to believe nothing of what we hear from others, or read in their writings, we should be in a state of almost total ignorance. It is very far, however, from being our duty to believe every thing that is said, or that

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VOL. II.

we read. We ought constantly to employ our discerning faculties, not only with respect to truths of the third class, but likewise of the two others.

We are so liable to suffer ourselves to be dazzled by the senses, and to mistake in our reasonings, that the very sources laid open by the Creator for the discovery of truth very frequently plunge us into error. Notions of the third class, therefore, ought not in reason to fall under suspicion, any more than such as belong to the other two. We ought, therefore, to be equally on our guard against deception; whatever be the class to which the notion belongs; for we find as many instances of error in the first and second classes as in the third. The same thing holds with regard to the certainty of the particular articles of knowledge which these three sources supply; and it cannot be affirmed that the truths of any one order have a surer foundation than those of another. Each class is liable to errors, by which we may be misled; but there are likewise precautions which, carefully observed, furnish us with nearly the same degree of conviction. I do not know whether you are more thoroughly convinced of this truth, that two triangles which have the same base and the same height are equal to one another; than of this, that the Russians have been at Berlin; though the former is founded on a chain of accurate reasoning, whereas the latter depends entirely on the veracity of your informer.

Respecting the truths, therefore, of each of these classes, we must rest satisfied with such proofs as correspond to their nature; and it would be ridiculous to insist upon a geometrical demonstration of the truths of experience, or of history. This is usually the fault of those who make a bad use of their penetration in intellectual truths, to require mathematical demonstration in proof of all the truths of

religion, a great part of which belongs to the third class.

There are persons determined to believe and admit nothing but what they see and touch; whatever you would prove to them by reasoning, be it ever so solid, they are disposed to suspect, unless you place it before their eyes. Chemists, anatomists, and natural philosophers, who employ themselves wholly in making experiments, are most chargeable with this fault. Every thing that the one cannot melt in his crucible, or the other dissect with his scalpel, they reject as unfounded. To no purpose would you speak to them of the qualities and nature of the soul; they admit nothing but what strikes the senses.

Thus, the particular kind of study to which every one is addicted, has such a powerful influence on his manner of thinking, that the natural philosopher and chemist will have nothing but experiments, and the geometrician and logician nothing but arguments; which constitute, however, proofs entirely different, the one attached to the first class, the other to the second, which ought always to be carefully distinguished, according to the nature of the objects.

But can it be possible that persons should exist, who, wholly absorbed in pursuits pertaining to the third class, call only for proofs derived from that source? I have known some of this description, who, totally devoted to the study of history and antiquity, would admit nothing as true, but what you could prove by history, or the authority of some ancient author. They perfectly agree with you respecting the truth of the propositions of Euclid, but merely on the authority of that author, without paying any attention to the demonstrations by which he supports them; they even imagine that the contrary of

these propositions might be true, if the ancient geometers had thought proper to maintain it.

This is a source of error which retards many in the pursuit of truth; but we find it rather among the learned, than among those who are beginning to apply themselves to the study of the sciences. We ought to have no predilection in favour of any one of the three species of proofs which each class requires; and provided they are sufficient in their kind, we are bound to admit them.

*I have seen or felt*, is the proof of the first class. *I can demonstrate it*, is that of the second; we likewise say, *I know it is so*. Finally, *I receive it on the testimony of persons worthy of credit*, or *I believe it on solid grounds*, is the proof of the third class.

4th April 1761.

LETTER II.—FIRST CLASS OF KNOWN TRUTHS, CONVINCION THAT THINGS EXIST EXTERNALLY, CORRESPONDING TO THE IDEAS REPRESENTED BY THE SENSES. OBJECTION OF THE PYRRHONISTS. REPLY.

WE include in the first class of known truths, those which we acquire immediately by means of the senses. I have already remarked, that they not only supply the soul with certain representations relative to the changes produced in a part of the brain; but that they excite there a conviction of the real existence of things external, corresponding to the ideas which the senses present to us.

The soul is frequently compared to a man shut up in a dark room, in which the images of external objects are represented on the wall by means of a glass. This comparison is tolerably just, as far as it respects the man looking at the images on the wall; for this

act is sufficiently similar to that of the soul, contemplating the impressions made in the brain; but the comparison appears to me extremely defective, as far as it respects the conviction, that the objects which occasion these images really exist.

The man in the dark room will immediately suspect the existence of these objects; and if he has no doubt about the matter, it is because he has been out of doors, and has seen them; besides this, knowing the nature of his glass, he is assured, that nothing can be represented on the wall but the images of the objects which are without the chamber before the glass. But this is not the case with the soul; it has never quitted its place of residence to contemplate the objects themselves; and it knows still less the construction of the sensitive organs, and the nerves which terminate in the brain. It is nevertheless much more powerfully convinced of the real existence of objects, than our man in the dark room possibly can be. I am apprehensive of no objection on the subject, the thing being too clear of itself to admit any, though we do not know the true foundation of it. No one ever entertained any doubt about it, except certain visionaries, who have bewildered themselves in their own reveries. Though they say, that they doubt the existence of external objects, they entertain no such doubt in fact; for why would they have affirmed it, unless they had believed the existence of other men, to whom they wished to communicate their extravagant opinions.

This conviction respecting the existence of the things whose images the senses represent, appears not only in men of every age and condition, but likewise in all animals. The dog which barks at me has no doubt of my existence, though his soul perceives but a slight image of my person. Hence I conclude, that this conviction is essentially connected



with our sensations, and that the truths which the senses convey to us, are as well founded as the most undoubted truths of geometry.

Without this conviction no human society could subsist, for we should be continually falling into the greatest absurdities, and the grossest contradictions.

Were the peasantry to dream of doubting about the existence of their bailiff, or soldiers about that of their officers, into what confusion should we be plunged! Such absurdities are entertained only by philosophers; any other giving himself up to them, would be considered as having lost his reason. Let us then acknowledge this conviction as one of the principal laws of nature, and that it is complete, though we are absolutely ignorant of its true reasons, and very far from being able to explain them in an intelligible manner.

However important this reflection may be, it is by no means, however, exempted from difficulties; but were they ever so great, and though it might be impossible for us to solve them, they do not in the smallest degree affect the truth which I have just established, and which we ought to consider as the most solid foundation of human knowledge.

It must be allowed, that our senses sometimes deceive us; and hence it is that those subtle philosophers, who value themselves on doubting of every thing, deduce the consequence, that we ought never to depend on our senses. I have perhaps oftener than once met an unknown person in the street, whom I mistook for an acquaintance: as I was deceived in that instance, nothing prevents my being always deceived; and I am, therefore, never assured, that the person to whom I speak is in reality the one I imagine.

Were I to go to Magdeburg, and to present myself to your Highness, I ought always to be appre-

hensive of grossly mistaking: nay, perhaps, I should not be at Magdeburg, for there are instances of a man's sometimes taking one city for another. It is even possible I may never have had the happiness of seeing you, but was always under the power of delusion when I thought myself to be enjoying that felicity.

Such are the natural consequences resulting from the sentiments of certain philosophers; and you must be abundantly sensible, that they not only lead to manifest absurdity, but have a tendency to dissolve all the bonds of society.

*7th April 1761.*

LETTER III.—ANOTHER OBJECTION OF THE PYRRHONISTS AGAINST THE CERTAINTY OF TRUTHS PERCEIVED BY THE SENSES. REPLY; AND PRECAUTIONS FOR ATTAINING ASSURANCE OF SENSIBLE TRUTHS.

THOUGH the objection raised against the certainty of truths perceived by the senses, of which I have been speaking, may appear sufficiently powerful, attempts have been made to give it additional support from the well known maxim, that we ought never to trust him who has once deceived us. A single example, therefore, of mistake in the senses, is sufficient to destroy all their credit. If this objection is well founded, it must be admitted, that human society is, of course, completely subverted.

By way of reply, I remark, that the two other sources of knowledge are subject to difficulties of a similar nature, nay perhaps still more formidable. How often are our reasonings erroneous? I venture to affirm, that we are much more frequently de-

ceived by these, than by our senses. But does it follow, that our reasonings are always fallacious, and that we can have no dependence on any truth discovered to us by the understanding? It must be a matter of doubt, then, whether two and two make four, or whether the three angles of a triangle be equal to two right angles; it would even be ridiculous to pretend that this should pass for truth. Though, therefore, men may have frequently reasoned inconclusively, it would be almost absurd to infer, that there are not many intellectual truths, of which we have the most complete conviction.

The same remark applies to the third source of human knowledge, which is unquestionably the most subject to error. How often have we been deceived by a groundless rumour, or false report, respecting certain events? And who would be so weak as to believe all that gazetteers and historians have written? At the same time, whoever should think of maintaining that every thing related or written by others is false, would undoubtedly fall into greater absurdities than the person who believed every thing. Accordingly, notwithstanding so many groundless reports and false testimonies, we are perfectly assured of the truth of numberless facts, of which we have no evidence but testimony.

There are certain characters which enable us to distinguish truth; and each of the three sources has characters peculiar to itself. When my eyes have deceived me, in mistaking one man for another, I presently discovered my error: it is evident, therefore, that precautions may be used for the prevention of error. If there were not, it would be impossible ever to perceive that we had been deceived. Those, then, who maintain that we so often deceive ourselves, are obliged to admit that it is possible for us

to perceive we have been deceived, or they must acknowledge that they themselves are deceived when they charge us with error.

It is remarkable, that truth is so well established, that the most violent propensity to doubt of every thing must come to this, in spite of itself. Therefore, as logic prescribes rules for just reasoning, the observance of which will secure us from error, where intellectual truth is concerned; there are likewise certain rules, as well for the first source, that of our senses, as for the third, that of belief.

The rules of the first are so natural to us, that all men, the most stupid not excepted, understand and practise them much better than the greatest scholars are able to describe them. Though it may be easy sometimes to confound a clown, yet when the hail destroys his crop, or the thunder breaks upon his cottage, the most ingenious philosopher will never persuade him that it was a mere illusion; and every man of sense must admit that the country fellow is in the right, and that he is not always the dupe of the fallaciousness of his senses. The philosopher may be able, perhaps, to perplex him to such a degree that he shall be unable to reply; but he will inwardly treat all the fine reasonings, which attempted to confound him, with the utmost scorn. The argument, that the senses sometimes deceive us, will make but a very slight impression on his mind; and when he is told, with the greatest eloquence, that every thing the senses represent to us has no more reality than the visions of the night, it will only provoke laughter.

But if the clown should pretend to play the philosopher in his turn, and maintain that the bailiff is a mere phantom, and that all who consider him as something real, and submit to his authority, are fools; this sublime philosophy would be in a mo-

ment overturned, and the leader of the sect soon made to feel, to his cost, the force of the proofs which the bailiff could give him of the reality of his existence.

You must be perfectly satisfied, then, that there are certain characters which destroy every shadow of doubt respecting the reality and truth of what we know by the senses; and these same characters are so well known, and so strongly impressed on our minds, that we are never deceived when we employ the precautions necessary to that effect. But it is extremely difficult to make an exact enumeration of these characters, and to explain their nature. We commonly say, that the sensitive organs ought to be in a good natural state; that the air ought not to be obscured by a fog; finally, that we must employ a sufficient degree of attention, and endeavour, above all things, to examine the same object by two or more of our senses at once. But I am firmly persuaded that every one knows, and puts in practice, rules much more solid than any which could be prescribed to him.

11th April 1761.

LETTER IV.—OF DEMONSTRATIVE, PHYSICAL, AND PARTICULARLY OF MORAL CERTAINTY.

THERE are, therefore, three species of knowledge which we must consider as equally certain, provided we employ the precautions necessary to secure us against error. And hence likewise result three species of certainty.

The first is called *physical certainty*. When I am convinced of the truth of any thing, because I myself have seen it, I have a physical certainty of it; and if I am asked the reason, I answer, that my own

senses give me full assurance of it, and that I am, or have been, an eye-witness of it. It is thus I know that Austrians have been at Berlin, and that some of them committed great irregularities there. I know, in the same manner, that fire consumes all combustible substances; for I myself have seen it, and I have a physical certainty of its truth.

The certainty which we acquire by a process of reasoning, is called *logical or demonstrative certainty*, because we are convinced of its truth by demonstration. The truths of geometry may here be produced as examples, and it is logical certainty which gives us the assurance of them.

Finally, the certainty which we have of the truth of what we know only by the report of others, is called *moral certainty*, because it is founded on the *credibility* of the persons who make the report. Thus you have only a moral certainty that the Russians have been at Berlin; and the same thing applies to all historical facts. We know with a moral certainty, that there was formerly at Rome a Julius Cæsar, an Augustus, a Nero, &c., and the testimonies respecting these are so authentic, that we are as fully convinced of them, as of the truths which we discover by our senses, or by a chain of fair reasoning.

We must take care, however, not to confound these three species of certainty—physical, logical, and moral—each of which is of a nature totally different from the others. I propose to treat of each separately; and shall begin with a more particular explanation of moral certainty, which is the third species.

It is to be attentively remarked, that this third source divides into two branches, according as others simply relate what they themselves have seen, or made full proof of by their senses, or as they com-

municate to us, together with these, their reflections and reasonings upon them. We might add still a third branch, when they relate what they have heard from others.

As to this third branch, it is generally allowed to be very liable to error, and that a witness is to be believed only respecting what he himself has seen or experienced. Accordingly, in courts of justice, when witnesses are examined, great care is taken to distinguish, in their declarations, what they themselves have seen and experienced, from what they frequently add of their reflections and reasonings upon it. Stress is laid only on what they themselves have seen or experienced; but their reflections, and the conclusions which they draw, however well founded they may otherwise be, are entirely set aside. The same maxim is observed with respect to historians; and we wish them to relate only what they themselves have witnessed, without pursuing the reflections which they so frequently annex, though these may be a great ornament to history. Thus we have a greater dependence on the truth of what others have experienced by their own senses, than on what they have discovered by pursuing their meditations. Every one wishes to be master of his own judgment; and unless he himself feels the foundation and the demonstration, he is not persuaded.

Euclid would in vain have announced to us the most important truths of geometry; we should never have believed him on his word, but have insisted on prosecuting the demonstration step by step ourselves. If I were to tell you, that I had seen such or such a thing, supposing my report faithful, you would without hesitation give credit to it; nay, I should be very much mortified if you were to suspect me of falsehood. But when I inform you, that in a right-angled triangle, the squares described on

the two smaller sides are together equal to the square of the greater side, I do not wish to be believed on my word, though I am as much convinced of it as it is possible to be of any thing; and though I could allege, to the same purpose, the authority of the greatest geniuses who have had the same conviction, I should rather wish you to discredit my assertion, and to withhold your assent, till you yourself comprehended the solidity of the reasonings on which the demonstration is founded.

It does not follow, however, that physical certainty, or that which the senses supply, is greater than logical certainty, founded on reasoning; but whenever a truth of this species presents itself, it is proper that the mind should give close application to it, and become master of the demonstration. This is the best method of cultivating the sciences, and of carrying them to the highest degree of perfection.

The truths of the senses, and of history, greatly multiply the particulars of human knowledge; but the faculties of the mind are put in action only by reflection or reasoning.

We never stop at the simple evidence of the senses, or the facts related by others; but always follow them up and blend them with reflections of our own: we insensibly supply what seems deficient, by the addition of causes and motives, and the deduction of consequences. It is extremely difficult, for this reason, in courts of justice, to procure simple unblended testimony, such as contains what the witnesses actually saw and felt, and no more; for witnesses ever will be mingling their own reflections, without perceiving that they are doing so.

14th April 1761.

LETTER V.—REMARKS THAT THE SENSES CONTRIBUTE TO THE INCREASE OF KNOWLEDGE; AND PRECAUTIONS FOR ACQUIRING THE CERTAINTY OF HISTORICAL TRUTHS.

THE knowledge supplied by our senses is undoubtedly the earliest which we acquire; and upon this the soul founds the thoughts and reflections which discover to it a great variety of intellectual truths. In order the better to comprehend how the senses contribute to the advancement of knowledge, I begin with remarking, that the senses act only on individual things, which actually exist under circumstances determined or limited on all sides.

Let us suppose a man suddenly placed in the world, possessed of all his faculties, but entirely destitute of experience; let a stone be put in his hand, let him then open that hand, and observe that the stone falls. This is an experiment limited on all sides, which gives him no information, except that this stone being in the left hand, for example, and dropped, falls to the ground; he is by no means absolutely certain that the same effect would ensue were he to take another stone, or the same stone, with his right hand. It is still uncertain whether this stone, under the same circumstances, would again fall, or whether it would have fallen had it been taken up an hour sooner. This experiment alone gives him no light respecting these particulars.

The man in question takes another stone, and observes that it falls likewise, whether dropped from the right hand or from the left: he repeats the experiment with a third and a fourth stone, and uniformly observes the same effect. He hence concludes that stones have the property of falling when

dropped, or when that which supports them is withdrawn.

Here, then, is an article of knowledge which the man has derived from the experiments which he has made. He is very far from having made trial of every stone, or, supposing him to have done so, what certainty has he that the same thing would happen at all times? He knows nothing as to this, except what concerns the particular moments when he made the experiments; and what assurance has he that the same effect would take place in the hands of another man? Might he not think, that this quality of making stones fall was attached to his hands exclusively? A thousand other doubts might still be formed on the subject.

I have never, for example, made trial of the stones which compose the cathedral church of Magdeburg, and yet I have not the least doubt, that all of them, without exception, are heavy, and that each of them would fall as soon as detached from the building. I even imagine that experience has supplied me with this knowledge, though I have never tried any one of those stones.

This example is sufficient to show how experiments made on individual objects only, have led mankind to the knowledge of universal propositions; but it must be admitted, that the understanding and the other faculties of the soul interfere in a manner which it would be extremely difficult clearly to unfold; and if we were determined to be over scrupulous about every circumstance, no progress in science could be made, for we should be stopped short at every step.

It must be allowed, that the vulgar discover in this respect much more good sense than those scrupulous philosophers, who are obstinately determined to doubt of every thing. It is necessary, at the same

time, to be on our guard against falling into the opposite extreme, by neglecting to employ the necessary precautions.

The three sources from which our knowledge is derived, require all of them certain precautions, which must be carefully observed, in order to acquire assurance of the truth; but it is possible, in each, to carry matters too far, and it is always proper to steer a middle course.

The third source clearly proves this. It would undoubtedly be extreme folly to believe every thing that is told us; but excessive distrust would be no less blame-worthy. He who is determined to doubt of every thing, will never want a pretence; when a man says or writes that he has seen such or such an action, we may say at once that is not true, and that the man takes amusement in relating things which may excite surprise; and if his veracity is beyond suspicion, it might be said, that he did not see clearly, that his eyes were dazzled; and examples are to be found in abundance of persons deceiving themselves, falsely imagining they saw what they did not. The rules prescribed, in this respect, lose all their weight when you have to do with a wrangler.

Usually, in order to be ascertained of the truth of a recital or history, it is required that the author should have been himself a witness of what he relates, and that he should have no interest in relating it differently from the truth. If afterwards two or more persons relate the same thing, with the same circumstances, it is justly considered as a strong confirmation. Sometimes, however, a coincidence carried to extreme minuteness becomes suspicious. For two persons observing the same incident, see it in different points of view; and the one will always discern certain little circumstances which the other

must have overlooked. A slight difference in two several accounts of the same event, rather establishes than invalidates the truth of it.

But it is always extremely difficult to reason on the first principles of our knowledge, and to attempt an explanation of the mechanism and of the moving powers which the soul employs. It would be glorious to succeed in such an attempt, as it would elucidate a great variety of important points respecting the nature of the soul and its operations. But we seem destined rather to make use of our faculties, than to trace their nature through all its depths.

18th April 1761.

LETTER VI.—WHETHER THE ESSENCE OF BODIES  
BE KNOWN BY US.

AFTER so many reflections on the nature and faculties of the soul, you will not perhaps be displeased to return to the consideration of body, the principal properties of which I have already endeavoured to explain.

I have remarked, that the nature of body necessarily contains three things, *extension*, *impenetrability*, and *inertia*; so that a being, in which these three properties do not meet at once, cannot be admitted into the class of bodies; and reciprocally, when they are united in any one being, no one will hesitate to acknowledge it for a body.

In these three things, then, we are warranted to constitute the essence of body, though there are many philosophers who pretend that the essence of bodies is wholly unknown to us. This is not only the opinion of the Pyrrhonists, who doubt of every thing; but there are other sects likewise, who maintain, that the essence of all things is absolutely un-

known: and, no doubt, in certain respects they have truth on their side: this is but too certain as to all the individual beings which exist.

You will easily comprehend, that it would be the height of absurdity were I to pretend so much as to know the essence of the pen which I employ in writing this letter. If I knew the essence of this pen, (I speak not of pens in general, but of that one only now between my fingers, which is an *individual being*, as it is called in metaphysics, and which is distinguished from all the other pens in the world,) if I knew, then, the essence of this individual pen, I should be in a condition to distinguish it from every other, and it would be impossible to change it without my perceiving the change; I must know its nature thoroughly, the number and the arrangement of all the parts whereof it is composed. But how far am I from having such a knowledge! Were I to rise but for a moment, one of my children might easily change it, leaving another in its room, without my perceiving the difference; and were I even to put a mark upon it, how easily might that mark be counterfeited on another pen? And supposing this impossible for my children, it must always be admitted as possible for God to make another pen so similar to this, that I should be unable to discern any difference. It would be, however, another pen, really distinguishable from mine, and God would undoubtedly know the difference of them; in other words, God perfectly knows the essence of both the one and the other of these two pens: but as to me, who discern no difference, it is certain that the essence is altogether beyond my knowledge.

The same observation is applicable to all other individual things; and it may be confidently maintained, that God alone can know the essence or nature of each. It were impossible to fix on any one

thing really existing, of which we could have a knowledge so perfect, as to put us beyond the reach of mistake: this is, if I may use the expression, the impress of the Creator on all created things, the nature of which will ever remain a mystery to us.

It is undoubtedly certain, then, that we do not know the essence of individual things, or all the characters whereby each is distinguished from every other; but the case is different with respect to *genera* and *species*: these are general notions which include at once an infinite number of individual things. They are not beings actually existing, but notions which we ourselves form in our minds, when we arrange a great many individual things in the same class, which we denominate a species or genus, according as the number of individual things which it comprehends is greater or less.

And to return to the example of the pen, as there are an infinite number of things, to each of which I give the same name, though they all differ one from another, the notion of *pen* is a general idea, of which we ourselves are the creators, and which exists only in our own minds. This notion contains but the common characters which constitute the essence of the general notion of a pen; and this essence must be well known to us, as we are in a condition to distinguish all the things which we call *pens* from those which we do not comprehend under that appellation.

As soon as we remark in any thing certain characters, or certain qualities, we say it is a pen; and we are in a condition to distinguish it from all other things which are not pens, though we are very far from being able to distinguish it from other pens.

The more general a notion is, the fewer it contains of the characters which constitute its essence; and it is accordingly easier also to discover this essence,

We comprehend more easily what is meant by a tree in general, than by the term cherry-tree, pear-tree, or apple-tree; that is, when we descend to the species. When I say, such an object which I see in the garden is a tree, I run little risk of being mistaken; but it is extremely possible I might be wrong, if I affirmed it was a cherry-tree. It follows, then, that I know much better the essence of tree in general, than of the species; I should not so easily conclude a tree with a stone, as a cherry-tree with a plum-tree.

Now a notion in general extends infinitely farther; its essence accordingly comprehends only the characters which are common to all beings bearing the name of *bodies*. It is reduced, therefore, to a very few particulars, as we must exclude from it all the characters which distinguish one body from another.

It is ridiculous then to pretend, with certain philosophers, that the essence of bodies in general is unknown to us. If it were so, we should never be in a condition to affirm with assurance, that such a thing is a body, or it is not; and as it is impossible we should be mistaken in this respect, it necessarily follows, that we know sufficiently the nature or essence of body in general. Now this knowledge is reduced to three articles, extension, impenetrability, and inertia.

21st April 1761.

#### LETTER VII.—THE TRUE NOTION OF EXTENSION.

I HAVE already demonstrated, that the general notion of body necessarily comprehends these three qualities, extension, impenetrability, and inertia, without which no being can be ranked in the class of

bodies. Even the most scrupulous must allow the necessity of these three qualities, in order to constitute a body; but the doubt with some is, Are these three characters sufficient? Perhaps, say they, there may be several other characters, which are equally necessary to the essence of body.

But I ask, were God to create a being divested of these other unknown characters, and that it possessed only the three above mentioned, Would they hesitate to give the name of body to such a being? No, assuredly; for if they had the least doubt on the subject, they could not say with certainty that the stones in the street are bodies, because they are not sure whether the pretended unknown characters are to be found in them or no.

Some imagine, that gravity is an essential property of all bodies, as all those which we know are heavy; but were God to divest them of gravity, would they therefore cease to be bodies? Let them consider the heavenly bodies which do not fall downward; as must be the case, if they were heavy as the bodies which we touch, yet they give them the same name. And even on the supposition, that all bodies were heavy, it would not follow that gravity is a property essential to them, for a body would still remain a body, though its gravity were to be destroyed by a miracle.

But this reasoning does not apply to the three essential properties above mentioned. Were God to annihilate the extension of a body, it would certainly be no longer a body; and a body divested of impenetrability would no longer be *body*; it would be a spectre, a phantom; the same holds as to inertia. You know that extension is the proper object of geometry, which considers bodies only in so far as they are extended, abstractedly from impenetrability and inertia; the object of geometry, therefore, is a



notion much more general than that of body, as it comprehends not only bodies, but all beings simply extended, without impenetrability, if any such there be. Hence it follows, that all the properties deduced in geometry from the notion of extension must likewise take place in bodies, in as much as they are extended; for whatever is applicable to a more general notion, to that of a tree, for example, must likewise be applicable to the notion of an oak, an ash, an elm, &c.; and this principle is even the foundation of all the reasonings in virtue of which we always affirm and deny of the species, and of individuals, every thing that we affirm and deny of the genus.

There are however philosophers, particularly among our contemporaries, who boldly deny that the properties applicable to extension in general, that is, according as we consider them in geometry, take place in bodies really existing. They allege, that geometrical extension is an abstract being, from the properties of which it is impossible to draw any conclusion with respect to real objects; thus, when I have demonstrated that the three angles of a triangle are together equal to two right angles, this is a property belonging only to an abstract triangle, and not at all to one really existing.

But these philosophers are not aware of the perplexing consequences which naturally result from the difference which they establish between objects formed by abstraction, and real objects; and if it were not permitted to conclude from the first to the last, no conclusion, and no reasoning whatever, could subsist, as we always conclude from general notions to particular.

Now all general notions are as much abstract beings as geometrical extension; and a tree in general, or the general notion of trees, is formed only by abstraction, and no more exists out of our mind than

geometrical extension does. The notion of man in general is of the same kind, and man in general nowhere exists: all men who exist are individual beings, and correspond to individual notions. The general idea, which comprehends all, is formed only by abstraction.

The fault which these philosophers are ever finding with geometers, for employing themselves about abstractions merely, is therefore groundless, as all other sciences principally turn on general notions, which are no more real than the objects of geometry. The patient, in general, whom the physician has in view, and the idea of whom contains all patients really existing, is only an abstract idea; may, the very merit of each science is so much the greater, as it extends to notions more general, that is to say, more abstract.

I shall endeavour by next post to point out the tendency of the censures pronounced by these philosophers upon geometers; and the reasons why they are unwilling that we should ascribe to real extended beings, that is, to existing bodies, the properties applicable to extension in general, or to abstract extension. They are afraid lest their metaphysical principles should suffer in the cause.

25<sup>th</sup> April 1761.

#### LETTER VIII.—DIVISIBILITY OF EXTENSION IN INFINITUM.

THE controversy between modern philosophers and geometers to which I have alluded, turns on the divisibility of body. This property is undoubtedly founded on extension; and it is only in so far as bodies are extended that they are divisible, and capable of being reduced to parts.

You will recollect, that in geometry it is always possible to divide a line, however small, into two equal parts. We are likewise by that science instructed in the method of dividing a small line, as  $a i$  (PLATE II. vol. i. Fig. 5.), into any number of equal parts at pleasure; and the construction of this division is there demonstrated beyond the possibility of doubting its accuracy.

You have only to draw a line  $A I$  parallel to  $a i$  of any length, and at any distance you please, and to divide it into as many equal parts  $AB, BC, CD, DE, &c.$  as the small line given is to have divisions, say eight. Draw afterwards, through the extremities  $A, a$ , and  $I, i$ , the straight lines  $A a O, I i O$ , till they meet in the point  $O$ ; and from  $O$  draw toward the points of division  $B, C, D, E, &c.$  the straight lines  $OB, OC, OD, OE, &c.$  which shall likewise divide the small line  $a i$  into eight equal parts.

This operation may be performed, however small the given line  $a i$ , and however great the number of parts into which you propose to divide it. It is true, that in execution we are not permitted to go too far; the lines which we draw have always some breadth, whereby they are at length confounded, as may be seen in the figure near the point  $O$ ; but the question is not what may be possible for us to execute, but what is possible in itself. Now, in geometry lines have no breadth, and consequently can never be confounded. Hence it follows that such division is illimitable.

If it is once admitted, that a line may be divided into a thousand parts, by dividing each part into two it will be divisible into two thousand parts, and for the same reason into four thousand, and into eight thousand, without ever arriving at parts indivisible. However small a line may be supposed, it is still divisible into halves, and each half again into two, and

each of these again in like manner, and so on to infinity.

What I have said of a line is easily applicable to a surface, and, with greater strength of reasoning, to a solid endowed with three dimensions, length, breadth, and thickness. Hence it is affirmed that all extension is divisible to infinity; and this property is denominated *divisibility in infinitum*.

Whoever is disposed to deny this property of extension, is under the necessity of maintaining, that it is possible to arrive at last at parts so minute as to be unsusceptible of any farther division, because they ceased to have any extension. Nevertheless, all these particles taken together must reproduce the whole, by the division of which you acquired them; and as the quantity of each would be a *nothing* or *cypher 0*, a combination of cyphers would produce quantity, which is manifestly absurd. For you know perfectly well, that in arithmetic two or more cyphers joined never produce any thing.

This opinion, that in the division of extension, or of any quantity whatever, we may come at last to particles so minute as to be no longer divisible, because they are so small, or because quantity no longer exists, is therefore a position absolutely untenable.

In order to render the absurdity of it more sensible, let us suppose a line of an inch long divided into a thousand parts, and that these parts are so small as to admit of no farther division; each part, then, would no longer have any length, for if it had any it would be still divisible. Each particle, then, would of consequence be a nothing. But if these thousand particles together constituted the length of an inch, the thousandth part of an inch would of consequence be a nothing; which is equally absurd with maintaining, that the half of any quantity whatever is

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nothing. And if it be absurd to affirm that the half of any quantity is nothing, it is equally so to affirm that the half of a half, or that the fourth part of the same quantity, is nothing; and what must be granted as to the fourth, must likewise be granted with respect to the thousandth and the millionth part. Finally, however far you may have already carried in imagination the division of an inch, it is always possible to carry it still farther; and never will you be able to carry on your subdivision so far as that the last parts shall be absolutely indivisible. These parts will undoubtedly always become smaller, and their magnitude will approach nearer and nearer to 0, but can never reach it.

The geometrician, therefore, is warranted in affirming, that every magnitude is divisible to infinity; and that you cannot proceed so far in your division as that all farther division shall be impossible. But it is always necessary to distinguish between what is possible in itself, and what we are in a condition to perform. Our execution is indeed extremely limited. After having, for example, divided an inch into a thousand parts, these parts are so small as to escape our senses; and a farther division would to us no doubt be impossible.

But you have only to look at this thousandth part of an inch through a good microscope, which magnifies, for example, a thousand times, and each particle will appear as large as an inch to the naked eye; and you will be convinced of the possibility of dividing each of these particles again into a thousand parts: the same reasoning may always be carried forward, without limit and without end.

It is therefore an indubitable truth, that all magnitude is divisible *in infinitum*; and that this takes place not only with respect to extension, which is the object of geometry, but likewise with respect to

every other species of quantity, such as time and number.

28th April 1761.

LETTER IX.—WHETHER THIS DIVISIBILITY IN INFINITUM TAKES PLACE IN EXISTING BODIES?

It is then a completely established truth, that extension is divisible to infinity, and that it is impossible to conceive parts so small as to be unsusceptible of farther division. Philosophers accordingly do not impugn this truth itself, but deny that it takes place in existing bodies. They allege, that extension, the divisibility of which to infinity has been demonstrated, is merely a chimerical object, formed by abstraction; and that simple extension, as considered in geometry, can have no real existence.

Here they are in the right; and extension is undoubtedly a general idea, formed in the same manner as that of man, or of tree in general, by abstraction; and as man or tree in general does not exist, no more does extension in general exist. You are perfectly sensible that individual beings alone exist, and that general notions are to be found only in the mind; but it cannot therefore be maintained that these general notions are chimerical; they contain, on the contrary, the foundation of all our knowledge.

Whatever applies to a general notion, and all the properties attached to it, of necessity take place in all the individuals comprehended under that general notion. When it is affirmed, that the general notion of man contains an understanding and a will, it is undoubtedly meant that every individual man is endowed with those faculties. And how many properties do these very philosophers boast of having

demonstrated as belonging to substance in general, which is surely an idea as abstract as that of extension; and yet they maintain, that all these properties apply to all individual substances, which are all extended. If, in effect, such a substance had not these properties, it would be false that they belonged to substance in general.

If then bodies, which infallibly are extended beings, or endowed with extension, were not divisible to infinity, it would be likewise false that divisibility in infinitum is a property of extension. Now those philosophers readily admit that this property belongs to extension, but they insist that it cannot take place in extended beings. This is the same thing with affirming, that the understanding and will are indeed attributes of the notion of man in general, but that they can have no place in individual men actually existing.

Hence you will readily draw this conclusion: If divisibility in infinitum is a property of extension in general, it must of necessity likewise belong to all individual extended beings; or if real extended beings are not divisible to infinity, it is false that divisibility in infinitum can be a property of extension in general.

It is impossible to deny the one or the other of these consequences without subverting the most solid principles of all knowledge; and the philosophers who refuse to admit divisibility in infinitum in real extended beings, ought as little to admit it with respect to extension in general; but as they grant this last, they fall into a glaring contradiction.

You need not be surprised at this; it is a failing from which the greatest men are not exempt. But what is rather surprising, these philosophers, in order to get rid of their embarrassment, have thought proper to deny that body is extended. They say,

that it is only an appearance of extension which is perceived in bodies, but that real extension by no means belongs to them.

You see clearly that this is merely a wretched cavil, by which the principal, and the most evident property of body is denied. It is an extravagance similar to that formerly imputed to the Epicurean philosophers, who maintained that every thing which exists in the universe is material, without even excepting the gods, whose existence they admitted. But as they saw that these corporeal gods would be subjected to the greatest difficulties, they invented a subterfuge similar to that of our modern philosophers, alleging, That the gods had not bodies, but *as it were* bodies (*quasi corpora*), and that they had not senses, but senses *as it were*; and so of all the members. The other philosophical sects of antiquity made themselves abundantly merry with these *quasi-corpora* and *quasi-sensus*; and they would have equal reason, in modern times, to laugh at the *quasi-extension* which our philosophers ascribe to body; this term *quasi-extension* seems perfectly well to express that appearance of extension, without being so in reality.

Geometricians, if they meant to confound them, have only to say, that the objects whose divisibility in infinitum they have demonstrated, were likewise only *as it were* extended, and that accordingly all bodies extended *as it were*, were necessarily divisible in infinitum. But nothing is to be gained with them; they resolved to maintain the greatest absurdities rather than acknowledge a mistake.

3<sup>d</sup> May 1761.

## LETTER X.—OF MONADS.

WHEN we talk in company on philosophical subjects, the conversation usually turns on such articles as have excited violent disputes among philosophers.

The divisibility of body is one of them, respecting which the sentiments of the learned are greatly divided. Some maintain that this divisibility goes on to infinity, without the possibility of ever arriving at particles so small, as to be susceptible of no farther division. But others insist that this division extends only to a certain point, and that you may come at length to particles so minute, that, having no magnitude, they are no longer divisible. These ultimate particles, which enter into the composition of bodies, they denominate *simple beings*, and *monads*.

There was a time when the dispute respecting monads employed such general attention, and was conducted with so much warmth, that it forced its way into company of every description, that of the guard-room not excepted. There was scarcely a lady at court who did not take a decided part in favour of monads or against them. In a word, all conversation was engrossed by monads—no other subject could find admission.

The Royal Academy of Berlin took up the controversy, and being accustomed annually to propose a question for discussion, and to bestow a gold medal, of the value of fifty ducats, on the person who, in the judgment of the Academy, has given the most ingenious solution, the question respecting monads was selected for the year 1748. A great variety of essays on the subject were accordingly produced. The president, Mr. de Maupertuis, named a committee to examine them, under the direction of the

late Count Dohna, great chamberlain to the queen; who, being an impartial judge, examined with all imaginable attention the arguments adduced both for and against the existence of monads. Upon the whole, it was found that those which went to the establishment of their existence were so feeble and so chimerical, that they tended to the subversion of all the principles of human knowledge. The question was therefore determined in favour of the opposite opinion, and the prize adjudged to Mr. Justi, whose piece was deemed the most complete refutation of the monadists.

You may easily imagine how violently this decision of the Academy must irritate the partisans of monads, at the head of whom stood the celebrated Mr. Wolff. His followers, who were then much more numerous, and more formidable than at present, exclaimed in high terms against the partiality and injustice of the Academy; and their chief had well nigh proceeded to launch the thunder of a philosophical anathema against it. I do not now recollect to whom we are indebted for the care of averting this disaster.

As this controversy has made a great deal of noise, you will not be displeased, undoubtedly, if I dwell a little upon it. The whole is reduced to this simple question, Is body divisible to infinity? or, in other words, Has the divisibility of bodies any bound, or has it not? I have already remarked as to this, that extension, geometrically considered, is on all hands allowed to be divisible in infinitum; because however small a magnitude may be, it is possible to conceive the half of it, and again the half of that half, and so on to infinity.

This notion of extension is very abstract, as are those of all *genera*, such as that of man, of horse, of

tree, &c. as far as they are not applied to an individual and determinate being. Again, it is the most certain principle of all our knowledge, that whatever can be truly affirmed of the genus, must be true of all the individuals comprehended under it. If therefore all bodies are extended, all the properties belonging to extension must belong to each body in particular. Now all bodies are extended, and extension is divisible to infinity; therefore every body must be so likewise. This is a syllogism of the best form; and as the first proposition is indubitable, all that remains, is to be assured that the second is true, that is, whether it be true or not that bodies are extended.

The partisans of monads, in maintaining their opinion, are obliged to affirm that bodies are not extended, but have only an appearance of extension. They imagine that by this they have subverted the argument adduced in support of the divisibility in infinitum. But if body is not extended, I should be glad to know from whence we derived the idea of extension; for if body is not extended, nothing in the world is, as spirits are still less so. Our idea of extension, therefore, would be altogether imaginary and chimerical.

Geometry would accordingly be a speculation entirely useless and illusory, and never could admit of any application to things really existing. In effect, if no one thing is extended, to what purpose investigate the properties of extension? But as geometry is beyond contradiction one of the most useful of the sciences, its object cannot possibly be a mere chimaera.

There is a necessity then of admitting, that the object of geometry is at least the same apparent extension which those philosophers allow to body; but

this very object is divisible to infinity: therefore existing beings, endowed with this apparent extension, must necessarily be extended.

Finally, let those philosophers turn themselves which way soever they will in support of their monads, or those ultimate and minute particles divested of all magnitude, of which, according to them, all bodies are composed, they still plunge into difficulties, out of which they cannot extricate themselves. They are right in saying, that it is a proof of dulness to be incapable of relishing their sublime doctrine; it may however be remarked, that here the greatest stupidity is the most successful.

*5th May 1761.*

LETTER XI.—REFLECTIONS ON DIVISIBILITY IN FINITUM, AND ON MONADS.

IN speaking of the divisibility of body, we must carefully distinguish what is in our power, from what is possible in itself. In the first sense, it cannot be denied, that such a division of body as we are capable of, must be very limited.

By pounding a stone we can easily reduce it to powder; and if it were possible to reckon all the little grains which form that powder, their number would undoubtedly be so great, that it would be matter of surprise to have divided the stone into so many parts. But these very grains will be almost indivisible with respect to us, as no instrument we could employ will be able to lay hold of them. But it cannot with truth be affirmed that they are indivisible in themselves. You have only to view them with a good microscope, and each will appear itself a considerable stone, on which are distinguishable a great many points and inequalities; which demon-