

CHRISTIANI
HUGENII
ΚΟΣΜΟΘΕΩΡΟΣ,

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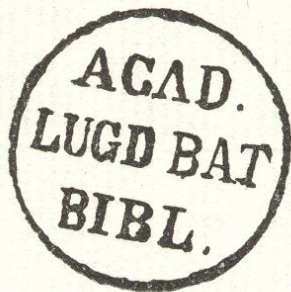
De Terris Cœlestibus, earumque ornatu,
CONJECTURÆ.

AD

CONSTANTINUM HUGENIUM,

Fratrem:

GULIELMO III. MAGNÆ BRITANNIÆ REGI,
A SECRETIS.



HAGÆ-COMITUM,
Apud ADRIANUM MOETJENS, Bibliopolam.

M. DC. XCVIII.

THE
Celestial Worlds
DISCOVER'D:
OR,
CONJECTURES
Concerning the
INHABITANTS,
PLANTS and PRODUCTIONS
OF THE
Worlds in the Planets

Written in Latin by
CHRISTIANUS HUYGENS,
And inscrib'd to his Brother
CONSTANTINE HUYGENS,
Late Secretary to his Majesty K. *William*

LONDON,
Printed for TIMOTHY CHILDE at the
White Hart at the West-end of St.
Paul's Church-yard. MDCXCVIII.

TO THE READER

THIS Book was just finished, and designed for the Press, when the Author, to the great loss of the Learned World, was seized by a Disease that brought him to his Death. However he took care in his last Will of its Publication, desiring his Brother, to whom it was writ, to take that Trouble upon him. But he was so taken up with Business and Removals, (as being Secretary in Holland to the King of Great Britain) that he could find no time for it till a year after the Death of the Author: When it so fell out, that the Printers being somewhat tardy, and this Gentleman dying, the Book was left without either Father or Guardian. Yet it now ventures into the Publick, in the same method that it was writ by the Au[iv]thor, and with the same Inscription to his Brother, tho dead; in confidence that this last Piece of his will meet with as kind a reception from the World as all the other Works of that Author have. 'Tis true there are not every where Mathematical Demonstrations; but where they are wanting, you have probable and ingenious Conjectures, which is the most that can be reasonably expected in such matters. What belongs to, or has any thing to do with Astronomy, you will see demonstrated, and the rest ingeniously and shrewdly guess'd at, from the affinity and relation of the heavenly Bodies to the Earth. For your farther Satisfaction read on, and farewell.

THE PUBLISHER TO THE READER

I Doubt not but I shall incur the Censures of learned Men for putting this Book into English, because, they'l say, it renders Philosophy cheap and vulgar, and, which is worse, furnishes a sort of injudicious People with a smattering of Notions, which being not able to make a proper use of, they pervert to the Injury of Religion and Science. I confess the Allegation is too true: but after Bishop Wilkins, Dr. Burnet, Mr. Whiston, and others, to say nothing of the antient Philosophers, who wrote in their own Tongues; I say after these great Authors have treated on as learned and abstruse Subjects in the same Language [vi] I hope their Example will be allowed a sufficient excuse for printing this Book in English. Concerning this Edition I can say, that I have taken care to have the Cuts exactly done, and have plac'd each Figure at the Page of the Book that refers to it, which I take to be more convenient to the Reader than putting 'em all at the end. I have been careful to procure the best Paper; that I might in some measure come up to the Beauty of the Latin Edition, tho this bear but half the Price of it. And I hope the Translator has express'd the Author's Sense aright, and has not committed Faults beyond what an ingenuous Reader can pardon.

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BOOK the First

A Man that is of Copernicus's Opinion, that this Earth of ours is a Planet, carry'd round and enlighten'd by the Sun, like the rest of them, cannot but [2] sometimes have a fancy, that it's not improbable that the rest of the Planets have their Dress and Furniture, nay and their Inhabitants too as well as this Earth of ours: Especially if he considers the later Discoveries made since Copernicus's time of the Attendants of Jupiter and Saturn, and the Champain and hilly Countrys in the Moon, which are an Argument of a relation and kin between our Earth and them, as well as a proof of the Truth of that System. This has often been our talk, I remember, good Brother, over a large Telescope, when we have been viewing those Bodies, a study that your continual business and absence have interrupted for this many years, But we were always apt to conclude, that 'twas in vain to enquire after what Nature had been pleased to do there, seeing there was no likelihood of ever coming to an end of the Enquiry. Nor could I ever find that any Philosophers, those bold Heros, either antient or modern, ventur'd so far. At the very birth of Astronomy, when the Earth was first asserted to [3] be Spherical, and to be surrounded with Air, even then there were some men so bold as to affirm, that there were an innumerable company of Worlds in the Stars.

Some have already talk'd of the Inhabitants of the Planets, but went no farther

But later Authors, such as Cardinal Cusanus, Brunus, Kepler (and if we may believe him, Tycho was of that opinion too) have furnish'd the Planets with Inhabitants. Nay, Cusanus and Brunus have allow'd the Sun and fixed Stars theirs too. But this was the utmost of their boldness; nor has the ingenious French Author of the Dialogues about the Plurality of Worlds carry'd the business any farther. Only some of them have coined some pretty Fairy Stories of the Men in the Moon, just as probable as Lucian's true History; among which I must count Kepler's, which he has diverted us with in his Astronomical Dream. But a while ago thinking somewhat seriously of this matter (not that I count my self quicker sighted than those great Men, but that I had the happiness to live after most of them) methoughts the enquiry was not so impracticable, nor the way so [4] stopt up with Difficulties, but that there was very good room left for probable Conjectures. As they came into my head, I clapt them down into common places, and shall now try to digest them into some tolerable Method for your better conception of them, and add somewhat of the Sun and Fixt Stars, and the Extent of that Universe of which our Earth is but an inconsiderable point. I know you have such an esteem and reverence for any thing that belongs to Heaven, that I perswade my self you will read

what I have written without pain: I'm sure I writ it with a great deal of pleasure; but as often before, so now, I find the saying of Archytas true, even to the Letter, That tho a Man were admitted into Heaven to view the wonderful Fabrick of the World, and the Beauty of the Stars, yet what would otherwise be Rapture and Extasie, would be but a melancholy Amazement if he had not a Friend to communicate it to. I could wish indeed that all the World might not be my Judges, but that I might chuse my Readers, Men like you, not [5] ignorant in Astronomy and true Philosophy; for with such I might promise my self a favourable hearing, and not need to make an Apology for daring to vent any thing new to the World. But because I am aware what other hands it's likely to fall into, and what a dreadful Sentence I may expect from those whose Ignorance or Zeal is too great, it may be worth the while to guard my self beforehand against the Assaults of those sort of People.

The Objections of ignorant Cavillers prevented

There's one sort who knowing nothing of Geometry or Mathematicks, will laugh at it as a whimsical and ridiculous undertaking. It's mere Conjurat[i]on to them to talk of measuring the Distance or Magnitude of the Stars: And for the Motion of the Earth, they count it, if not a false, at least a precarious Opinion; and no wonder then if they take what's built upon such a slippery Foundation for the Dreams of a fanciful Head and a distemper'd Brain. What should we answer to these Men, but that their Ignorance is the cause of their Dislike, and that if they had more Sense they [6] would have fewer Scruples? But few people having had an opportunity of prosecuting these Studies, either for want of Parts, Learning, or Leisure, we cannot blame their Ignorance; and if they resolve to find fault with us for spending time in such matters, because they do not understand the use of them, we must appeal to proper Judges.

These Conjectures do not contradi[ct] the holy Scriptures

The other sort, when they hear us talk of new Lands, and Animals endued with as much Reason as themselves will be ready to fly out into religious Exclamations, that we set up Conjectures against the Word of God, and broach Opinions directly opposite to Holy Writ. For we do not there read one word of the Production of such Creatures, no not so much as of their Existence; nay rather we read the quite contrary. For, That only mentions this Earth with its Animals and Plants, and Man the Lord of them; but as for Worlds in the Sky, 'tis wholly silent. Either these Men resolve not to understand, or they are very ignorant; For they have [7] been answer'd so often, that I am almost ashamed to repeat it: That it's evident God had no design to make a particular Enumeration in the Holy Scriptures, of all the Works of his Creation. When therefore it is plain that under the general name of Stars or Earth are comprehended all the Heavenly Bodies, even the little Gentlemen round Jupiter and Saturn, why must all that multitude of Beings which the Almighty Creator has been pleased to place upon them, be excluded the Privilege, and not suffer'd to have a share in the Expression? And these Men themselves can't but know in what sense it is that all things are said to be made for the use of Man, not certainly for us to stare or peep through a Telescope at; for that's little better than nonsense. Since then the greatest part of God's Creation, that innumerable multitude of Stars, is plac'd out of the reach of any man's Eye; and many of them, it's likely, of

the best Glasses, so that they don't seem to belong to us; is it such an unreasonable Opinion, that there are [8] some reasonable Creatures who see and admire those glorious Bodies at a nearer distance?

This Enquiry not overcurious

But perhaps they'll say, it does not become us to be so curious and inquisitive in these things which the Supreme Creator seems to have kept for his own knowlege: For since he has not been pleased to make any farther Discovery or Revelation of them, it seems little better than presumption to make any inquiry into that which he has thought fit to hide. But these Gentlemen must be told, that they take too much upon themselves when they pretend to appoint how far and no farther Men shall go in their Searches, and to set bounds to other Mens Industry; just as if they had been of the Privy Council of Heaven: as if they knew the Marks that God has plac'd to Knowlege: or as if Men were able to pass those Marks. If our Forefathers had been at this rate scrupulous, we might have been ignorant still of the Magnitude and Figure of the Earth, or of such a place as America. The Moon might have [9] shone with her own Light for all us, and we might have stood up to the ears in Water, like the Indians at every Eclipse: and a hundred other things brought to light by the late Discoveries in Astronomy had still been unknown to us. For what can a Man imagine more abstruse, or less likely to be known, than what is now as clear as the Sun? That vigorous Industry, and that piercing Wit were given Men to make advances in the search of Nature, and there's no reason to put any stop to such Enquiries. I must acknowledge still that what I here intend to treat of is not of that nature as to admit of a certain knowlege; I can't pretend to assert any thing as positively true (for that would be madness) but only to advance a probable guess, the truth of which every one is at his own liberty to examine. If any one therefore shall gravely tell me, that I have spent my time idly in a vain and fruitless enquiry after what by my own acknowledgement I can never come to be sure of; the answer is, that at this rate he would put down all [10] Natural Philosophy as far as it concerns it self in searching into the Nature of things:

Conjectures not useless, because not certain

In such noble and sublime Studies as these, 'tis a Glory to arrive at Probability, and the search it self rewards the pains. But there are many degrees of Probable, some nearer Truth than others, in the determining of which lies the chief exercise of our Judgment.

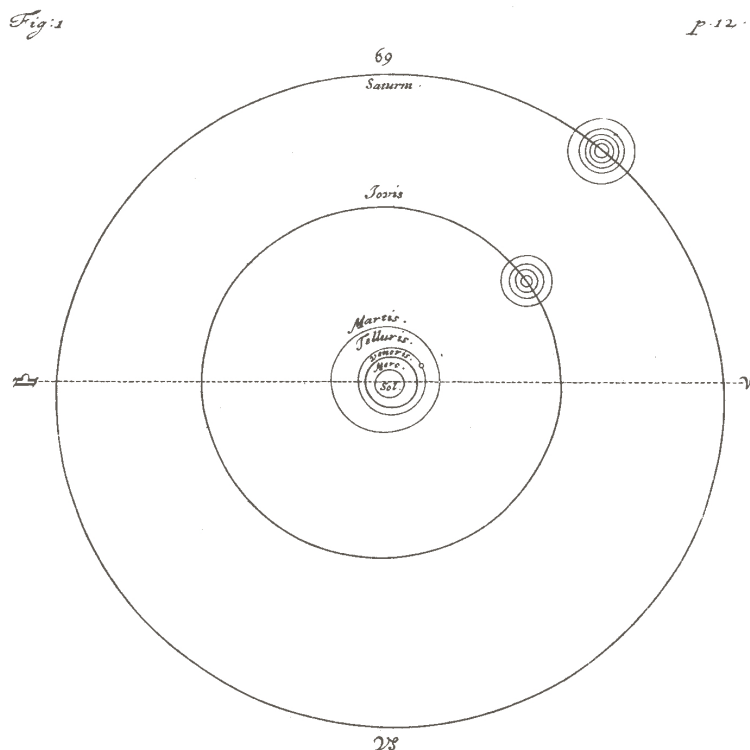
These Studies useful to Religion

But besides the Nobleness and Pleasure of the Studies, may not we be so bold as to say, they are no small help to the advancement of Wisdom and Morality? so far are they from being of no use at all. For here we may mount from this dull Earth, and viewing it from on high, consider whether Nature has laid out all her cost and finery upon this small speck of Dirt. So, like Travellers into other distant Countrys, we shall be better able to judg of what's done at home, know how to make a true estimate of, and set its own value upon every thing. We shall be less apt to admire what this World calls great, shall nobly despise those Trifles the generality

of Men set their Affections [11] on, when we know that there are a multitude of such Earths inhabited and adorned as well as our own. And we shall worship and reverence that God the Maker of all these things; we shall admire and adore his Providence and wonderful Wisdom which is displayed and manifested all over the Universe, to the confusion of those who would have the Earth and all things formed by the shuffling Concourse of Atoms, or to be without beginning. But to come to our purpose.

Copernicus's System explain'd

And now because the chief Argument for the proof of what we intend will be taken from the disposition of the Planets, among which without doubt the Earth must be counted in the Copernican System, I shall here first of all draw two Figures.

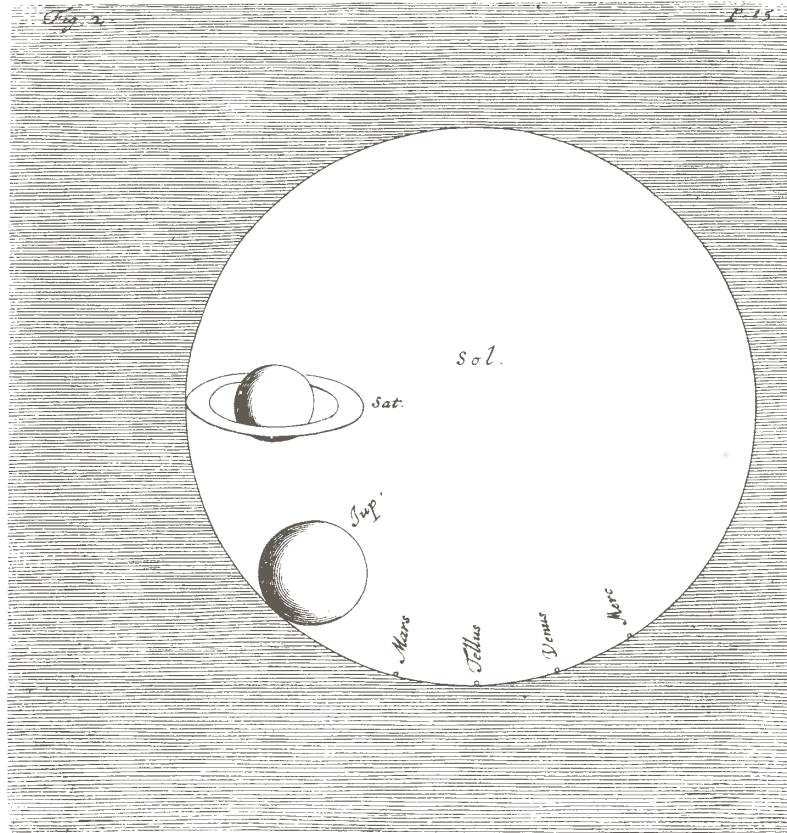


The first is a Description of the Orbs the Planets move in, in that order that they are placed round the Sun, drawn as near as can be in their true Proportions, like what you have seen in my Clock at home. The second shows the Proportions of their Magnitudes in respect of one another and of the [12] Sun, which you know is upon that same Clock of mine too. In the first the middle Point or Center is the Place of the Sun, round which, in an order that

everyone knows, are the Orbits of Mercury, Venus, the Earth with that of the Moon about it; then those of Mars, Jupiter and Saturn: and about the two last the small Circles that their Attendants march in: about Jupiter four, and about Saturn five. Which Circles as well as that of the Moon are drawn larger than their true Proportion would admit, otherwise they could not have been seen. You may easily apprehend the Vastness of these Orbits by this, that the distance of the Earth from the Sun is ten or twelve thousand of the Earth's Diameters. Almost all these Circles are in the same Plane, declining very little from that in which the Earth moves, call'd the Plane of the Ecliptick. This Plane is cut obliquely by the Axis upon which the Earth turns it self round in 24 hours, whence arise the Successions of Day and Night: The Axis of the Earth always keep[13]ing the same Inclination to the Ecliptick (except a small change best known to Astronomers) while the Earth it self is carry'd in its yearly Course round the Sun, causes the regular Order of the Seasons of the Year: as you may see in all Astronomers Books. Out of which I shall transcribe hither the Periods of the Revolutions of the Planets, viz. Saturn moves round the Sun in 29 Years, 174 Days, and 5 Hours: Jupiter finishes his Course in 11 Years, 317 Days, and 15 Hours: Mars his in about 687 Days. Our Year is 365 Days 6 Hours: Venus's 224 Days 18 Hours: and Mercury's 88 Days. This is the now commonly receiv'd System, invented by Copernicus, and very agreeable to that frugal Simplicity Nature shows in all her Works.

Arguments for the truth of it

If any one is resolved to find fault with it, let him first be sure he understands it. Let him first see in the Books of Astronomers with how much greater ease and plainness all the Motions of the Stars, and Appearances in the Heavens are explained and demonstrated in this than either in [14] that of Ptolemy or Tycho. Let him consider that Discovery of Kepler, that the distances of the Planets from the Sun, as well of the Earth as the rest; are in a fixt certain proportion to the times they spend in their Revolutions. Which Proportion it's since observed that their Satellites keep round Jupiter and Saturn. Let him examine what a contradictory Motion they are fain to invent for the solution of the Polar Star's changing its distance from the Pole. For that Star in the end of the Little Bear's Tail which now describes so small a Circle round the Pole, that it is not above two Degrees and twenty Minutes, was observed about 1820 Years ago, in the time of Hipparchus, to be above 12: and will within a few ages more be forty five Degrees distant from it: and after 25000 years more will return to the same place it is now in. Now if with them we allow the Heavens to be turned upon their own Axis, at this rate they must have a new Axis every day: a thing most abominably absurd, and repugnant to the nature of all motion. Where[15]as nothing is easier with Copernicus than to give us satisfaction in this matter. Then he may impartially weigh those Answers that Galileus, Gassendus, Kepler, and others have given to all Objections proposed, which have so satisfied all Scruples, that generally all Astronomers now adays are brought over to our side, and allow the Earth its Motion and Place among the Planets. If he cannot be satisfied with all this, he is either one whose Dulness can't comprehend it, or who has his Faith at another man's disposal, and so for fear of Galileo's fate dare not own it.



The Proportion of the Magnitude of the Planets, in respect of one another, and the Sun

In the other Figure you have the Globes of the Planets, and of the Sun, represented to your eyes as plac'd near one another. Where I have observ'd the same Proportion of their Diameters to that of the Sun, that I publish'd to the World in my Book of the Appearances of Saturn: namely, the Diameter of the Ring round Saturn is to that of the Sun as 11 is to 37; that of Saturn himself about as 5 to 37; that of Jupiter as 2 to 11; that [16] of Mars as 1 to 166; of the Earth as 1 to 111; and of Venus as 1 to 84: to which I shall now add that of Mercury observ'd by Hevelius in the Year 1661, but calculated by my self, and found to be as 1 to 290.

The Lamellæ more convenient than Micrometers

If you would know the way that we came to this knowledge of their Magnitudes, by knowing the Proportion of their Distances from the Sun, and the measure of their Diameters, you may find it in the Book beforementioned: and I cannot yet see any reason to make an alteration in

those I then settled, altho I will not say they are without their faults. For I can't yet be of their mind, who think the use of micrometers, as they call them, is beyond that of our Plates, but must still think that those thin Plates or Rods of which I there taught the use, not to detract from the due praises of so useful an Invention, are more convenient than the Micrometers.

The Earth justly liken'd to the Planets, and the Planets to it

In this Proportion of the Planets it is worth while to take notice of the prodigious Magnitude of the Sun in comparison with the four innermost, [17] which are far less than Jupiter and Saturn. And 'tis remarkable, that the Bodies of the Planets do not increase together with their distances from the Sun, but that Venus is much bigger than Mars. Having thus explain'd the two Schemes, there's no body I suppose but, sees, that in the first the Earth is made to be of the same sort with the rest of the Planets. For the very Position of the Circles shows it. And that the other Planets are round like it, and like it receive all the Light they have from the Sun, there's no room (since the Discoveries made by Telescopes) to doubt, Another thing they are like it in is, that they are moved round their own Axis; for since 'tis certain that Jupiter and Saturn are, who can doubt it of the others? Again, as the Earth has its Moon moving round it, so Jupiter and Saturn have theirs. Now since in so many things they thus agree, what can be more probable than that in others they agree too; and that the other Planets are as beautiful and as well stock'd with [18] Inhabitants as the Earth? or what shadow of Reason can there be why they should not? If anyone should be at the dissection of a Dog, and be: there shewn the Intrails, the Heart, Stomach, Liver, Lungs and Guts, all the Veins, Arteries and Nerves; could such a Man reasonably doubt whether there were the same Contexture and Variety of Parts in a Bullock, Hog, or any other Beast, tho he had never chanc'd to see the like opening of them? I don't believe he would. Or were we thorowly satisfy'd in the Nature of one of the Moons round Jupiter, should not we straight conclude the same of the rest of them? So if we could be assur'd in but one Comet, what it was that is the cause of that strange appearance, should we not make that a Standard to judg of all others by?

Arguments from their Similitude of no small weight

'Tis therefore an Argument of no small weight that is fetch'd from Relation and Likeness; and to reason from what we see and are sure of, to what we cannot, is no false Logick. This must be our Method in this Treatise, [19] wherein from the Nature and Circumstances of that Planet which we see before our eyes, we may guess at those that are farther distant from us.

The Planets are solid, and not without Gravity

And; First, 'tis more than probable that the Bodies of the Planets are solid like that of our Earth, and that they don't want what we call Gravity, that Virtue, which like a Loadstone attracts whatsoever is near the Body to its Center. And that they have such a quality, their very Figure is a proof; for their Roundness proceeds only from an equal pressure of all their Parts tending to the same Center. Nay more, we are so skilful now adays, as to be able to tell

how much more or less the Gravitation in Jupiter or Saturn is than here; of which Discovery and its Author you may read my Essay of the Causes of Gravitation.

Have Animals and Plants

But now to carry the search farther, let us see by what steps we must rise to the attaining some knowlege in the more private Secrets concerning the State and Furniture of these new Earths. And, first, how likely is it [20] that they may be stock'd with Plants and Animals as well as we? I suppose no body will deny but that there's somewhat more of Contrivance, somewhat more of Miracle in the production and growth of Plants and Animals, than in lifeless heaps of inanimate Bodies, be they never so much larger; as Mountains, Rocks, or Seas are. For the finger of God, and the Wisdom of Divine Providence, is in them much more clearly manifested than in the other. One of Democritus's or Cartes's Scholars may venture perhaps to give some tolerable Explication of the appearances in Heaven and Earth, allow him but his Atoms and Motion; but when he comes to Plants and Animals, he'll find himself non-plus'd, and give you no likely account of their Production. For every thing in them is so exactly adapted to some design, every part of them so fitted to its proper life, that they manifest an Infinite Wisdom, and exquisite Knowlege in the Laws of Nature and Geometry, as, to omit those Wonders in Generation, we shall by and by show; and [21] make it an absurdity even to think of their being thus haply jumbled together by a chance Motion of I don't know what little Particles. Now should we allow the Planets nothing but vast Deserts, lifeless and inanimate Stocks and Stones, and deprive them of all those Creatures that more plainly speak their Divine Architect, we should sink them below the Earth in Beauty and Dignity; a thing that no Reason will permit, as I said before. Well then, now we have gain'd the Point for them, and the Planets may be allow'd some Bodys capable of moving themselves, not at all inferior to ours, (for why should they?) and these are Animals. Now for fear of starving there poor Creatures, we must have Plants you know. And so the other Point is gain'd. And as for their Growth and Nourishment, 'tis no doubt the same with ours, seeing they have the same Sun to warm and enliven them as ours have.

Not to be imagin'd too unlike ours

But perhaps some body may say, we conclude too fast. They will not deny indeed but that there may be [22] Plants and Animals on the Surface of the Planets, that deserve as well to be provided for by their Creator as ours do: but why must they be of the same nature with ours? Nature seems to court variety in her Works, and may have made them widely different from ours either in their matter or manner of Growth, in their outward Shape, or their inward Contexture; she may have made them such as neither our Understanding nor Imagination can conceive. That's the thing we shall now examin, and whether it be not more likely that she has not observ'd such a variety as they talk of. Nature seems most commonly, and in most of her Works, to affect Variety, 'tis true; But they should consider 'tis not the business of a man to pretend to settle how great this Difference and Variety must be. Nor does it follow, because it may be Infinite, and out of our comprehension and reach, that therefore things in reality are so. For suppose God should have pleased to have made all things there just as he has here, the Inhabitants of those Places (if there [23] are any such strange things) would

admire his Wisdom and Contrivance no less than if they were widely different; seeing they can't come to know what's done in the other Planets. Who doubts but that God, if he had pleased, might have made the Animals in America and other distant Countries nothing like ours? (and Nature you know affects Variety) yet we see he has not done it. They have indeed some difference in their shape, and 'tis fit they should, to distinguish the Plants and Animals of those Countries from ours, who live on this side the Earth; but even in this variety there is an Agreement, an exact Correspondence in figure and shape, the same ways of Growth, and new Productions, and of continuing their own kind. Their Animals have Feet and Wings like ours, and like ours have Heart, Lungs, Guts, and the Parts serving to Generation; whereas all these things, as well with them as us, might, if it had so pleased Infinite Wisdom, have been order'd a very different way. 'Tis plain then that Nature has not exhibited that Variety in her Works that she could, and therefore we must not allow that weight to this Argument, as upon the account of it to make every thing in the Planets quite different from what is here. 'Tis more probable that all the difference there is between us and them, springs from the greater or less distance and influence from that Fountain of Heat and Life the Sun; which will cause a difference not so much in their Form and Shape, as in their Matter and Contexture.

Planets have Water

And as for the matter whereof the Plants and Animals there consist, tho it is impossible ever to come to the knowledge of its Nature, yet this we may venture to assert (there being scarce any doubt of it) that their Growth and Nourishment proceeds from some liquid Principle. Far all Philosophers agree that there can be no other way of Nutrition; some of the chief among them having made Water to be the Original of all things: Far whatsoever's dry and without moisture, is without motion too; and [25] without motion it's impossible there should be any increase. But the parts of a Liquid being in continual motion one with another, and insinuating and twisting themselves into the smallest Places, are thereby very proper and apt to add not themselves only, but whatsoever else they may bring along with them to the increase and growth of Bodies. Thus we see that by the means of Water the Plants grow, blossom, and bear Fruit; and by the addition of that only, Stones grow together out of Sand. And there's no doubt but that Metals, Crystals, and Jewels, have the same method of Production: Tho in them there has been no opportunity to make the same observation, as well by reason of their slow advances, as that they are commonly found far from the Places of their Generation; thrown up I suppose by some Earthquakes or Convulsions. That the Planets are not without Water, is made not improbable by the late Observations: For about Jupiter are observ'd some spots of a darker hue than the rest of his Body, [26] which by their continual change show themselves to be Clouds: For the spots of Jupiter which belong to him, and never remove from him, are quite different from these, being sometimes for a long time not to be seen for these Clouds; and again, when there disappear, showing themselves. And at the going off of these Clouds, some spots have been taken notice of in him, much brighter than the rest of his Body, which remain'd but a little while, and then were hid from our sight. These Monsieur Cassini thinks are only the Reflection from the Snow that covers the tops of the Hills in Jupiter: but I should rather think that it is only the colour of the Earth, which chances to be free from those Clouds that commonly darken it. Mars too is found not to be

without his dark spots, by means of which he has been observ'd to turn round his own Axis in 24 hours and 40 minutes; the length of his day: but whether he has Clouds or no, we have not had the same opportunity of observing as in Jupiter, as well because even when [27] he is nearest the Earth, he appears to us much less than Jupiter, as that his Light not coming so long a Journey, is so brisk as to be an Impediment to exact Observations: And this Reason is as much stronger in Venus as its Light is. But since 'tis certain that the Earth and Jupiter have their Water and Clouds, there is no reason why the other Planets should be without them.

But not just like ours

I can't say that they are exactly of the same nature with our Water; but that they should be liquid their use requires, as their beauty does that they should be clear. For this Water of ours, in Jupiter or Saturn, would be frozen up instantly by reason of the vast distance of the Sun. Every Planet therefore must have its Waters of such a temper, as to be proportion'd to its heat: Jupiter's and Saturn's must be of such a nature as not to be liable to Frost; and Venus's and Mercury's of such, as not to be easily evaporated by the Sun. But in all of them, for a continual supply of Moisture, whatever Water is drawn up by the Heat of the Sun into Vapors, must necessarily return back again thither. And this it cannot do but in drops, which are caused as well there as with us, by their ascending into a higher and colder Region of the Air, out of that which, by reason of the Reflection of the Rays of the Sun from the Earth, is warmer and more temperate.

Plants grow and are nourish'd there as they are here

Here then we have found in these new Worlds Fields warm'd by the kindly Heat of the Sun, and water'd with fruitful Dews and Showers: That there must be Plants in them as well for Ornament as Use, we have shewn just now. And what Nourishment, what manner of Growth shall we allow them? Why, I think there can be no better, nay no other, than what we here experience; by having their Roots fastned into the Earth, and imbibing its nourishing Juices by their tender Fibres. And lest they should be only like so many bare Heaths, with nothing but creeping Shrubs and Bushes, we'll e'en send them some nobler and loftier Plants, Trees, or somewhat like them: These being the greatest, and, except Waters, the only [29] Ornament that Nature has bestow'd upon the Earth. For not to speak of those many uses that are made of their Wood, there's no one that is ignorant either of their Beauty or Pleasantness. Now what way can anyone imagine for a continual Production and Succession of these Plants, but their bearing Seed? A Method so excellent that it's the only one that Nature has here made use of, and so wonderful, that it seems to be design'd not far this Earth alone. In fine, there's the same reason to think that this Method is observ'd in those distant Countries, as there was of its being follow'd in the remote Quarters of this same Earth.

The same true of their Animals

'Tis much the same in Animals as 'tis in Plants, as to their manner of Nourishment, and Propagation of their kind. For since all the living Creatures of this Earth, whether Beasts,

Birds, Fishes, Worms, or Insects, universally and inviolably follow the same constant and fixt Institution of Nature; all feed on Herbs, or Fruits, or the Flesh of other Animals that fed [30] on them: since all Generation is perform'd by the impregnating of the Eggs, and the Copulation of Male and Female: Why may not the same rule be observ'd in the Planetary Worlds? For't is certain that the Herbs and Animals that are there would be lost, their whole Species destroy'd without some daily new Productions: except there be no such thing there as Misfortune or Accident: except the Plants are not like other humid Bodies, but can bear Heat, Frost and Age, without being dry'd up, kill'd, or decay'd: except the Animals have Bodies as hard and durable as Marble; which I think are gross Absurdities. If we should invent some new way for their coming into the World, and make them drop like Soland Geese from Trees, how ridiculous would this be to any one that considers the vast difference between Wood and Flesh? Or suppose we should have new ones made every day out of some such fruitful Mud as that of Nile, who does not see how contrary this is to all that's reasonable? And that 'tis much more agreeable to [31] the Wisdom of God, once for all to create of all sorts of Animals, and distribute them all over the Earth in such a wonderful and inconceivable way as he has, than to be continually obliged to new Productions out of the Earth? And what miserable, what helpless Creatures must these be, when there's no one that by his duty will be obliged, or by that strange natural fondness, which God has wisely made a necessary argument for all Animals to take care of their own, will be moved to assist, nurse or educate them? As for what I have said concerning their Propagation, I cannot be so positive; but the other thing, namely, that they have Plants and Animals, I think I have fully proved. And by the same Argument, of their not being inferiour to our Earth, they must have as great a variety of both as we have. What this is, will be best known to him that considers the different ways our Animals make use of in moving from one place to another. Which may be reduc'd, I think, to these; ei[32]ther that they walk upon two feet or four; or like Insects, upon six, nay sometimes hundreds; or that they fly in the Air bearing up, and wonderfully steering themselves with their Wings; or creep upon the Ground without feet; or by a violent Spring in their Bodies, or paddling with their feet, cut themselves a way in the Waters. I don't believe, nor can I conceive, that there should be any other way than these mention'd. The Animals then in the Planets must make use of one or more of these, like our amphibious Birds, which can swim in Water as well as walk on Land, or fly in the Air; or like our Crocodiles and Sea-Horses, must be Mongrels, between Land and Water. There can no other method be imagin'd but one of these. For where is it possible for Animals to live, except upon such a solid Body as our Earth, or a fluid one like the Water, or still a more fluid one than that, such as our Air is? The Air I confess may be much thicker and heavier than ours, and so, without any disadvantage to its Transpa[33]rency, be fitter for the volatile Animals. There may be too many sorts of Fluids ranged over one another in rows as it were. The Sea perhaps may have such a fluid lying on it, which tho ten times lighter than Water, may be a hundred times heavier than Air; whose utmost Extent may not be so large as to cover the higher places of their Earth. But there's no reason to suspect or allow them this, since we have no such thing; and if we did, it would be of no advantage to them, for that the former ways of moving would not be hereby at all increas'd: But when we come to meddle with the Shape of these Creatures, and consider the incredible variety that is even in those of the different parts of this Earth, and that America has some which are no where else to be found, I must then confess that I think it beyond the force of Imagination to arrive at any knowlege in the matter, or reach probability concerning the figures of these Planetary Animals. Altho considering

these ways of Motion we e'en now recounted; [34] they may perhaps be no more different from ours than ours (those of ours I mean that are most unlike) are from one another.

Great variety of Animals in this Earth

If a man were admitted to a Survey of Jupiter or Venus, he would no doubt find as great a number and variety as he had at home. Let us then, that we may make as near a guess at, and as reasonable a judgment of the matter as we can, consider the many sorts, and the admirable difference in the shapes of our own Animals; running over some of the chief of them (for 'twould be tedious to set about a general Catalogue) that are notoriously different from one another, either in their Figure or some peculiar Property belonging to them; as they belong to the Land, or the Water, or the Air. Among the Beasts we may take notice of the great distance between the Horse, the Elephant, the Lion, the Stag, the Camel, the Hog, the Ape, the Porcupine, the Tortoise, the Cameleon: in the Water, of that between the Whale, and the Sea-Calf, the Skait, the Pike, the Eel, the Ink-[35]Fish, the Pourcontrol, the Crocodile, the flying Fish, the Cramp Fish, the Crab, the Oyster, and the Purple Fish: and among Birds, of that between the Eagle, the Ostrich, the Peacock, the Swan, the Owl, and the Bat: and in Insects, of that between the Ants, the Spider, the Fly, and the Butterfly; and of that Prodigy in their wonderful change from Worms. In this Roll I have pass'd by the creeping kind as one sort, and skip'd over that vast multitude of less different Animals that fill the intermediate spaces.

And no less in the Planets

But be they never so many, there is no reason to think that the Planets can- not match them. For tho we in vain guess at the Figures of those Creatures, yet we have discover'd somewhat of their manner of Life in general; and of their Senses we shall more by and by.

Rational Animals in the Planets

But still the main and most diverting Point of the Enquiry is behind, which is the placing some Spectators in these new Discoveries, to enjoy these Creatures we have planted them with, and to admire their Beauty and Variety. And among all, that have never so slightly meddled with these matters, I don't find any that have scrupled to allow them their Inhabitants: not Men perhaps like ours, but [37] some Creatures or other endued with Reason. For all this Furniture and Beauty the Planets are stock'd with seem to have been made in vain, without any design or end, unless there were some in them that might at the same time enjoy the Fruits, and adore the wise Creator of them. But this alone would be no prevailing Argument with me to allow them such Creatures. For what if we should say, that God made them for no other design, but that he himself might see (not as we do 'tis true; but that he that made the Eye sees, who can doubt?) and delight himself in the contemplation of them? For was not Man himself, and all that the whole World contains, made upon this very account? That which makes me of this opinion, that those Worlds are not without such a Creature endued with Reason, is, that otherwise our Earth would have too much the advantage of them, in

being the only part of the Universe that could boast of such a Creature so far above, not only Plants and Trees, but all [38] Animals whatsoever: a Creature that has a Divine somewhat within him, that knows, and understands, and remembers such an innumerable number of things; that deliberates, weighs and judges of the Truth: a Creature upon whose account, and for whose use, whatsoever the Earth brings forth seems to be provided. For every thing here he converts to his own ends. With the Trees, Stones, and Metals, he builds himself Houses: the Birds and Fishes he sustains himself with: and the Water and Winds he makes subservient to his Navigation; as he doth the sweet Smell and glorious Colours of the Flowers to his Delight. What can there be in the Planets that can make up for its Defects in the want of so noble an Animal? If we should allow Jupiter a greater variety of other Creatures, more Trees, Herbs and Metals, all these would not advantage or dignify that Planet so much as that one Animal doth ours by the admirable Productions of his penetrating Wit. If I am out in this, I do not know when [39] to trust my Reason, and must allow my self to be but a poor Judge in the true estimate of things.

Vices of Men no hindrance to their being the Glory of the Planet they inhabit

Nor let anyone say here, that there's so much Villany and Wickedness in this Man that we have thus magnified, that it's a reasonable doubt, whether he would not be so far from being the Glory and Ornament of the Planet that enjoys his Company, that he would be rather its Shame and Disgrace. For first, the Vices that most Men are tainted with, are no hindrance, but that those that follow the Dictates of true Reason, and obey the Rules of a rigid Virtue, are still a Beauty and Ornament to the place that has the happiness to harbour them. Besides, the Vices of Men themselves are of excellent use, and are not permitted and allow'd in the World without wise design. For since it has so pleased God to order the Earth, and every thing in it as we see it is (for it's nonsense to say it happen'd against his Will or Knowledge) we must not think that those different Opinions, and that various multiplicity of Minds [40] were plac'd in different Men to no end or purpose: but that this mixture of bad Men with good, and the Consequents of such a mixture, as Misfortunes, Wars, Afflictions, Poverty, and the like, were given us for this very good end, viz. the exercising our Wits, and sharpening our Inventions; by forcing us to provide for our own necessary defence against our Enemies. 'Tis to the fear of Poverty and Misery that we are beholden for all our Arts, and for that natural Knowledge which was the product of laborious Industry; and which makes us that we cannot but admire the Power and Wisdom of the Creator, which otherwise we might have pass'd by with the same indifference as Beasts. And if Men were to lead their whole Lives in an undisturb'd continual Peace, in no fear of Poverty, no danger of War, I don't doubt they would live little better than Brutes, without all knowledge or enjoyment of those Advantages that make our Lives pass on with pleasure and profit. We should want the wonderful Art of Writing, if its great [41] use and necessity in Commerce and War had not forc'd out the Invention. 'Tis to these we owe our Art of Sailing, our Art of Sowing, and most of those Discoveries of which we are Masters; and almost all the Secrets in experimental Knowledge. So that those very things that make up their Indictment against Reason, are no small helps to its advancement and perfection. For those Virtues themselves, Fortitude and Constancy; would be of no use if there were no Dangers, no Adversity, no Afflictions for their exercise

and trial. If we should therefore imagine in the Planets some such reasonable Animal as Man is, adorn'd with the same Virtues, and infected with the same Vices, it would be so far from degrading or vilifying them, that while they want such a one, I must think them inferior to our Earth.

Reason there not different from what 'tis here

Well, but allowing these Planetarians some sort of Reason must it needs be the same with ours? Why truly I think 'tis, and must be so; whether we consider it as applied to Justice and [42] Morality, or exercised in the Principles and Foundations of Science. For Reason with us is that which gives us a true sense of Justice and Honesty, Praise, Kindness and Gratitude: 'tis that that teaches us to distinguish universally between Good and Bad; and renders us capable of Knowledge and Experience in it. And can there be any where a Reason contrary to this? or can what we call just and generous in Jupiter or Mars be thought unjust Villany? This is not at all, I don't say probable, but possible. For the aim and design of the Creator is every where the preservation and safety of his Creatures. Now when such a Reason as we are masters of, is necessary for the preservation of Life, and promoting of Society (a thing that they be not without, as we shall show) would it not be strange that the Planetarians should have such a perverse sort of Reason given them, as would necessarily destroy and confound what it was design'd to maintain and defend? But allowing Morality and Passions with those Gentlemen to be somewhat [43] different from ours, and supposing they may act by other principles in what belongs to Friendship, and Anger, Hatred, Honesty, Modesty, and Comeliness, yet still there would be no doubt, but that in the search after Truth, in judging of the Consequences of things, in reasoning, particularly in that sort which belongs to Magnitude or Quantity, about which their Geometry (if they have such a thing) is employ'd, there would be no doubt I say, but that their Reason here must be exactly the same, and go the same way to work with ours, and that what's true in one part will hold true over the whole Universe; so that all the difference must lie in the degrees of Knowledge, which will be proportional to the Genius and Capacity of the Inhabitants.

They have Senses

But I perceive I am got a little too far: For till I have furnished them with Senses, neither will Life be any pleasure to them, nor Reason of any use. And I think it very probable, that all their Animals, as well their Beasts as rational Creatures, are like [44] ours in all that relates to the Senses: For without the power of Seeing we should find it impossible for Animals to provide Food for themselves, or be forewarn'd of any approaching danger, so as to guard themselves from it. So that where-ever we plant any Animals, except we would have them lead the Life of Worms or Moles, we must allow them Sight; than which nothing can conduce more either to the preservation or pleasure of their Lives.

Sight

Then if we consider the wonderful nature of Light, and the amazing Artifice in the fit framing the eye for the reception of it, we cannot but see that Bodies so vastly remote could not be view'd by us in their proper Figures and just Distances, any other way than by Sight. For this Sense, and all others that we know of, must proceed from an external Motion. Which in the sense of Seeing must come either from the Sun, the fixt Stars, or Fire: whose Particles being whirled about with a rapid Motion, communicate it to the Celestial Matter about, whence 'tis convey'd in an instant to the most [45] distant parts, just like Sound through the Air. If it were not for this Motion of the intermediate Matter, we should be all in darkness, and have sight neither of Sun nor Stars, nor any thing else, for all other Light must come to us at second-hand from them. This Motion perceived by the Eyes is called Light. And the nice Curiosity of this Perception is admirable, in that it is caused by the smallest Particle of that fine Matter, and can at the same time determine the Coast from whence the Motion comes; in that all these different Roads of Motion, these Waves crossing and interfering with one another, are yet no hindrance to every ones free passage. All these things are so wisely, so wonderfully contrived, that it's above the power of humane Wit, not to invent or frame somewhat like them, but even to imagine and comprehend them. For what can be more amazing, than that a Particle of Body should be so devised and framed, as by its means to show us the Shape, the Position, the Distance, and all the Motions, nay and all the [46] Colours, distinguishing of a Body that is far remote from us? And then the artful Composition of the Eye, drawing an exact Picture of the Objects without it, upon the concave side of the Choroides, is even above all admiration, nor is there any thing in which God has more plainly manifested his excellent Geometry. And these things are not only contrived and framed with so great Wisdom and Skill, as not to admit of better, but to any one that considers them attentively, they seem to be of such a nature as not to allow any other Method. For it's impossible that Light should represent Objects to us at so vast a distance, except by such an intervening Motion; and it's as impossible that any other Composition of the Eye should be equally fitted to the reception of such Impressions. So that I cannot but think them mightily out, that maintain these things might have been contrived many other ways. It's likely then, and credible, that in these things the Planets have an exact correspondence with us, and that their Animals [47] have the same Organs, and use the same way of sight that we do. Well then they have Eyes, and two at least we must grant them, otherwise they would not perceive some things close to them, and so could not avoid Mischiefs that take them on the blind side. And if we must allow them all Animals for the preservation of their Life, how much more must they that make more, and more noble uses of them, not be deprived of the Blessing of so advantageous Members? For by them we view the various Flowers, and the elegant Features of Beauty: with them we read, we write, we contemplate the Heavens and Stars, and measure their Distances, Magnitudes, and Journeys: which how far they are common to the Inhabitants of those Worlds with us, I shall strait examine.

Hearing

But first I shall enquire whether now we have given them one, we may not venture upon the other four Senses, to make them as good Men as our selves. And truly Hearing puts in

hard, and almost persuades me to give it a share in the Animals of those new Coun[48]tries. And 'tis of great consequence in defending us from sudden accidents; and, especially when Seeing is of no use to us, it supplys its place, and gives us seasonable warning of any imminent danger. Besides, we see many Animals call their fellows to them with their Voice, which Language may have more in it than we are aware of, tho we don't understand it. But if we do but consider the vast uses and necessary occasions of Speaking on the one side, and Hearing on the other, among those Creatures that make use of their Reason, it will scarce seem credible that two such useful, such excellent things were designed only for us. For how is it possible but that they that are without these, must be without many other Necessaries and Conveniences of Life? Or what can they have to recompense this want?

A Medium to convey Sound to the Ears

Then, if we go still farther, and do but meditate upon the neat and frugal Contrivance of Nature in making this same Air, by the drawing in of which we live, by whose Motion we sail, and by whose means Birds fly, for a [49] conveyance of Sound to our ears; and this Sound for the conveyance of another man's Thoughts to our Minds: can we ever imagin that she has left those other Worlds destitute of so vast Advantages? That they don't want the means of them is certain, for their having Clouds in Jupiter puts it past doubt that they have Air too; that being mostly formed of the Particles of Water flying about, as the Clouds are of them gathered into small Drops. And another proof of it is, the necessity of breathing for the preservation of Life, a thing that seems to be as universal a Dictate of Nature, as feeding upon the Fruits of the Earth.

Touch

As for Feeling, it seems to be given upon necessity to all Creatures that are cover'd with a fine and sensible Skin, as a Caution against coming too near those things that may injure or incommode them: and without it they would be liable to continual Wounds, Blows and Bruises. Nature seems to have been so sensible of this; that she has not left the least place free from such a perception. Therefore it's probable that the Inhabitants of those Worlds are not without so necessary a Defence, and so fit a Preservative against Dangers and Mishaps.

Smell and Taste

And who is there that doth not see the inevitable necessity for all Creatures that live by feeding to have both Taste and Smell, that they may distinguish those things that are good and nourishing, from those that are mischievous and harmful? If therefore we allow the Planetary Creatures to feed upon Herbs, Seeds, or Flesh, we must allow them a distinguishing Taste and Smell too, that they may chuse or refuse any thing according as they find it likely to be advantageous or noxious to them.

Their Senses not very different from ours

I know that it hath been a question with many, whether there might not have been more Senses than those five. If we should allow this, it might nevertheless be reasonably doubted whether the Senses of the Planetary Inhabitants are much different from ours. I must confess, I cannot deny but there might possibly have been more Senses; but when I consider the Uses [51] of those we have, I cannot think but they would have been superfluous. The Eye was made to discern near and remote Objects, the Ear to give us notice of what our Eyes could not, either in the dark or behind our back: Then what neither the Eye nor the Ear could, the Nose was made (which in Dogs is wonderfully nice) to warn us of. And what escapes the notice of the other four Senses, we have Feeling to inform us of the too near approaches of, before it can do us any mischief. Thus has Nature so plentifully, so perfectly provided for the necessary preservation of her Creatures here, that I think she can give nothing more to those there, but what will be needless and superfluous. Yet the Senses were not wholly design'd for use: but Men from all, and all other Animals from some of them, reap Pleasure as well as Profit, as from the Taste in delicious Meats; from the Smell in Flowers and Perfumes; from the Sight in the contemplation of beauteous Shapes and Colours; from the Hearing in the sweetness and harmony [52] of Sounds; from the Feeling in Veneries, unless you please to count that for a particular Sense by it self.

They have Pleasure arising from the Senses

Since it is thus, I think 'tis but reasonable to allow the Inhabitants of the Planets these same advantages that we have from them. For upon this consideration only, how much happier and easier a man's Life is render'd by the enjoyment of them, we must be obliged to grant them these Blessings, except we would ingross every thing that is good to our selves, as if we were worthier and more deserving than any else. But moreover, that Pleasure which we perceive in eating or in copulation, seems to be a necessary and provident Command of Nature, whereby it tacitly compels us to the preservation and continuance of our Life and Kind. It is the same in Beasts. So that both for their happiness and preservation it's very probable the rest of the Planets are not without it. Certainly when I consider all these things, how great, noble, and useful they are; when I consider what an admirable Providence it is [53] that there's such a thing as Pleasure in the World, I can't but think that our Earth, the smallest part almost of the Universe, was never design'd to monopolize so great a Blessing. And thus much for those Pleasures which affect our bodily Senses, but have little or no relation to our Reason and Mind. But there are other Pleasures which Men enjoy, which their Soul only and Reason can relish: some airy and brisk, others grave and solid, and yet nevertheless Pleasures, as arising from the Satisfaction which we feel in Knowledge and Inventions, and searches after Truth, of which whether the Planetary Inhabitants are not partakers, we shall have an opportunity of enquiring by and by. There are some other things to be consider'd first, in which it's probable they have some relation to us. That the Planets have those Elements of Earth, Air, and Water, as well as we, I have already made not unlikely.

All the Planets have Fire

Let us now see whether they may not have Fire too: which is not so properly call'd an Element, as a rapid [54] Motion of the Particles in the inflammable Body. But be it what it will, there are many Arguments for their not being without it. For this Earth is not so truly call'd the Place of Fire as the Sun: and as by the heat of that all Plants and Animals here thrive and live; so, no doubt, is it in the other Planets. Since then Fire is caused by a most intense and vigorous Heat, it follows that the Planets, especially those nearer the Fountain of it, have their proportionate degrees of Heat and Fire. And when there are so many ways of its Production, as by the collection of the Rays of the Sun, by the reflection of Mirrors, by the striking of Flint and Steel, by the rubbing of Wood, by the close loading of moist Grass, by Lightning, by the eruptions of Mountains and Volcanos, it's strange if neither Art should have produc'd it, nor Nature effected it there by one of these many means. Then how useful and necessary is it to us? By it we drive away Cold, and supply the want of the Sun in those Countries where his oblique Rays [55] make a less vigorous Impression, and so keep a great part of the Earth from being an uninhabited Desert: which is equally necessary in all the Planets, whether we allow them Succession of Seasons, or a, perpetual Spring and Æquinox: for even then the Countries near the Pole would receive but little advantage from the Heat of the Sun. By the help of this we turn the night into day, and thereby make a considerable addition to the shortness so our Lives. Upon all these accounts I must not let this Earth of ours enjoy it all alone, and exclude all the other Planets from so advantageous and so profitable a Gift.

The bigness of their Creatures not rightly guest at by the bigness of the Planets

But perhaps it maybe asked as well concerning Brutes as rational Creatures, and of their Plants and Trees too, whether they are proportionably larger or less than ours. For if the Magnitude of the Planets was to be the Standard of their measure, there would be Animals in Jupiter ten or fifteen times larger than Elephants, and as much longer than our Whales. And then their Men must be mere Goliahs, [56] in respect of our Pygmiships. Now tho I don't see any so great absurdity in this as to make it impossible, yet there is no reason to think it is really so, seeing Nature has not always ty'd her self to those Rules which we have thought more convenient for her: for example, the magnitude of the Planets is not answerable to their distances from the Sun; but Mars, tho more remote, is far less than Venus: and Jupiter turns round his Axis in ten hours, when the Earth which is much lees than him, spends 24. But since Nature, perhaps some body will say, has not observ'd such a Regularity in the proportion of things, for ought we know we may have a Race of Pygmies about the bigness of Frogs and Mice, possess'd of the Planets. But I shall show that this is very improbable by and by.

In the Planets are many sorts of rational Creatures as well as here

There may arise another Question, whether there be in the Planets but one or more sorts of rational Creatures possess'd of different degrees of Reason and Sense. There is something not unlike this to be observ'd among [57] us. For to pass by those who have human Shape

(altho some of them would very well bear that enquiry too) if we do but consider some sorts of Beasts, as the Dog, the Ape, the Beaver, the Elephant, nay some Birds and Bees, what sense and Understanding they are masters of, we shall be forc'd to allow, that Man is not the only rational Animal. For we discover somewhat in them of Reason independent on, and prior to all teaching and practice. But still no body can doubt, but that the Understanding and Reason of Man is to be prefer'd to theirs as being comprehensive of innumerable things, indued with an infinite memory of what's past, and capable of providing against what's to come. That there is some such rational Creature in the other Planets, which is the Head and Sovereign of the rest, is very reasonable to believe: for otherwise, were many endued with the same Wisdom and Cunning, we should have them always doing mischief, always quarrelling and fighting one another [58] for Empire and Sovereignty, a thing that we feel too much of where we have but one such Creature. But to let that pass, our next Enquiry shall be concerning those Animals in the Planets which are furnish'd with the greatest Reason, whether it's possible to know wherein they employ it, and whether they have made as great advances in Arts and Knowledge as we in our Planet. Which deserves most to be consider'd and examin'd of any thing belonging to their nature; and for the better performance of it we must take our rise somewhat higher, and nicely view the Lives and Studies of Men. And in those things wherein Men provide and take care only of what's absolutely necessary for the preservation of their Life; in defending themselves from the Injuries of the Air; in securing themselves against the Incursions of Enemies by Walls; and against Fraud and Disturbances by Laws; in educating their Children, and providing for themselves and them: In all these I can see no great [59] reason that Man has to boast of the preeminency of his Reason above Beasts and other Animals. For most of these things they perform with greater ease and art than us, and some of them they have no need of. For that sense of Virtue and Justice in which Man excels, of Friendship, Gratitude and Honesty, of what use are they, but either to put a stop to the Wickedness of Men, or to secure us from mutual Assaults and Injuries, a thing wherein the Beasts want no Guide but Nature and Inclination? Then if we set before our eyes the manifold Cares, the disturbances of Mind, the restless Desires, the dread of Death, that are the result of this our Reason; and compare them with that easy, quiet, and harmless Life which other Animals enjoy, we should be apt to wish a change, and conclude that they, especially Birds, liv'd with more pleasure and happiness than Man could with all his Wisdom. For they have as great a gusto of bodily Pleasures as we, let the new Philosophers say what they will, who would [60] have them go for nothing but Clocks and Engines of Flesh; a thing which Beasts so plainly confute by crying and running away from a stick, and all other actions, that I wonder how anyone could subscribe to so absurd and cruel an Opinion. Nay I can scarce doubt but that Birds feel no small pleasure in their easy, smooth sailing through the Air; and would much more if they but knew the advantages it hath above our slow and laborious Progression.

Men chiefly differ from Beasts in the study of Nature

What is it then after all that sets human Reason above all other, and makes us preferable to the rest of the Animal World? Nothing in my mind so much as the contemplation of the Works of God, and the study of Nature, and the improving those Sciences which may bring us to some knowledge in their Beauty and Variety. For without Knowledge what would be Contem-

plation? And what difference is there between a Man, who with a careless supine negligence views the Beauty and Use of the Sun, and the fine golden Furniture of the Heaven, and one [61] who with a learned Niceness searches into their Courses; who understands wherein the Fixt Stars, as they are call'd, differ from the Planets, and what is the reason of the regular Vicissitude of the Seasons; who by sound reasoning can measure the magnitude and distance of the Sun and Planets? Or between such a one as admires perhaps the nimble Activity and strange Motions of some Animals, and one that knows their whole Structure, understands the whole Fabrick and Architecture of their Composition?

They have Astronomy

If therefore the Principle we before laid down be true, that the other Planets are not inferior in dignity to ours, what follows but that they have Creatures not to stare and wonder at the Works of Nature only, but who employ their Reason in the examination and knowledge of them, and have made as great advances therein as we have? They do not only view the Stars, but they improve the Science of Astronomy: nor is there any thing can make us think this improbable, but that fond conceitedness of every thing that we [62] call our own, and that pride that is too natural to us to be easily laid down. But I know some will say, we are a little too bold in these Assertions of the Planets, and that we mounted hither by many Probabilities, one of which, if it chance to be false, and contrary to our supposition, would, like a bad Foundation, ruin the whole Building, and make it fall to the ground. But I would have them to know, that all I have said of their Knowledge in Astronomy, has proofs enough, antecedent to those we now produc'd. For supposing the Earth, as we did, one of the Planets of equal dignity and honor with the rest, who would Venture to say, that no where else were to be found any that enjoy'd the glorious sight of Nature's Opera? Or if there were any fellow-Spectators, yet we were the only ones that had dived deep into the secrets and knowledge of it? So then here's a proof not so far fetch'd for the Astronomy of the Planets, the same which we used for their having rational Creatures, and enjoying the other advantages we before talk'd of, which serves at the same time for the confirmation of our former Conjectures. But if Amazement and Fear at the Eclipses of the Moon and Sun gave the first occasion to the study of Astronomy, as they say it did, then it's almost impossible that Jupiter and Saturn should be without it; the Argument being of much greater force in them, by reason of the; daily Eclipses of their Moons, and the frequent ones of the Sun to their Inhabitants. So that if a Person disinterested in his Judgment, and equally ignorant of the Affairs of all the Planets, were to give his Opinion in the matter, I don't doubt he would give the cause for Astronomy to those two Planets rather than us. This supposition of their Knowledge and Use of Astronomy in the Planetary World, will afford us many new Conjectures about their manner of life, and their state as to other things.

And all its subservient Arts

For, First: No Observations of the Stars, that are necessary to the knowledge of their Motions, can be made without Instruments; nor can [64] these be made without Metal, Wood, or some such solid Body. Here's a necessity of allowing them the Carpenters Tools, the Saw, the

Ax, the Plane, the Mallet, the File: and the making of these requires the use of Iron, or some equally hard Metal.

Geometry and Arithmetick

Again, these Instruments can't be without a Circle divided into equal Parts, or a streight line into unequal. Here's a necessity for introducing Geometry and Arithmetick.

And Writing

Then the necessity in such Observations of marking down the Epochas or Accounts of Time, and of transmitting them to Posterity, will force us to grant them the Art of Writing; I won't say the same with ours which is commonly used, but I dare affirm not more ingenious or easy. For how much more ready and expeditious is our way, than by that multitude of Characters used in China; and how vastly preferable to Knots tied in Cords, or the Pictures in use; among the barbarous People of Mexico and Peru? There's no Nation in the World but has some way or other of writing and marking down [65] their Thoughts: So that it's no wonder if the Planetarians have been taught it by that great School-mistress Necessity, and apply it to the Study of Astronomy and other Sciences. In Astronomical matters the necessity of it is moreover apparent from hence, that the motion of the Stars is as 'twere to be fancied and guess'd at in different Systems, and these Systems to be continually improved and corrected, as later and more exact Observations shall convince the old ones of faults: all which can never be deliver'd down to succeeding Generations, unless we make use of Letters and Figures.

And Opticks

But for all our large and liberal allowances to these Gentlemen, they will still be behind-hand with us, For we have so certain a knowledge of the true System and Frame of the Universe; we have so admirable an Invention of Telescopes to help our failing Eye-sight in the view of the bigness and different forms of the Planetary Bodies, in the discovery of the Mountains, and the Shadows of them on [66] the Surface of the Moon, in the bringing to light an innumerable multitude of Stars otherwise invisible, that we must necessarily be far their Masters in that Knowledge. What must I do here? I could find in my heart (and I can see no reason why I may not, except it be to flatter and complement our selves in being the only People that have the advantage of such excellent Inventions) either to allow these Planetary Inhabitants such sharp Eyes as not to need them, or else the use of Glasses to help the deficiency of their Sight. And yet I dare not, for fear People should be so disturbed at the ridiculous Extravagancy of such an Opinion, as to take the measure of my other Conjectures by it, and hiss them all off, upon the account of this alone.

These Sciences not contrary to Nature

But some body may perhaps object, and that not without reason at first sight, that the Planetarians it's likely are destitute of all refined Knowledge, just as the Americans were before they

had Commerce with the Europeans. For if one considers the Ignorance of [67] those Nations, and of others in Asia and Africa equally barbarous, it will appear as if the main design of the Creator in placing Men upon the Earth was that they might live, and, in a just sense of all the Blessings and Pleasure they enjoy, worship the Fountain of their Happiness; but that some bold fellows have leapt over the bounds of Nature, and made searches into those forbidden depths only out of an affectation of knowing more than they were made for. There does not want an Answer for these Men. For God could not but foresee the advances Men would make, in their enquiring into the Affairs of Heaven: that they would discover Arts useful and advantageous to Life: that they would cross the Seas, and dig up the Bowels of the Earth. Nothing of all this could happen contrary to the Mind and Knowledge of the Infinite Author of all things. And if he foresaw these things would be, he so appointed and destin'd them to human kind. And the Studies of Arts and Sciences cannot be said to be con[68]trary to Nature, since in the search thereof they are employ'd: especially if we consider the natural desire and love of Knowledge, rooted in all men. For it's impossible this should have been given them upon no design or account. But they will urge, that if such a Knowledge is natural, if we were born for it, why are there so very few, especially in Astronomy, that prosecute these Studies? For Europe is the only Quarter of the Earth in which there have been any advancements made in Astronomy. And as for the Judicial Astrology, that pretends to foretel what is to come, it is such a ridiculous, and oftentimes mischievous Folly, that I do not think it fit to be so much as named. And even in Europe, not one in a hundred thousand meddles with these Studies. Besides, its Original and Rise is so late, that many Ages were past before the very first Rudiments of Astronomy or Geometry (which is necessary to the learning of it) were known. For every body is acquainted almost with its first beginnings in Egypt and Greece. Add to [69] this, that 'tis not yet above fourscore years since the bungling Epicycles were discarded, and the true and easy plain Motion of the Planets was discover'd. For the satisfaction of these Scruples, to what we said before, concerning the Fore-knowledge of God, may be added this; That God never design'd we should come into the World Astronomers or Philosophers; these Arts are not infus'd into us at our birth, but were order'd, in long tracts of Time, by degrees to be the rewards and result of laborious Diligence: especially those Sciences which are now in debate, are so much the more difficult and abstruse, that their late Invention and slow Progress are so far from being a wonder, that it is rather strange they were ever discover'd at all. There are but few, I acknowledge one or two perhaps, in an age, that pursue them, or think them their business: but their number will be very considerable if we take in those that have liv'd in all the ages in which Astronomy hath flourished: and no body can deny them that happiness and contentment which [70] they have pretended to above all others. In fine, it was sufficient that so small a number should make it their study; so that the Profit and Advantage of their Inventions might but spread it self over all the World. Since then the Inhabitants of this Earth, let them be never so few, have had Parts and Genius sufficient for the attainment of this Knowledge; and there's no reason to think the Planetarians less ingenious or happy than our selves; we have gained our point, and 'tis probable that they are as skilful Astronomers as we can pretend to be. So that now we may venture to deduce some Consequences from such a Supposition. We have before show'd the necessary Dependence and Connexion, not only of Geometry and Arithmetick, but of mechanical Arts and Instruments with this Science. This leads us naturally to the enquiry how they can use these Instruments and Engines for the observation of the Stars, how they can write down such their Observations, and perform other things which we do with our hands.

They have Hands

So [71] that we must necessarily give them hands, or some other Member, as convenient for all those uses, instead of them. I know an antient Philosopher laid such stress upon the use and conveniency of the hands, that he made no scruple to affirm, they were the cause and foundation of all our Knowledge. By which, I suppose, he meant no more, than that without their help and assistance men could never arrive to the improvement of their Minds in natural Knowledge: And truly not without reason. For suppose instead of them they had had Hoofs like Horses or Bullocks given them, they might have laid indeed the model and design of them in their Head, but they would never have been able to have built Cities and Houses. They would have had no Subject of Discourse but what belong'd to their Victuals, Marriages, or Self-preservation. They would have been void of all Knowledge and Memory, and indeed would have been but one degree distant from brute Beasts. What could we invent or imagine that could be so [72] exactly accommodated to all the design'd uses as the Hands are? Shall we give them an Elephants Proboscis. 'Tis true, these Beasts can lay hold of, or throw any thing, can take up even the smallest things from the Ground, and can perform such admirable feats with it, that it has not very improperly been call'd their Hand, tho indeed it is nothing but a Nose somewhat longer than ordinary. Nor do Birds show less Art and Design in the use of their Bills in the picking up their Meat, and the wonderful composure of their Nests. But all this is nothing to those Conveniences the Hand is so admirably suted to; nothing to that amazing contrivance in its capacity of being stretch'd, or contracted, or turned to any part as occasion shall require. And then, to pass by that nice Sense that the ends of the Fingers are endued with, even to the feeling and distinguishing most sorts of Bodies in the dark, what Wisdom and Art is show'd in the disposition of the Thumb and Fingers, so as to take up or keep fast hold of any thing we please? Ei[73]ther then the Gentlemen that live there must have Hands, or somewhat equally convenient, which is no easy matter; or else we must say that Nature has been kinder not only to us, but even to Squirrels and Monkeys than them.

And Feet

That they have Feet scarce anyone can doubt, that does but consider what we said but just now of the different methods of Progression, which it's hard to imagin can be perform'd any other ways than what we there recounted. And, of all those, there's none can agree so well with the state of the Planetarians, as that that we here make use of. Except (what is not very probable, if they live in Society, as I shall show they do) they have found out the art of flying in some of these Worlds.

That they are upright

The Stature and Shape of Men here does show forth the Divine Providence so much in its being so fitly adapted to its design'd Uses, that it is not without reason that all the Philosophers have taken notice of it nor without probability that the Planeta[74]rians have their Eyes and Countenance upright, like us, for the more convenient and easy Contemplation and Observations of the Stars. And the Wisdom of the Creator is so observable, so praiseworthy in the position of the other Members; in the convenient situation of the Eyes, as Watches in

the higher Region of the Body; in the removing of the more uncomely parts out of sight as 'twere; that we cannot but think he has almost observed the same Method in the Bodies of those remote Inhabitants.

It follows not therefore that they have the same shape with us

Nor does it follow from hence that they must be of the same shape with us. For there is such an infinite possible variety of Figures to be imagined, that both the Oeconomy of their whole Bodies, and every part of them; may be quite distinct and different from ours. How warmly and conveniently are some Creatures clothed with Wool, and how finely are others deck'd and adorn'd with Feathers? Perhaps among the rational Creatures in the Planets there may some such distinction be observ'd in their Garb and Co[75]vering; a thing in which Men are apt to envy the happiness of Beasts, tho perhaps without reason. For men might be born naked, only perhaps for the employment and exercising their Wits, in the inventing and making that Attire that Nature had made necessary for them. And 'tis this necessity that has been the greatest, if not only occasion of all the Trade and Commerce of all the Mechanical Inventions and Discoveries that we are masters of. Besides, Nature might have another great Conveniency in her eye, by bringing men into the World naked, namely, that they might accommodate themselves to all places of the World, and go thicker or thinner cloth'd, according as the Season and Climate they liv'd in required. There may still be a greater difference between us and them; for there is a sort of Animals in the World, as Oysters, Lobsters, and Crab-fish, whose Flesh is on the inside of their Bones as 'twere. What if the Planetarians should be such? O no, some body will say, it would be a hideous sight, [76] so ugly, that Nature has not made any but her refuse and meaner Creatures of such an odd Composition. As for that, I should not be at all moved with their ugly shape, if it were not, that hereby they would be deprived of that quick easy motion of their Hands and Fingers, which is so useful and necessary to them.

A rational Soul may inhabit another Shape than ours

For 'tis a very ridiculous opinion, that the common people have got among them, that it is impossible a rational Soul should dwell in any other shape than ours. And yet as silly as 'tis, it has been the occasion of many Philosophers allowing the Gods no other shape; nay, the Foundation of a Sect among the Christians, that from hence have the name of Anthropomorphites. This can proceed from nothing but the Weakness, Ignorance, and Prejudice of Men; as well as that too of humane Figure being the handsomest and most excellent of all others, when indeed it's nothing but a being accustomed to that figure that makes us think so, and a conceit that we and all other Animals natu[77]rally have, that no shape or colour can be so good as our own. Yet methinks this fancy has such a rule upon my mind, that I cannot without horror and impatience suffer any other figure for the habitation of a reasonable Soul. For when I do but represent to my Imagination or Eyes a Creature like a Man in every thing else, but that has a Neck four times as long, and great round sawcer Eyes five or six times as big, and farther distant, I cannot look upon't without the utmost aversion, altho at the same time I can give no account of my Dislike.

The Planetarians not less than we

As I was talking somewhat above of the Stature of the Planetary Inhabitants, I hinted that 'twas improbable they should be less than we are. For it's likely, that as our Bodies are made in such a proportion to our Earth, as to render us capable of travelling about it, and making Observations upon its bulk and figure, the same Order is observ'd in the Inhabitants of the other Planets, except here too our Pride put in for our Preeminence. Then seeing we have before [78] allow'd them Astronomy and Observations, we must give them Bodies and Strength sufficient for the ruling their Instruments, and the erecting their Tubes and Engines. And for this the larger they are the better. For if we should make them little Fellows about the bigness of Rats or Mice, they could neither make such Observations as are requisite; nor such Instruments as are necessary to those Observations. Therefore we must suppose them larger than, or at least equal to our selves, especially in Jupiter and Saturn, which are so vastly bigger than the Planet which we inhabit.

They live in Society

Astronomy, we said before, could never subsist without the writing down the Observations: nor could the Art of Writing (any more than the Carpenters and Founders) ever be found out except in a Society of reasonable Creatures, where the necessities of Life forc'd them upon Invention: So that what I promis'd to prove follows from hence, namely, that the Planetarians must in this be like us, that they maintain a Society and Fel[79]lowship with, and afford mutual Assistancess and Helps to one another. Hereupon we must allow them a settled, not a wandring Scythian way of living, as more convenient for men in such circumstances. But what then? Shall they have every thing else proper for such a manner of living granted them too? Shall they have their Governours, Houses, Cities, Trade, and Bartering? Why not? when even the barbarous People of America and other places were at their first discovery found to have somewhat of that nature in use among them. I won't say, that things must be the same there as they are here. We have many that may very well be spared among rational Creatures, and were design'd only for the preservation of Society from all Injury, and for the curbing of those men who make an ill use of their Reason to the detriment of others, Perhaps in the Planets they have such plenty and affluence of all good things, as they neither need or desire to steal from one another; perhaps they may be so just and good as to be at perpetual [80] Peace, and never to lie in wait for, or take away the Life of their Neighbour: perhaps they may not know what Anger or Hatred are; which we to our cost and misery know too too well. But still it's more likely they have such a medly as we, such a mixture of good with bad, of wise with fools, of war with peace, and want not that Schoolmistress of Arts Poverty. For these things are of no small use: and if there were no other, 'twould, be reason enough that we are as good Men as themselves.

They enjoy the pleasures of Society

What I am now going to say may seem somewhat more bold, and yet is not less likely than the former. For if these new Nations live in Society, as I have pretty well show'd they do,

'tis somewhat more than probable that they enjoy not only the Profit, but the Pleasures arising from such a Society: such as Conversation, Amours, Jestings, and Sights. Otherwise we should make them live like so many Catos, without Diversion or Merriment; we should deprive them of the great Sweetness of Life, which it can't well [81] be without, and give ourselves such an advantage over them as Reason will by no means admit of.

They have Houses to secure 'em from Weather

But to proceed to a farther Enquiry into their Business and Employment, let's consider what we have not already mention'd, wherein they may bear any likeness to us. And first we have good reason to believe they build themselves Houses, because we are sure they be not without their Showers. For in Jupiter have been observ'd Clouds, big no doubt with Vapors and Water, which hath been proved by many other Arguments, not to be wanting in that Planet. They have then their Rain, for otherwise how could all the Vapors drawn up by the heat of the Sun be disposed of? and their Winds, for they are caused only by Vapors dissolved by heat, and it's plain that they blow in Jupiter by the continual motion and variety of the Clouds about him. To protect themselves from these, and that they may pass their Nights in quiet and safety, they must build themselves Tents or Huts, or live in holes of the Earth. [82] For I dare not affront the Pride of Men so much as to say, they are as good Architects, have as noble Houses, and as stately Palaces as our selves. And good now who are we? Why a company of mean fellows living in a little corner of the World, upon a Ball ten thousand times less than Jupiter or Saturn. And yet we forsooth must be the only skilful People at Building: and all others must be our Inferiours in the knowlege of uniform Symmetry; and not be able to raise Towers and Pyramids as high, magnificent, and beautiful, as ourselves. For my part, I see no reason why they may not be as great Masters at it as we are, and have the use of all those Arts subservient to it, as Stone-cutting and Brick-making, and whatsoever else is necessary for it, as Iron, Lead and Glass; or ornamental to it, as Gilding and Picture.

They have Navigation and all Arts subservient

If their Globe is divided like ours, between Sea and Land, as it's evident it is (else whence could all those Vapors in Jupiter proceed?) we have great reason to allow them the Art of [83] Navigation, and not proudly ingross so great, so useful a thing to our selves. Especially considering the great advantages Jupiter and Saturn have for sailing, in having so many Moons to direct their Course, by whose guidance they may attain easily to the Knowlege that we are not Masters of, of the Longitude of Places. And what a troop of other things follow from this allowance? If they have Ships, they must have Sails and Anchors, Ropes, Pullies, and Rudders, which are of particular use in directing a Ship's Course against the Wind, and in sailing different ways with the same Gale. And perhaps they may not be without the use of the Compass too, for the magnetical matter, which continually passes through the Pores of our Earth, is of such a nature, that it's very probable the Planets have something like it. But there's no doubt but that they must have the Mechanical Arts and Astronomy, without which Navigation can no more subsist, than they can without Geometry. [84]

As Geometry

But Geometry stands in no need of being proved after this manner. Nor doth it want assistance from other Arts which depend upon it, but we may have a nearer and shorter assurance of their not being without it in those Earths. For that Science is of such singular worth and dignity, so peculiarly imployes the Understanding, and gives it such a full comprehension and infallible certainty of Truth, as no other Knowledge can pretend to: it is moreover of such a nature, that its Principles and Foundations must be so immutably the same in all times and places, that we cannot without Injustice pretend to monopolize it, and rob the rest of the Universe of such an incomparable Study. Nay Nature it self invites us to be Geometricians: it presents us with Geometrical Figures, with Circles and Squares, with Triangles, Polygons, and Spheres, and proposes them as it were to our consideration and study, which abstracting from its Usefulness, is most delightful and ravishing. Who can read Euclid, or Apollonius, [85] about the Circle, without admiration? or Archimedes of the Surface of the Sphere, and Quadrature of the Parabola without amazement? or consider the late ingenious Discoveries of the Moderns with Boldness and Unconcernedness? And all these Truths are as naked and open, and depend upon the same plain Principles and Axioms in Jupiter and Saturn as here, which makes it not improbable that there are in the Planets some who partake with us in these delightful and pleasant Studies. But what's the greatest Argument with me, that there are such is their use, I had almost said necessity, in most Affairs of humane Life. Now we are got thus far, what if we should venture somewhat farther, and tell you, that they have our Inventions of the Tables of Sines, of Logarithms, and Algebra: I know I should be laugh'd at for an idle Discoverer of nothing but ridiculous Whimsies, and yet there's no reason but the old one, of our being better than all the World, to hinder them from being as happy in their Discoveries, and as ingenious [86] in their Inventions as we our selves are.

They have Musick

It's the same with Musick as with Geometry, it's every where immutably the same, and always will be so. For all Harmony consists in Concord, and Concord is all the World over fixt according to the same invariable measure and proportion. So that in all Nations the difference and distance of Notes is the same, whether they be in a continued gradual progression, or the voice makes skips over one to the next. Nay very credible Authors report, that there's a sort of Bird in America, that can plainly sing in order six musical Notes: whence it follows that the Laws of Musick are unchangeably fix'd by Nature, and therefore the same Reason holds valid for their Musick, as we e'en now proposed for their Geometry. For why, supposing other Nations and Creatures, endued with Reason and Sense as well as we, should not they reap the Pleasures arising from these Senses as well as we too? I don't know what effect this Argument, from the immutable nature of these [87] Arts, may have upon the Minds of others; I think it no inconsiderable or contemptible one, but of as great Strength as that which I made use of above to prove that the Planetarians had the sense of Seeing. But if they take delight in Harmony, 'tis twenty to one but that they have invented musical Instruments. For, if nothing else, they could scarce help lighting upon some or other by chance; the sound of a tight String, the noise of the Winds, or the whistling of Reeds, might have given them the hint. From these small beginnings they perhaps, as well as we, have advanced by degrees

to the use of the Lute, Harp, Flute, and many string'd Instruments. But altho the Tones are certain and determinate, yet we find among different Nations a quite different manner and rule for Singing; as formerly among the Dorians, Phrygians, and Lydians, and in our time among the French, Italians, and Persians. In like manner it may so happen, that the Musick of the Inhabitants of the Planets may widely differ [88] from all these, and yet be very good. But why we should look upon their Musick to be worse than ours, there's no reason can be given; neither can we well presume that they want the use of half-notes and quarter-notes, seeing the invention of halfnotes is so obvious, and the use of 'em so agreeable to nature. Nay, to go a step farther, what if they should excel us in the Theory and practick part of Musick, and outdo us in Consorts of vocal and instrumental Musick, so artificially compos'd, that they shew their Skill by the mixtures of Discords and Concorde? and of this last sort 'tis very likely the 5th and 3d in use with them. This is a very bold Assertion, but it may be true for ought we know, and the Inhabitants of the Planets may possibly have a greater insight into the Theory of Musick than has yet bin discover'd amongst us. For if you ask any of our Musicians, why two or more perfect fifths cannot be us'd regularly in composition; some say 'tis to avoid that Sweetness and Lushiousness which arises from the repetition of this plea[89]sing Chord: Others say, this must be avoided for the sake of that variety of Chords that are requisite to make a good composition; and these Reasons are brought by Cartes and others. But an Inhabitant of Jupiter or Venus will perhaps give you a better reason for this, viz. because when you pass from one perfect fifth to another, there is such a change made as immediately alters your Key, you are got into a new Key before the Ear is prepared for it, and the more perfect Chords you use of the same kind in Consecution, by so much the more you offend the Ear by these abrupt Changes. Again, one of these Inhabitants will tell you how it comes about, that in a Song of one or more Parts, the Key cannot be kept so well in the same agreeable Tenor, unless the intermediate Closes and Intervals be so temper'd, as to vary from their usual Proportions, and thereby to hear a little this way or that, in order to regulate the Scale. And why this Temperature is best in the System of the Strings, when out of the fifth the fourth part of a [90] Comma is usually cut off; This same thing I have formerly shew'd at large. But for the regulating the Tone of the Voice (as I before hinted) that may admit of a more easy proof, and we shall give you an Essay of it, being unwilling still to put you off with my own whims: I say therefore, if any Persons strike those Sounds which the Musicians distinguish by these Letters, C, F, D, G, C, by these agreeable Intervals, altogether, perfect, interchangeable, ascending and descending with the Voice: Now this latter sound C will be one Comma, or very small portion lower than the first sounding of C. Because of these perfect Intervals, which are as 4 to 3, 5 to 4, 4 to 3, 2 to 3, an account is made in such a proportion, as 160 to 162, that is as 80 to 81, which is what they call a Comma. So that if the same Sound should be repeated nine times; the Voice would fall near the matter a greater Tone, whose proportion is as 8 to 9. But this the sense of the Ears by no means endures, but remembers the first Tone, and returns to it again. [91] Therefore we are compell'd to use an occult Temperament, and to sing these imperfect Intervals, from doing which less offence arises. And for the most part, all Singing wants this Temperament, as may be collected by the aforesaid Computations. And these things we have offer'd to those that have some Knowledge in Geometry. We have spoke of these Arts and Inventions, which it is very probable the Inhabitants of the Planets partake of in common with us, besides which it seems requisite to take in many other things that serve either for the use or pleasure of their Lives. But what these things are we shall the better account for, by laying before us many of those things which are found amongst us. I have

before mention'd the variety of Animals and Vegetables, which very much differ from each other, among which there are some that differ but little; and I have said, that there are no less differences in these things in the Planetary Worlds. I shall now take a short view of the Benefits we receive both from those [92] Herbs and Animals, and see whether we may not with very good reason conclude that the Planetarians reap as great and as many from those that their Countries afford them.

The Advantages we reap from Herbs and Animals

And here it may be worth our while to take a review of the variety and multitude of our Riches. For Trees and Herbs do not only serve us for Food, they in their delicious Fruits, these in their Seeds, Leaves and Roots; but Herbs moreover furnish us with Physick, and Trees with Timber for our Houses and Ships. Flax, by the means of those two useful Arts of Spinning and Weaving, affords us Clothing. Of Hemp or Matweed we twist our selves Thread and small Ropes, the former of which we employ in Sails and Nets, the latter in making larger Ropes for Masts and Anchors. With the sweet Smells and beauteous Colours of Flowers we feast our Senses: and even those of them that offend our Nostrils, or are mischievous to our Bodies, are seldom without excellent uses: or were made perhaps by Nature as a foil to set off, [93] and make us the more value the good by comparing them with these. What vast advantages and profit do we reap from the Animals? The Sheep give us Clothing, and the Cows afford us Milk: and both of them their Flesh for our Sustenance. Asses, Camels, and Horses do, what if we wanted them we must do ours selves, carry our Burdens; and the last of them we make use of, either themselves to carry us, or in our Coaches to draw us. In which we have so excellent, so useful an Invention of Wheels, that I can't let the Planets enjoy Society and all its consequences, and be without them. Whether they are Pythagoreans there, or feed upon Flesh as we do, I dare not affirm any thing. Tho it seems to be allow'd Men to feed upon whatsoever may afford them Nourishment, either on Land, or in Water, upon Herbs, and Pomes, Milk, Eggs, Honey, Fish, and no less upon the Flesh of many Birds and Beasts. A strange thing! that a rational Creature should live upon the Ruin and Destruction of such a number of other [94] his Fellow-Creatures! And yet not at all unnatural should it seem, since not only he, but even Lions, Wolves, and other ravenous Beasts, prey upon Flocks of other harmless things, and make mere Fodder of them; as Eagles do of Pidgeons and Hares; and large Fish of the helpless little ones. We have different sorts of Dogs for Hunting, and what our own Legs cannot, that their Nose and Legs can help us to. But the Use and Profit of Herbs and Animals are not the only things they are good for, but they raise our delight and admiration when we consider their various Forms and Natures, and enquire into all their different ways of Generation: things so infinitely multifarious, and so delightfully amazing, that the Books of Natural Philosophers are deservedly fill'd with their Encomiums. For even in the very Insects, who can but admire the six-corner'd Cells of the Bees, or the artificial Web of a Spider, or the fine Bag of a Silk-worm, which last affords us, with the help of incredible Industry, even Shiploads of soft delicate [95] Clothing. This is a short Summary of those many profitable Advantages the animal and herbal World serve us with.

And from Metals

But this is not all. The Bowels of the Earth too must contribute to Man's Happiness. For what art and cunning does he employ in finding, in digging, in trying Metals, and in melting, refining, and tempering them? What Skill and Nicety in beating, drawing or dissolving Gold, so as with inconsiderable changes to make every thing he pleases put on that noble Lustre? Of how many and admirable uses is Iron? and how ignorant in all Mechanical Knowledge were those Nations that were not acquainted with it, so as to be fain to use no Arms but Bows, Clubs, and Spears, made of Wood. Poor Weapons! There's one thing indeed we have, which it's a question whether it has done more harm or good, and that's a devilish Powder made of Nitre and Brimstone. At first indeed it seem'd as if we had got a more secure Defence than former Ages against all Assaults, and could [96] easily guard our Towns, by the wonderful strength of that Invention, against all hostile Invasions: but now we find it has rather encouraged them, and at the same time bin no small occasion of the decay of Valor, by rendring it and Strength almost useless in War. Had the Grecian Emperor who said, Virtue was ruin'd only when Slings and Rams first came into use, liv'd in our days, he might well have complain'd; especially of Bombs, against which neither Art nor Nature is of sufficient proof: but which be it never so strong, lays every thing, Castles and Towers, even with the Ground. If for nothing else, yet upon this one account, I think we had better have bin without the Discovery. Yet, when we were talking of our Discoveries, it was not to be pass'd over, for the Planets too may have their mischievous as well as useful Inventions. We are happier in the uses for which the Air and Water serve us; both of which help us in our Navigation, and furnish us with a Strength [97] sufficient, without any labor of our own, to turn round our Mills and Engines; things which are of use to us in so many different Employments. For with them we grind our Corn, and squeeze out our Oyl; with them we cut Wood, and mill Cloth, and with them we beat our stuff for Paper. An incomparable Invention! Where the nastiest useless scraps of Linen are made to produce fine white Sheets. To these we may add the late discovery of Printing, which not only preserves from Death Arts and Knowledge, but makes them much easier to be attained than before. Nor must we forget the Arts of Engraving and Painting, which from mean beginnings have improv'd to that Excellence, that nothing that ever sprung from the Wit of Man can claim Preeminence to them. Nor is the way of melting and blowing Glasses, and of polishing and spreading Quicksilver over Mirrors, unworthy of being mention'd, nor above all the admirable uses that Glasses have bin put to in natural Knowledge, since the invention [98] of the Telescope and Microscope. And no less nice and fine is the Art of making Clocks, some of which are so small as to be no weight to the Bearer; and others so exact as to measure out the Time in as small Portions as any one can desire: the improvement of which the World owes to my Inventions [The Author invented the Pendulum for Clocks].

From the discoveries of our Age

I might add much here of the late Discoveries, most of them of this age, which have bin made in all sorts of Natural Knowledge as well as in Geometry and Astronomy, as of the weight and spring of the Air, of the Chymical Experiments that have brought to light a way of making Liquors that shall shine in the dark, and with gentle moving shall burn of themselves. I could

tell you of the Circulation of the Blood through the Veins and Arteries, which was understood indeed before; but now, by the help of the Microscope, has an ocular Demonstration in the Tails of some Fishes: of the Generation of Animals, which now is found to be perform'd no otherwise than by the Seed of one [99] of the same kind; and that in the Seed of the Male are discover'd, by the help of Glasses, Millions of sprightly little Animals, which it's probable are the very Offspring of the Animals themselves: a wonderful thing, and never before now known!

The Planets have, tho not these same, yet as useful inventions

Thus have I heap'd together all these late Discoveries of our Earth: and now, tho perhaps some of them may be common to the Planetarians with us, yet that they should have all of them is not credible. But then they have somewhat to make up that defect, others as good and as useful, and as wonderful, that we want. We have allow'd that they may have rational Creatures among them, and Geometricians, and Musicians: we have prov'd that they live in Societies, have Hands and Feet, are guarded with Houses and Walls: yet if a Man was but carried thither by some powerful Genius, some Pegasus, I don't doubt 'twould be a very pretty sight, pretty beyond all imagination, to see the odd ways, and the unusual manner of their setting about any thing, and their [100] strange methods of living. But since there's no hopes of a Mercury to carry us such a Journey, we shall e'en be contented with what's in our power: we shall suppose our selves there, and inquire as far as we can into the Astronomy of each Planet, and see in what manner the Heavens present themselves to their Inhabitants. We shall make some Observations of the Eminence of each of them, in respect of their Magnitude, and number of Moons they have to wait on them; and shall propose a new Method of coming to some knowlege of the incredible distance of the fix'd Stars. But first after this long Trouble we will give our Reader a breathing while. [101]

BOOK the Second

'T WAS a pretty many years ago that I chanc'd to light upon Athanasius Kircher's Book, call'd, The Ecstatick Journey, which treats of the nature of the Stars, and, of all things that are to be found in the Planets: I wonder'd to see nothing there of what I had often thought not improbable, but quite other things, nothing but a company of idle unreasonable stuff: which I was the more confirm'd in, when, after the writing of the former part, I ran over the Book again. And methoughts mine were very notable weighty Matters if but compar'd with Kircher's. That other People may be satisfied in this, and see how vainly those, who cast off the only Foundations of Probability in such matters, which we have all the way made use of, pretend to philoso[102]phize in this case, I don't care if I bestow some few Reflections upon that Book.

Kircher's Journey in Ecstasy examin'd

That ingenious Man supposing himself carry'd by some Angel through the vast spaces of Heaven, and round the Stars, tells us, he saw a great many things, some of which he had out of the Books of Astronomers, the rest are the product: of his own Fancy and Thoughts. But, before he enters upon his Journey, he lays down these two things as certain; that no Motion must be allow'd the Earth, and that God has made nothing in the Planets, no not so much as Herbs, which has either Life or Sense in it. Leaving then the System of Copernicus, he chuses Tycho for his Guide. But when he supposes all the fix'd Stars to be Suns, and round each of them places their Planets, here (against his will I suppose) he has unawares made an infinite number of Copernican Systems. All which, besides their own Motion, he absurdly makes to be carry'd, with a monstrous swiftness, in twenty four hours, round the Earth. When most of these Worlds are out of the reach [103] of any Man's sight, as he owns they are, I cannot think for what he makes so many Suns to shine upon desolate Lands (like our Earth in every thing, he says, only that they have neither Plants nor Animals) where there's no one to whom they should give light. And from hence he still falls into more and more Absurdities. And because he could find no other use of the Planets, even in our System, he is forc'd to beg help of the Astrologers; and would have all those vast Bodies made upon no other account than to preserve and rule the inferior World by, and govern the Mind of Man by their various and regular Influences. Accordingly, to gratify Astrology, he says that Venus was the prettiest pleasant place, every thing fine and handsom, its Light gentle, its Waters sweet and purling, and it self beset all about with shining Crystals. In Jupiter he found wholesom and sweet Gales, delicate Waters, and a Land shining like Silver. For from these two Planets forsooth,

Men have all that is happy and healthful poured down upon them; and all that renders [104] them handsom and lovely, wise and grave, is owing to their Influences. Mercury had I don't know what ye call't, Airiness and Briskness about him; whence Men derive, when they are first born, all their Wit and Cunning. Mars was nothing but devilish, infernal, stinking, black Flames and Smoke: and Saturn was all melancholy, dreadful, nasty, and dark: for these are the Planets (I don't know why, but all your Fortune-tellers hate them) that bring all the Plagues and Mischiefs that we feel upon us, and would exercise their spite still more, except they were sometimes mitigated and corrected by the benign and kind Influences of the other Planets. All this fine stuff his Genius teaches him. Which he makes give a serious Answer to this idle Question, Whether a Jew or Heathen could be duly and rightly baptiz'd in the Waters of Venus? Of him too he learns that the Heaven of the fix'd Stars is no solid stuff: but a thin fluid, wherein an innumerable company of Stars and Suns lie floating here and there, not chain'd down to any place, (thus far he's in [105] the right) and making in the space of a day that prodigious Tour round the Earth. He forgets here, if there were such a Motion, with what an incredible swiftness they would fly out from their Centers. But I suppose the Intelligences that he has plac'd in them will take care of that, those Angels that preside over, and regulate their Motions. And in that he follows a company of Doctors that harbour'd that idle fancy of Aristotle upon no account or consideration. But Copernicus has set them all at liberty, only by bringing in the Motion of the Earth: which, if upon no other account, every one that is not blind purposely must own to be necessary upon this. I dare say Kircher, if he had d ar'd freely to speak his mind, could have afforded us otherguess things than these. But when he could not have that liberty, I think he might as well have let the whole matter alone. But enough, let's have done with this famous Author: And now that we have ventur'd to place Spectators in the Planets, let's take a Journey to each of them, [106] and see what their Years, Days, and Astronomy are.

The System of the Planets in Mercury

To begin with the innermost and nearest the Sun: We know that Mercury is three times nearer that vast body of Light than we are. Whence it follows that they see him three times bigger, and feel him nine times hotter than we do. Such a degree of Heat would be intolerable to us, and set afire all our dry'd Herbs, our Hay and Straw that we use. And yet I warrant the Animals there, are made of such a temper, as to be but moderately warm, and the Plants such as to be able to endure the Heat. The Inhabitants of Mercury, it's likely, have the same opinion of us that we have of Saturn, that we mull be intolerably cold, and have little or no Light, we are so far from the Sun. There's reason to doubt, whether the Mercurians, tho they live so much nearer the Sun, the Fountain of Life and Vigour, are much more airy and ingenious than we. For if we may guess at them by what we see here, we shall not be obliged to grant it [107] the Inhabitants of Africa and Brasil, that have got for their share the hottest places in the Earth, being neither so wise nor so industrious as those that belong to colder and more temperate Climates; they have scarce any Arts or Knowledge among them, and those of them that live upon the very shore, understand little or no Navigation. Nor can I be willing to make all that vast: number that must inhabit those two large Planets, Jupiter and Saturn, and have such noble Attendance, mere dull Blockheads, or without as much Wit as our selves, tho they are so far more distant from the Sun. The Astronomy of the Mercurials, and the appearance

of the Planets to them, opposite at certain times to the Sun, may be easily conceived by the Scheme of the Copernican System in the former Part. At the times of these Oppositions Venus and the Earth must needs appear very bright and large to them. For if Venus shines so gloriously to us when she is new and horned, she must necessarily in opposition to the Sun, when she is full, be at least six or se[108]ven times larger, and a great deal nearer to the Inhabitants of Mercury, and afford them Light so strong and bright, that they have no reason to complain of their want of a Moon. What the length of their Days are, or whether they have different seasons in the Year, is not yet discover'd, because we have not yet bin able to observe whether his Axis have any inclination to his Orbit, or what time he spends in his diurnal Revolution upon himself. And yet seeing Mars, the Earth, Jupiter and Saturn, have certainly such Successions, there's no reason to doubt but that he has his Days and Nights as well as they. But his Year is scarce the fourth part so long as ours.

In Venus

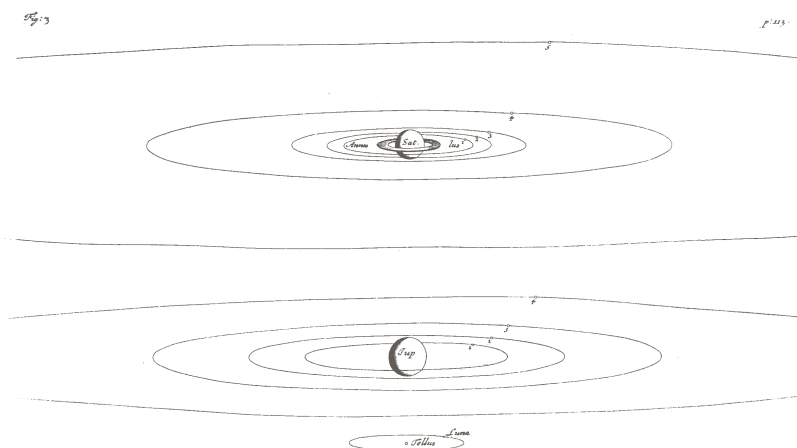
The Inhabitants of Venus have much the same face of things as those in Mercury, only they never see him in opposition to the Sun, which is occasioned by his never removing above 38 degrees, or thereabouts, from it. The Sun appears to them by half larger in his Diameter, and above twice in his Circumference, than to [109] us: and by consequence affords them but twice as much Light and Heat, so that they are nearer our Temperature than Mercury. Their Year is compleated in seven and a half of our Months. In the Night our Earth, when 'tis on the other side of the Sun from Venus, must needs seem much larger and lighter to Venus than she doth ever to us; and then they may easily see, if they have not very weak eyes, our constant At- tendant the Moon. I have often wonder'd that when I have viewed Venus at her nearest to the Earth, when she resembled an Half-moon, just beginning to have something like Horns, through a Telescope of 45 or 60 Foot long, she always appear'd to me all over equally lucid, that I can't say I observ'd so much as one spot in her, tho in Jupiter and Mars, which seem much less to us, they are very plainly perceived. For if Venus had any such thing as Sea and Land, the former must necessarily show much more obscure than the other, as anyone may satisfy himself, that from a very high Mountain will [110] but look down upon our Earth. I thought that perhaps the too brisk Light of Venus might be the occasion of this equal appearance; but when I used an Eye-glass that was smok'd for the purpose, it was still the same thing. What then, must Venus have no Sea, or do the Waters there reflect the Light more than ours do, or their Land less? or rather (which is most probable in my opinion) is not all that Light we see reflected from an Atmosphere surrounding Venus, which being thicker and more solid than that in Mars or Jupiter, hinders our seeing any thing of the Globe it self, and is at the same time capable of sending back the Rays that it receives from the Sun? For it's certain that if we look'd on the Earth from the outside of the Atmosphere, we should not perceive such a difference as we do from a Mountain; but by reason of the interposed Atmosphere, we should observe very little disparity between Sea and Land. 'Tis the same thing that hinders us from seeing the spots in the Moon as plain in the day as in the [111] night, because the Vapors that surround the Earth being then enlightned by the Rays of the Sun, are an impediment to our prospect.

In Mars

But Mars, as I said before, has some Parts of him darker than other some. By the constant Returns of which his Nights and Days have bin found to be of about the same length with ours. But the Inhabitants have no perceivable difference between Summer and Winter, the Axis of that Planet having very little or no inclination to his Orbit, as has bin discover'd by the Motion of his Spots. Our Earth must appear to them almost as Venus doth to us, and by the help of a Telescope will be found to have its Wane, Increase, and Full, like the Moon: and never to remove from the Sun above 48 Degrees, by whose discovery they see it, as well as Mercury and Venus, sometimes pass. They as seldom see Venus as we do Mercury. I am apt to believe, that the Land in Mars is of a blacker hue than that of Jupiter or the Moon, which is the reason of his appearing of a Copper Colour, and his [112] reflecting a weaker Light than is proportionable to his distance from the Sun. His Body, as I observ'd before, tho farther from the Sun, is less than Venus. Nor has he any Moon to wait upon him, and in that, as well as Mercury and Venus, he must acknowledge himself our inferiour. His Light and Heat is twice, and sometimes three times less than ours, to which I suppose the Constitution of his Inhabitants is answerable.

Jupiter and Saturn the most eminent of the Planets both for bigness and attendants

If our Earth can claim preeminence of the fore-mentioned Planets for having a Moon to attend upon it, (for its Magnitude can make but a small difference) how much superiour must Jupiter and Saturn be to all four of them, Earth and all? For whether we consider their bulk, in which they far exceed all the others, or the number of Moons that wait upon them, it's very probable that they are the chief, the primary Planets in our System, in comparison with which the other four are nothing, and scarce worth mentioning.



For the easier conception of their vast disparity, I have thought fit [113] to add a Scheme of our Earth, with the Path of the Moon about it, and the Globe of the Moon it self; and the

Systems of Jupiter and Saturn, where I have drawn every thing as near the true Proportion as possible. Jupiter you see has his four, and Saturn his five Moons about him, all plac'd in their Orbits. The Jovial we owe to Galilæo, 'tis well known: and anyone may imagine he was in no small rapture at the discovery. The outermost but one, and brightest of Saturn's, it chanc'd to be my lot, with a Telescope not above 12 foot long, to have the first sight of in the year 1655. The rest we may thank the industrious Cassini for, who used the Glasses of Jos. Campanus's Work, first of 36, and afterwards of as many above 100 foot long. He has often, and particularly in the year 1672, show'd me the third and fifth. The first and second he gave me notice of by Letters in the year 1684. but they are scarce ever to be seen, and I can't positively say I had ever that happiness: but am as satisfied that they are [114] there, as if I had; not in the least suspecting the Credit of that worthy man. Nay, I am afraid there are one or two more still behind, and not without reason. For between the fourth and fifth there's a distance not at all proportionable to that between all the others: Here for ought I know may lurk a sixth Gentleman; or perhaps there may be another without the fifth that may yet have escaped us: for we can never see the fifth but in that part of his Orbit, which is towards the West: for which we shall give you a very good reason. Perhaps when Saturn comes into the Northern Signs, and is at a good height from the Horizon (for at the writing of this he is at his lowest) you may happen to make some new Discoveries, good Brother, if you would but make use of your two Telescopes of 170 and 210 foot long; the longest, and the best I believe now in the World. For tho we have not yet had an opportunity of observing the Heavens with them (as well by reason of their unweildiness, as for [115] the interruption of our Studies by your absence) yet I am satisfied of their Goodness by our trial of them one night, in reading a Letter at a vast distance by the help of a Light. I cannot but think of those times with pleasure, and of our diverting labour in polishing and preparing such Glasses, in inventing new Methods and Engines, and always pushing forward to still greater and greater things. But to return to those Diagrams.

The proportion of the Diameter of Jupiter, and of the Orbs of his Satellites, to the Orbit of the Moon round the Earth

I have there made the Diameter of Jupiter about two third parts of our distance from the Moon: for the Diameter of Jupiter is above twenty times bigger than that of the Earth; which the distance of the Moon contains about thirty times. The Orbit of the outermost of Jupiter's Guards is to that of the Moon round the Earth, as 8 and $\frac{1}{2}$ is to 1. And each of these Moons, by the shadow they make upon Jupiter, cannot be less than our Earth.

The periods of Jupiter's Moons

Their Periods, that I may not omit them, are according to Cassini's account these. That of the inmost is one day, 18 hours, 28 minutes, [116] and 36 seconds. The second spends 3 days, 13 hours, 13 min. 52 sec. in going round him. The third 7 days, 3 hours, 59 min. 40 sec. The fourth 16 days, 18 hours, 5 min. 6 sec. The distance of the innermost from Jupiter himself is $2\frac{5}{6}$ of his Diameters. That of the second is 4 and a half: Of the third 7 and one sixth part: Of the fourth 12 and two thirds, of the same Diameters.

And Saturn's

The innermost of Saturn's Guards moves round him in 1 day, 21 hours, 18 min. 31 sec. The second in 2 days, 17 hours, 41 min. 27 sec. The third in 4 days, 11 hours, 47 min. 16 sec. The fourth in 15 days, 22 hours, 41 min. 11 sec. The fifth in 79 days, 7 hours, 53 min. 57 sec. Their distances from the Center of Saturn are, that of the first almost one, that is 39 fortieth parts of the Diameter of his Ring; that of the second one and a quarter of those Diameters; of the third one and three quarters of them; of the fourth four, or according to my calculation, but 3 and a half; of the fifth 12, which were found with vast pains and labour. [117] Now can any one took upon, and compare there Systems together, without being amazed at the vast Magnitude and noble Attendance of there two Planets, in respect of this little pitiful Earth of ours? Or can they force themselves to think, that the wise Creator has disposed of an his Animals and Plants here, has furnish'd and adorn'd this Spot only, and has left all those Worlds bare and destitute of Inhabitants, who might adore and worship him; or that all those prodigious Bodies were made only to twinkle to, and be studied by some few perhaps of us poor fellows?

This proportion true according to all modern Observations

I do not doubt but there will be some who will think we Romance very much about the Magnitude of these Planets. For will you pretend to make them who are taken up in admiring the largeness of this Globe, its multitude of Nations, Cities, and Empires; can you pretend I say to make them ever believe that there are Places in comparison of which the Earth is as inconsiderable as my Figure would make it? No, they know better things [118] they'll cry. But they may vouchsafe to be inform'd, that these Proportions are those which the best Astronomers of this Age have agreed upon. For if the Earth be distant from the Sun ten or eleven thousand of its own Diameters, according to the accounts of Monsieur Cassini in France, and Mr. Flamsted in England, wherein they made use of very exact Observations of the Parallaxes of Mars; or if, according to a very probable Conjecture of mine, it be distant twelve thousand, then the Magnitudes of the other Orbs will very near answer the Proportions here settled.

The apparent magnitude of the Sun in Jupiter, and a way of finding what light they there enjoy

But to return to Jupiter. The Sun appears to them five times less than to us, and consequently they have but the five and twentieth part of the Light and Heat that we receive from it. But that Light is not so weak there as we imagine, as is plain by the brightness of that Planet in the Night; and that when the Sun is so far eclips'd to us, as that the 25th part of his Disk be not free from the Shadow, he is not sensibly darken'd. But if you have a [119] mind exactly to know the quantity of light that Jupiter enjoys, you may take a Tube of what length you please. Let one end of it be clos'd with a Plate of Brass, or any such thing, in the middle of which there must be a hole, whose breadth must have the same proportion to the length of the Tube, as the Chord of 6 Minutes bears to the Radius; that is about as one is to 570. Let the Tube be turn'd so to the Sun, that no Light may fall upon a white Paper plac'd at the

end of it, but what comes through the little hole at the other end of the Tube. The Rays that come through this will represent the Sun upon the Paper of the same Brightness that the Inhabitants of Jupiter see it in a clear day. And if removing the Paper you place your eye in the same place, you will see the Sun of the same Magnitude and Brightness as you would were you in Jupiter.

And in Saturn

If you make the hole twice as little in breadth, you will see the same of Saturn. And altho his Light be but the hundredth part of ours, yet you [120] see it makes him shine finely in a dark night. But in cloudy days what shall the poor Inhabitants do? Why if we were to be Judges but miserably, but yet I warrant they do not at all complain. Perhaps they may be like Owls and Bats, and may love the Twilight better than open day.

In Jupiter their days are 5 hours

But it's a little strange, that when Jupiter is so much bigger than our Planet, their Days and Nights should be but five of our Hours. By this we may see that Nature has not observ'd that proportion that their bulk seems to require, seeing in Mars the days are very little different from ours. But in the length of their years, that is in the revolution of the Planets round the Sun, there is an exact proportion to their distances from the Sun followed. For as the Cubes of their distances, so are the Squares of their Revolutions, as Kepler first found out. Which proportion the Moons of Jupiter and Saturn keep in their Courses round those.

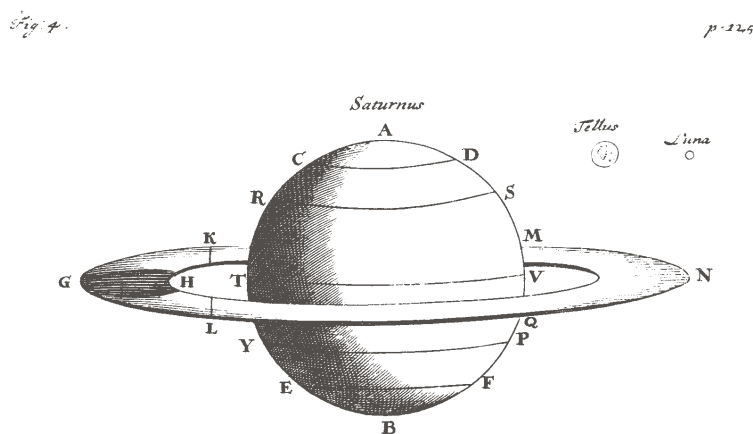
Always the same length

As the Years and Days in Jupiter are different from ours in this respect, so are the Days in another; [121] namely, that they are all of the same length. For they there enjoy a perpetual Equinox, their Axis having little or no inclination to their Orbit, as the Earth's has, as has bin discover'd by Telescopes. The Countries that lie near their Poles have little or no heat, by reason the Rays of the Sun fall so obliquely upon them; but then they are freed from the Inconveniency that ours are troubled with, of tedious long half-year Nights, and have the constant returns of Day and Night every five hours. Indeed we should not be contented with such short days, and should count our selves very ill dealt with if we had not twice as long, tho upon no other account, but that what is our own, to be sure, must be best. The rest of the Planets are so near the Sun, (Mars himself never being above 18 degrees from it) that in Jupiter they have the sight only of Saturn. But we cannot deny but that their four Moons stand them in greater stead than our one doth us, if 'twere only that they seldom know any such thing as to be without Moonshiny [122] Nights. And they are of great advantage to them, as we said before, in their Navigation, if they have any such thing. Not to mention the pleasant sights of their frequent Conjunctions and Eclipses, things that they are seldom a day without. Saturn enjoys all those Pleasures and Advantages in a still higher degree, as well for his five Moons, as for the delightful prospect that the Ring about him affords his

Inhabitants night and day. But we will be as kind to them as we have bin to the rest of the Planets, in giving an account of their Astronomy.

They see the fixt Stars just as we do

And first of all we shall observe what we might have remark'd before, but will be more strange here, that the fix'd Stars appear to them of the same Figure and Magnitude, and with the same degree of Light that they do to us: and this, by reason of their immense distance, of which we shall have occasion to speak by and by. In comparison with which the space that a Bullet shot out of a Cannon could travel in 25 years, would be almost nothing. [123] Their Astronomers have all the same Signs of the Bear, the Lion, Orion, and the rest, but not turning upon the same Axis with us: for that's different in all the Planets. As Jupiter can see no Planet but Saturn, so Saturn knows of no Planet but Jupiter; which appears to him much as Venus doth to us, never removing above 37 degrees from the Sun. The length of their days I cannot determine: But if from the distance and period of his innermost Attendant, and comparing it with the innermost of Jupiter's, a Man may venture to give a guess, they are very little different from Jupiter's, 10 hours or somewhat less. But whereas in Jupiter there are equally divided between Light and Darkness, the Saturnians must perceive a more sensible difference than we, especially between Summer and Winter. For our Axis inclines to the place of the Ecliptick but 23 degrees and a half, but there's above 31. Upon this account his Moons must decline very much from the Path that the Sun seems to move [124] in, and his Inhabitants can never have a full Moon but just at the Equinoxes: two of which fall out in 30 of our years. 'Tis this Position of the Axis too that is the cause of those delightful appearances, and wonderful prospects that its Inhabitants enjoy: for the better understanding of which I shall draw a Figure of Saturn with his Ring about him: in which the proportion between the Diameters of the Globe and Ring is as 9 to 4. And the empty space between them is of the same breadth with the Ring it self. All Observations conspire to prove that that is of no great thickness, altho if we should allow it six hundred German Miles, I think, considering its Diameter, we should not overdo the matter.



Suppose then that to be the Globe of Saturn, whose Poles are A, B. GN es the Diameter of the Ring, as you view it sideways, representing a narrow Oval. Those that live about the Poles within the Arches CAD, EBF, each of which are 54 degrees, (if the Cold will suffer any body to live [125] there) never have a sight of the Ring.

The appearances of the Ring in Saturn

From all other parts it is continually to be seen for fourteen years and nine Months, which is just: half their year. The other half it is hid from their view. Those then that dwell between the Polar Circle CD, and the Equator TV, all that time that the Sun enlightens the part opposite to them, have every night the sight of a piece of it HGL, much in the shape of a shining Bow, which comes from the Horizon, but is darken'd in the middle by the shadow of Saturn GH, which reaches most commonly to the outermost rim of it. But after midnight that Shadow by little and little begins to move towards the right hand to those in the Northern, but the left to those in the Southern Hemisphere. In the morning it disappears, leaving behind it a likeness indeed of a Bow, but much paler and weaker than our Moon is in the day-time. For they, as I said before, have an Atmosphere, or an Air surrounding them enlighten'd by the Sun. Otherwise Night and Day they would have their Ring, [126] their Moons, and all the fix'd Stars, equally conspicuous. Another thing that must make the sight of their Ring very curious, is, that by some Spots in it, it is discover'd to turn round upon it self: A thing that those that are so near cannot but take notice of, when we that live at this distance can descry a great Inequality, the inside of it being brighter much than the outside is. When the shadow of the Globe falls upon that part of the Ring GH, the shadow of the Ring at the same time darkens another part of the Globe about PF, which otherwise would have the Sun upon it. So that there is always a Zone of the Globe PYFE, sometimes of a larger extent than at others, which is depriv'd of the sight both of the Sun and Ring for a considerable time, the latter of which hides some, part of the Stars from it too. An amazing thing it must be, all of a sudden to have the Sun darken'd, and, fall into a pitch-night, without seeing any cause of such an accident. All which while their Moons are their only Comfort. The other half of the [127] year the Hemisphere TBV enjoys the same Light that TAU before did, and then this undergoes those long Eclipses that that before suffer'd. At the Equinoxes, when the Sun is in the same Plane with the Ring, the Saturnians cannot well perceive it: no not even we with our Glasses, by reason of its Darkness. This happens when Saturn, viewed from the Sun, is advanced one and twenty degrees and a half in Virgo or Pisces, as I show'd formerly in my System of Saturn: Where there is an account given of the Risings of the Sun above the Ring, throughout all the Saturnian Year. With Saturn in this Scheme you have the Globes of the Earth and Moon drawn in their true proportion, to put you in mind again of a thing very fit to be remember'd, how very small our Habitation is when compar'd with that Globe or the Ring about it. And now anyone, I suppose, can frame to himself a picture of the Night in Saturn, with two Arches of the Ring, and five Moons shining [128] about, and adorning him. This then shall be what I have to say to the primary Planets. We are now come a little lower, to make an enquiry into the Attendants of there Planets, especially our own. And here we shall meddle not only with their Astronomy, but shall also search into their Furniture and Ornament, if they are found to have any such thing, which we have put off considering till now.

Very little to be said of the Moon

And here one would think that when the Moon is so near us, and by the means of a Telescope may be so nicely and exactly observ'd; it should afford us matter for more probable Conjectures than any of the other remote Planets. But it is quite otherwise, and I can scarce find any thing to say of it, because I have not a Planet of the same nature before my eyes, as in all the primary ones I have. For they are of the same kind with our Earth; and seeing all the Actions, and every thing that is here, we may make a reasonable Conjecture at what we cannot see in those Worlds. [129]

The Guards of Jupiter and Saturn of the same nature with our Moon

But this we may venture to say, without fear, that all the Attendants of Jupiter and Saturn are of the same nature with our Moon, as going round them and being carry'd with them round the Sun just as the Moon is with the Earth. Their Likeness reaches to other things too, as you'll see by and by. Therefore whatsoever we can with reason affirm or fancy of our Moon (and we may say a little of it) must be suppos'd with very little alteration to belong to the Guards of Jupiter and Saturn, as having no reason to be at all inferior to that.

The Moon hath Mountains

The Surface of the Moon then is then found, by the least Telescopes of about three or four foot, to be diversified with long Tracts of Mountains, and again with broad Valleys. For in those parts opposite to the Sun you may see the Shadows of the Mountains, and often discover the little round Valleys between them, with a hillock or two perhaps rising out of them. Kepler from the exact roundness of them would prove that they are some vast work of the rational [130] Inhabitants. But I can't be of his mind, both for their incredible largeness, and that they might easily be occasion'd by natural Causes.

But no Sea, nor Rivers, nor Clouds, nor Airs and Waters

Nor can I find any thing like Sea there, tho he and many others are of the contrary opinion I know. For those vast Countries which appear darker than the other, commonly taken for and call'd by the names of Seas, are discover'd with a good long Telescope, to be full of little round Cavities; whose Shadow falling within themselves, makes them appear of that colour: and those large Champains there in the Moon you will find not to be always even and smooth, if you look carefully upon them: neither of which two things can agree to the Sea. Therefore those Plains in her that seem brighter than the other parts, must consist, I suppose, of a whiter sort of Matter than they. Nor do I believe that there are any Rivers, for if there were, they could never escape our sight, especially if they run between the Hills as ours do. Nor have they any Clouds to furnish the Rivers with [131] Water. For if they had, we should sometimes see one part of the Moon darken'd by them, and sometimes another, whereas we have always the same prospect of her. 'Tis certain moreover, that the Moon has no Air or Atmosphere

surrounding it as we have. For then we could never see the very outermost Rim of the Moon so exactly as we do, when any Star goes under it, but its Light would terminate in a gradual faint shade, and there would be a sort of a down as it were about it; not to mention, that the Vapors of our Atmosphere consist of Water, and consequently that where there are no Seas or Rivers, there can be no Atmosphere. This is that notable difference between that Planet and us that hinders all probable Conjectures about it. If we could but once be sure that they had Water, we might come to an Agreement, and plant a Colony perhaps there; we might allow it then most of our other Privileges, and, with Xenophanes, furnish it with Inhabitants, Cities, and Mountains. But as 'tis, I [132] cannot imagine how any Plants or Animals, whose whole nourishment comes from liquid Bodies, can thrive in a dry, waterless, parch'd Soil.

The Conjecture of its Plants and Animals very dubious

What then, shall this great Ball be made for, nothing but to give us a little puny light in the Night-time, or to raise our Tides in the Sea? Shall not we plant some People there that may have the pleasure of seeing our Earth turn upon itself, presenting them some times with a prospect of Europe and Africa, and then of Asia and America; sometimes half, and sometimes full? What! and must all those Moons round Jupiter and Saturn be condemn'd to the same uselessness? I do not know what to think of it, because I know of nothing like them to found a Conjecture upon. And yet 'tis not improbable that those great and noble Bodies have somewhat or other growing and living upon them, tho very different from what we see and enjoy here. Perhaps their Plants and Animals may have another sort of Nourishment there. Perhaps the moisture of the Earth there is but just sufficient [133] to cause a Mist or Dew, which may be very sutable to the growth of their Herbs. Which I remember is Plutarch's opinion, in his Dialogue upon this Subject. For in our Earth a very little Water drawn from the Sea into Dew, and falling down again upon the Herbs, would be sufficient for all our needs, without any Rain or Showers.

Jupiter's and Saturn's Moons turn always the same side to them

But these are mere guesses, or rather doubts, but yet they are the best we can make of this, and all those other Moons: for, as I said before, they are all of the same nature, which is proved likewise by this, that as our Moon can afford us the sight never but of one side of her, so they turn always the same face to their primary Planets. You wonder, I suppose, how we came to know so much; but 'twas no hard matter, after that Observation which I just now made, that the outermost of Saturn's Moons can never be seen but when she is on the West-side of her Planet. The reason of which is plainly this, that one side of her is darker, and does not reflect the Light so much as the other, [134] which when it is turned towards us, we cannot see by reason of its weak Light. This always happening when 'tis East of him, and never on the other side, is a manifest proof that she always keeps the same side toward Saturn. Now since the outermost of Saturn's and our Moon carry themselves thus to the Planets round which they move, who can well doubt it of all the rest round Jupiter and Saturn? And there's a very good reason for it, namely, that the matter of which those Moons consist, being heavier, and more solid on the side that is averse from us, than on that which we have the sight of, does consequently fly with a greater force from the Centre of its Motion: for otherwise, according

to the Laws of Motion, it should turn the same side always, not to its Planet; but to the same fixt Stars. This Position of the Moons, in respect of their Planets, must occasion great many very pretty, wonderful sights to their Inhabitants, if they have any: which is very doubtful, but may for the present be suppos'd. [135]

The Astronomy of the Inhabitants of the Moon

An enquiry into our Moon may serve for all the rest. Its Globe is divided into two parts, after that manner, that those who live on one side never lose the sight of us, and those on the other never enjoy it. Only those who live on the Confines of each of these lose us, and see us again by turns. The Earth to them must seem much larger than the Moon doth to us, as being in Diameter above four times bigger. But the best of it is, that night and day they see it always in the very same part of the Heaven, as if it never moved: some of them as if 'twas falling upon their heads: others somewhat above the Horizon, and others always in the Horizon, still turning upon it self, and presenting them every twenty four hours with a view of all its Countries, even of those that lie near the Poles (I could wish my self in the Moon only for the sight of them) yet unknown and undiscover'd by us. They have it in its monthly Wane and Increase, they see it half, and horned, and full, by turns, just as we do their Planet. But the Light [136] that they borrow of us is five times larger than what they pay us again. So that in dark nights that part that hath the advantage of being towards us, receives a very glorious Light, tho let Kepler say what he will, no Heat from us. Their Days are always of the same length with their Nights; and the Sun rising and setting to them but once in one of our Months, makes the time both of their Light and Darkness to be equal to 15 of our days. If their Bodies are of the same Metal with ours, those that have the Sun pretty high in their Horizon, must be like to be burnt up in such long days. For the Sun is not farther from them than he is from us. This will be the case of those that live upon the Borders of the two Hemispheres we talk'd of; but those that live under the Poles of the Moon will be just about as hot as our Whale-Fishers about Island and Nova Zemla are, in the Summer-time: who are in so little danger of being roasted, that in the middle of their Summer, in their days of three Months length, they are ready to lose their [137] fingers ends. The Poles of the Moon I call those, round which the fixt Stars seem to turn to its Inhabitants, which are different from ours, and those of the Ecliptick, altho they move round these latter, at the distance of five degrees, in a period of nineteen Years. Their Year they count by the Motion of the Stars, and their return to the Sun, and 'tis the same with ours. They can easily do it, because they have the Stars day and night, notwithstanding the Light of the Sun: for they have no Atmosphere (which is the only reason that we don't every day enjoy the same sight) to hinder their Observations. Nor have they any Clouds to obstruct their view, so that they have an easier work than we to find out the Courses, but a more difficult to make a true System of the Planets. For they will be apt to lay a wrong Foundation upon the Immobility of the Earth, which will lead them into more dangerous Errors than ever it did us.

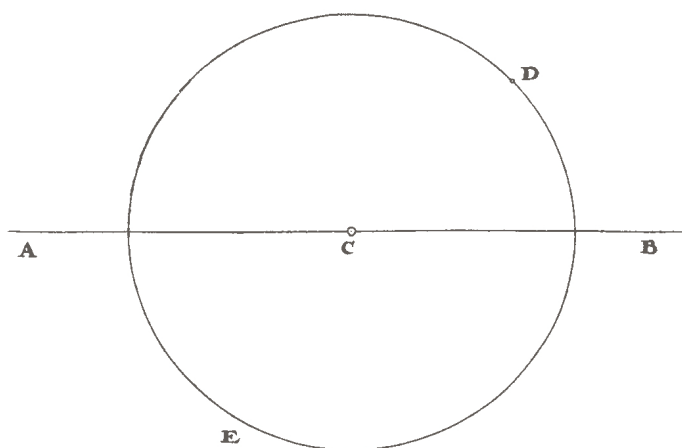
This may be applied to the Moons about Jupiter and Saturn

All that I have said belongs as well to Jupiter's and Saturn's as to our Moon in respect of [138] the Planets they move round. The length of their Day and Night is always equal to the time

of their Revolution: for example, the fifth Moon moves round Saturn in 80 days, and the days and nights there are equal to forty of ours. Both their Summer and Winter (Saturn moving round the Sun in thirty years) are fifteen years long. Therefore it is impossible but that their way of living must be very different from ours, having such tedious Winters, and such long watching and sleeping times. Having thus explain'd the primary and secondary Planets round the Sun, we should next set about the third sort, the Sun and fixt Stars; but before we do that, it will be worth while to set before you at once, in a clearer and more plain Method than hitherto, the Magnificence and Fabrick of the Solar System. Which we can't possibly do in so small a space as one of our Leaves will but admit of, because the Bodies of the Planets are so prodigiously small in comparison of their Orbs. But what is wanting in Figure shall be [139] made up in Words. Going back then to the first Scheme, suppose another like it, and proportionable, drawn upon a very large smooth Plain; whose outermost Circle representing the Orb of Saturn, must be conceived three hundred and sixty foot in Semidiameter. In which you must place the Globe and Ring of Saturn of that bigness as the 2d Figure shows you. Let all the other Planets be supposed everyone in his own Orbit, and in the middle of all the Sun, of the same bigness that that Figure represents, namely, about four inches in Diameter. And then the Orbit or Circle in which the Earth moves, which the Astronomers call the *magnus Orbis*, must have about six and thirty foot in Semidiameter. In which the Earth must be conceived moving, not bigger than a grain of Millet, and her Companion the Moon scarcely perceivable, moving round her in a Circle a little more than two Inches broad, as in the Figure here adjoined, where the line AB represents a small portion of that Circle which the Earth moves in: [140] the small Circle therein C is the Earth and the Circle DE the path of the Moon round it, in which the body of the Moon is D.

Fig: 5.

p: 139



The outermost of Saturn's Moons move in an Orbit whose Semidiameter is 29 inches; that of Jupiter in a somewhat smaller, whose Semidiameter is 19 and a quarter. And thus we have a true and exact Description of the Sun's Palace, where the Earth will be twelve thousand of its Semidiameters distant from him, which in German Miles makes above seventeen Millions. But perhaps we may have a clearer comprehension of this vast length, by comparing it with some very swift Motion. 'Twas a pretty fancy of Hesiod, that an Anvil let fall from the top of Heaven, reach'd the Earth the tenth day of its Journey, and in ten more arriv'd at the bottom of Hell, the end of it: so making the Earth the midway between Heaven and Hell. I shan't make use of the Anvil, but of one as good, namely, a Bullet shot out of a great Gun, which may travel per[141]haps in a moment, or pulse of an Artery, about a hundred Fathom, as is prov'd by those Experiments that Mersennus in a Treatise of his relates; wherein the Sound was found to extend it self eighty hundredth parts in that time.

The immense distance between the Sun and the Planets illustrated

I say then, that supposing a Bullet to move with this swiftness from the Earth to the Sun, it would spend 25 years in its passage. To make a Journey from Jupiter to the Sun, would require 125, and from Saturn thither 250 years. This account depends upon the measure of the Earth's Diameter, which, according to the accurate Observations of the French, is 6 538 594 times six Paris feet, one degree being 57 060 of that measure. This shows us how vast those Orbs must be, and how inconsiderable this Earth, the Theatre upon which all our mighty Designs, all our Navigations, and all our Wars are transacted, is when compared to them. A very fit Consideration, and matter of Reflection, for those Kings and Princes who sacrifice the Lives of so many People, only to flatter their Ambition in being [142] Masters of some pitiful corner of this small Spot. But to return to the matter in hand, now we have given you an account of the Sun's proportion to those Orbs and Bodies, we'll see what more we can say of him.

No ground for Conjecture in the Sun

And there are some that have bin so civil, as to allow the Sun himself his Inhabitants. But upon what reason I cannot imagine, there being less ground for a probability in him than in the Moon. For we are not yet sure, whether he be a compact or liquid Globe; altho, if my account of Light be true, upon that account I should rather think him liquid: which his roundness and equal distribution of his Light to all parts are an Argument for. For that inequality on his Surface, which is discover'd by the Telescopes, (and that not always neither) which makes men fancy boiling Seas and belching Mountains of Fire, is nothing but the trembling Motion of the Vapors our Atmosphere is full of near the Earth; which is likewise the cause of the Stars twinkling.

The Faculæ in the Sun not easily seen

Nor could I ever have the luck to discern those [143] bright Spots they brag so much of in the Sun as well as of his dark ones, tho the latter I have very often seen; so that with very good reason I can doubt whether there's any such thing. For, in all the exact Observations, I could never find any such pretended to be seen any where but just about his dark Spots; and it is no great wonder that those Parts which are so near the darker, should appear somewhat brighter than the rest.

By reason of its Heat no Inhabitants like ours can live in the Sun

That the Sun is extremely hot and fiery, is beyond all dispute, and such Bodies as ours could not live one moment in such a Furnace. We must make new sort of Animals then, such as we have no Idea or Likeness of among us, such as we can neither imagine nor conceive: which is as much as to say, that truly we have nothing at all to say. No doubt that glorious and vast Body was made for some noble end and use, and fram'd with excellent design. And I think we all very well know and feel its Usefulness in that effusion of Light and Heat to all the Planets round it; in the preservation and happiness of all [144] living Creatures, and that not only in our Ball, but in those vast Globes of Jupiter and Saturn, not much inferior to its own. These are such great, such wise ends, that it is not strange that the Sun should have bin made, if it had bin only upon their account. For, as for Kepler's fancy, that he hath another Office, namely, to help on the Motion of the Planets in their own Orbs, by turning them round their Axis, (which he would fain establish in his Epitome) I shall give good Reasons why I cannot assent to it.

The fix'd Stars so many Suns

Before the invention of Telescopes, Stars so it seem'd to contradict Copernicus's Opinion, to make the Sun one of the fix'd Stars. For the Stars of the first Magnitude being esteemed to be about three minutes Diameter; and Copernicus (observing that tho the Earth changed its place, they always kept the same distance from us) having ventur'd to say that the Magnus Orbis was but a point in respect of the Sphere in which they were placed, it was a plain consequence that everyone of them that appeared any thing bright, must [145] be larger than the Path or Orbit of the Earth: which is very absurd. This is the topping Argument that Tycho Brahe set up against Copernicus. But when the Telescopes shav'd them of their fictitious Rays, and show'd 'em to us bare and naked (which they do best when the Eye-glass is black'd with Smoke) just like little shining Points, then that difficulty vanished, and the Stars might still be Suns. Which is the more probable, because their Light is certainly their own: for it's impossible that ever the Sun should send, or they reflect it at such a vast distance. This is the opinion that commonly goes along with Copernicus's System.

They are not all in the same Sphere

And the Patrons of it do also with reason suppose, that all these Stars are not in the same Sphere, as well because there's no Argument for it, as that the Sun, which is one of them, cannot be brought to this Rule. But it's more likely they are scatter'd and dispersed all over the immense spaces of the Heaven, and are as far distant perhaps from one another, as the nearest of them are from the Sun. [146] Here again too I know Kepler is of another opinion in his Epitome of Copernicus's System, that we mention'd above. For tho he agrees with us, that the Stars are diffus'd through all the vast Profundity, yet he cannot allow that they have as large an empty space about them as our Sun has. For at that rate, 'twas his opinion, we should see but very few, and those of very different Magnitudes: For, seeing the largest of all appear so small to us, that we can scarce observe or measure them with our best Instruments; how must those appear that are three or four times farther from us? Why, supposing them no larger than these, they must seem three or four times less, and so on till a little farther they will not be to be seen at all: Thus we shall have the sight of but very few Stars, and those very different one from another; Whereas we have thousands, and those not considerably bigger or less than one another. But this by no means proves what he would have it; and his mistake was chiefly, that he did not consider the nature of Fire, which makes it be seen at such [147] distances, and at such small Angles as all other Bodies would totally disappear under. A thing that we need go no farther than the Lamps set along the Streets to prove. For altho they are a hundred foot from one another, yet you may count twenty of them in a continued row with your eyes, and yet the twentieth of them scarce makes an Angle of six Seconds. Certainly then the glorious Light of the Stars must do much more than this; so that it's no wonder we should see a thousand or two of them with our bare eyes, and with a Telescope discover twenty times that number. But Kepler had a private design in making the Sun thus superior to all the other Stars, and planting it in the middle of the World, attended with the Planets: a favor that he did not desire to grant the rest. For his aim was by it to strengthen his Cosmographical Mystery, that the distances of the Planets from the Sun are in a certain proportion to the Diameters of the Spheres that are inscrib'd within, and circumscrib'd about Euclid's Polyedrical Bodies. [148] Which could never be so much as probable, except there were but one Chorus of Planets moving round the Sun, and so the Sun were the only one of his kind. But that whole Mystery is nothing but an idle Dream taken from Pythagoras or Plato's Philosophy. And the Author himself acknowledges that the Proportions do not agree so well as they should, and is fain to invent two or three very silly excuses for it. And he uses yet poorer Arguments to prove that the Universe is of a spherical Figure, and that the number of the Stars must necessarily be finite, because the Magnitude of each of them is so. But what is worst of all is, that he settles the space between the Sun and the concavity of the Sphere of the fix'd Stars, to be six hundred thousand of the Earth's Diameters. For this very good reason, forsooth, that as the Diameter of the Sun is to that of the Orbit of Saturn, which he makes to be as 1 to 2000, so is this Diameter to that of the Sphere of the fix'd Stars. A mere fancy without any shadow of [149] Reason. I cannot but wonder how such things as these could fall from so ingenious a Man, and so great an Astronomer. But I must give my Vote, with all the greatest Philosophers of our Age, to have the Sun of the same nature with the fix'd Stars. And this will give us a greater Idea of the World, than all those other Opinions.

The Stars have Planets about them like our Sun

For then why may not every one of these Stars or Suns have as great a Retinue as our Sun, of Planets, with their Moons, to wait upon them? Nay there's a manifest reason why they should. For let us fancy our selves placed at an equal distance from the Sun and fix'd Stars; we should then perceive no difference between them. For, as for all the Planets that we now see attend the Sun, we should not have the least glimpse of them, either that their Light would be too weak to affect us, or that all the Orbs in which they move would make up one lucid point with the Sun. In this station we should have no occasion to imagine any difference between the Stars, and should make no doubt if we [150] had but the sight, and knew the nature of one of them, to make that the Standard of all the rest. We are then plac'd near one of them, namely, our Sun, and so near as to discover six other Globes moving round him, some of them having others performing them the same Office. Why then shall not we make use of the same Judgment that we would in that case; and conclude, that our Star has no better attendance than the others? So that what we allow'd the Planets, upon the account of our enjoying it, we must likewise grant to all those Planets that surround that prodigious number of Suns. They must have their Plants and Animals, nay and their rational ones too, and those as great Admirers, and as diligent Observers of the Heavens as our selves; and must consequently enjoy whatsoever is subservient to, and requisit for such Knowledge. What a wonderful and amazing Scheme have we here of the magnificent Vastness of the Universe! So many Suns, so many Earths, and every one of them stock'd with so many [151] Herbs, Trees and Animals, and adorn'd with so many Seas and Mountains! And how must our wonder and admiration be encreased when we consider the prodigious distance and multitude of the Stars? That their distance is so immense, that the space between the Earth and Sun (which is no less than twelve thousand of the former's Diameters) is almost nothing when compar'd to it, has more Proofs than one to confirm it. And this among the rest, If you observe two Stars near one another, as for example those in the middle of the Great Bears Tail, differing very much from one another in Clearness, notwithstanding our changing our Position in our Annual Orbit round the Sun, and that there would be a Parallax were the Star which is brighter nearer us than the other, as is very probable it is, yet whatever part of the year you look upon them, they will not in the least have altered their distance. Those that have hitherto undertook to calculate their Distance, have not bin able perfectly to [152] compass their design, by reason of the extreme niceness and almost impossibility of the Observations requisite for their purpose. The only Method that I see remaining, to come at any tolerable probability in so difficult a case, I shall here make use of. Seeing then that the Stars, as I said before, are so many Suns, if we do but suppose one of them equal to ours, it will follow that its distance from us is as much greater than that of the Sun, as its apparent Diameter is less than the Diameter of the Sun. But the Stars, even those of the first: Magnitude, tho view'd through a Telescope, are so very small that they seem only like so many shining Points, without any perceivable breadth. So that such Observations can here do us no good.

A way of making a probable guess at the distance of the Stars

When I saw this would not succeed, I studied by what way I could so lessen the Diameter of the Sun, as to make it not appear larger than the Dog, or any, other of the chief stars. To

this purpose I clos'd one end of my twelve-foot Tube with a very thin Plate, in the middle of which I made a hole not [153] exceeding the twelfth part of a Line, that is the hundred and forty fourth part of an Inch. That end I turn'd to the Sun, placing my Eye at the other, and I could see so much of the Sun as was in Diameter about the 182d part of the whole. But still that little piece of him was brighter much than the Dog-Star is in the clearest night. I saw that this would not do, but that I must lessen the Diameter of the Sun a great deal more. I made then such another hole in a Plate, and against it I plac'd a little round Glass that I had made use of in my Microscopes, of much about the same Diameter with the former hole. Then looking again towards the Sun (taking care that no Light might come near my eye to hinder my Observation) I found it appear'd of much the same Clearness with Sirius. But casting up my account, according to the Rules of Dioptricks, I found his Diameter now was but $1/152$ part of that hundred and eighty second part of his whole Diameter that I saw through the former hole. Multiplying $1/152$ and $1/182$ into [154] one another, the Product I found to be $1/27664$. The Sun therefore being contracted into such a compass, or being removed so far from us (for it's the same thing) as to make his Diameter but the 27664 part of that we every day see, will send us still the same Light as the Dog-star now doth. And his distance then from us will be to his present distance undoubtedly as 27664 is to 1; and his Diameter little above four thirds, 4". Seeing then Sirius is supposed equal to the Sun, it follows that his Diameter is likewise 4", and that his distance to the distance of the Sun from us is as 27664 to 1. And what an incredible distance that is, will appear by the same way of reasoning that we used in measuring that of the Sun. For if 25 years are required for a Bullet out of a Cannon, with its utmost Swiftmess, to travel from the Sun to us; then by multiplying the number 27664 into 25, we shall find that such a Bullet would spend almost seven hundred thousand years in its Journey between us and the nearest of the fix'd [155] Stars. And yet when in a clear night we look upon them, we cannot think them above some few miles over our heads. What I have here enquir'd into, is concerning the nearest of them, And what a prodigious number must there be besides of those which are, placed so deep, in the vast spaces of Heaven, as to be as remote from there as there are from the Sun! For if with our bare Eye we can observe above a thousand, and with a Telescope can discover ten or twenty times as many; what bounds of number must we set to those which are out of the reach even of these Assistances! especially if we consider the infinite Power of God. Really, when I have bin reflecting thus with my self, methoughts all our Arithmetick was nothing, and we are vers'd but in the very Rudiments of Numbers, in comparison of this great Sum. For this requires an immense Treasury, not of twenty or thirty Figures only, in our decuple Progression, but of as many as there are Grains of Sand upon the shore. And yet who can say, that [156] even this number exceeds that of the Fixt Stars? Some of the Antients, and Jordanus Brunus carry'd it further, in declaring the Number infinite: he would perswade us that he has prov'd it by many Arguments, tho in my opinion they are none of them conclusive. Not that I think the contrary can ever be made out. Indeed it seems to me certain, that the Universe is infinitely extended; but what God has bin pleas'd to place beyond the Region of the Stars, is as much above our Knowledge, as it is our Habitation. Or what if beyond such a determinate space he has left an infinite Vacuum; to show, how inconsiderable all that he has made is, to what his Power could, had he so pleas'd, have produc'd? But I am falling, before I am aware, into that intricate Dispute of Infinity: Therefore I shall wave this, and not, as soon as I am free of one, take upon me another difficult Task. All that I shall do more is to add somewhat of my opinion concerning the World, as it is a place for the reception of the Suns or fix'd Stars, [157] every one of which,

I have show'd may have their Planetary Systems about them.

Every Sun has a Vortex round it, very different from those of Cartes

I am of opinion then that every Sun is surrounded with a Whirl-pool or Vortex of Matter in a very swift Motion; tho not in the least like Cartes's either in their bulk, or manner of Motion. For Cartes makes his so large, as everyone of them to touch all the others round them, in a flat Surface, just as you have seen the Bladders that Boys blow up in Soap-suds do: and would have the whole Vortex to move round the same way. But the Angles of every Vortex will be no small hindrance to such a Motion. Then the whole matter moving round at once, upon the Axis as it were of a Cylinder, did not a little puzzle him in giving Reasons for the Roundness of the Sun: which however they may satisfy some People that do not consider them, really prove nothing of the matter. In this æthereal matter the Planets float, and are carry'd round by its motion: and the thing that keeps them in their own Orbs is, that they [158] themselves, and the matter in which they swim. equally strive to fly out from the Center of this Motion. Against all which there are many Astronomical Objections, some of which I touch'd upon in my Essay of the Causes of Gravity. Where I gave another account of the Planets not deserting their own Orbs; which is their Gravitation towards the Sun. I show'd there the Causes of that Gravitation, and cannot but wonder that Cartes, the first man that ever began to talk reasonably of that matter, should never meddle with, or light on it. Plutarch in his Book of the Moon above mentioned says, that some of the Antients were of opinion, that the reason of the Moon's keeping her Orbit was, that the force of her Circular Motion was exactly equal to her Gravity, the one of which pull'd her to, as much as the Other forc'd her off from the Centre. And in our Age Alphonsus Borellus, who was of this same opinion in the other Planets as well as the Moon, makes the Gravitation of the primary Planets to be towards the Sun, as that of the secondary is towards the Planets round which they move: Which Mr. Isaac Newton has more fully explained, with a great deal of pains and subtilty; and how from that cause proceeds the Ellipticity of the Orbs of the Planets, found out by Kepler. According to my Notion of the Gra[159]vitation of the Planets to the Sun, the matter of his Vortex must not all move the same way, but after such a manner as to have its parts carry'd different ways on all sides. And yet there is no fear of its being destroy'd by such an irregular motion, because the Æther round it, which is at rest, keeps the parts of it from flying out. With the help of such a Vortex as this I have pretended in that Essay to explain the Gravity of Bodies on this Earth, and all the effects of it. And I suppose there may be the same cause as well of the Gravitation of the Planers, and of our Earth among the rest, towards the Sun, as of their Roundness: a thing so very hard to give an account of in Cartes's System. I must differ from him too in the bigness of the Vortices, for I cannot allow them to be so large as he would make them. I would have them dispers'd all about the immense space, like so many little Whirl-pools of Water, that one makes by the stirring of a stick in any large Pond or River, a great way distant from one another. And as their motions do not all intermix or communicate with one another; so in my opinion must the Vortices of Stars be plac'd as not to hinder one anothers free Circumrotations. So that we may be secure, and never fear that they will swallow up or destroy one another; for that was a mere fancy of Car[160]tes's; when he was showing how a fix'd Star or Sun might be turn'd into a Planet. And 'tis plain, that when he writ it,

he had no thoughts of the immense distance of the Stars from one another; particularly, by this one thing, that he would have a Comet as soon as ever it comes into our Vortex, to be seen by us. Which is as absurd as can be. For how could a Star, which gives us such a vast Light only from the Reflection of the Beams of the Sun, as he himself owns they do; how I say could that be so plainly seen at a distance ten thousand times larger than the Diameter of the Earth's Orbit? He could not but know that all round the Sun there is a vast Extensum; so vast, that in Copernicus's System the *magnus Orbis* is counted but a point in comparison with it. But indeed all the whole story of Comets and Planets, and the Production of the World, is founded upon such poor and trifling grounds, that I have often wonder'd how an ingenious man could spend all that pains in making such fancies hang together. For my part, I shall be very well contented, and shall count I have done a great matter, if I can but come to any knowledge of the nature of things, as they now are, never troubling my head about their beginning, or how they were made, knowing that to be out of the reach of human Knowledge, or even Conjecture.

FINIS