John Deakin Heaton, M.D.

COSMOTHEOROS:

OR

CONJECTURES

CONCERNING THE

PLANETARY WORLDS,

AND THEIR

INHABITANTS.

WRITTEN IN LATIN BY

CHRISTIANUS HUYGENS.

Illuſtrated with plates.

This Tranſlation was firſt publiſhed in 1689;

In the preſent Edition many places have been corrected.

GLASGOW,

PRINTED AND SOLD BY ROB. & AND. FOULIS

M.DCC.LVII.

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 author, 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 farewel.

COSMOTHEOROS:

OR

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CONCERNING THE

PLANETARY WORLDS.

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 ſometimes have a fancy, that it is 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 champaign and hilly countries 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 theſe many years. But we were always apt to conclude, that it was 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 heroes, either ancient or modern, ventur'd ſo far. At the very birth of aſtronomy, when the earth was firſt aſſerted to be ſpherical, and to be ſurrounded with air, even then there were ſome men ſo

bold as to affirm, there were an innumerable company of worlds in the ſtars. 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 allowed 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 matter 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

Some have already talk'd of the inhabitants of the planets, but went no farther.

ago thinking ſomewhat ſeriouſly of this matter (not that I count myſelf 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 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 perſuade 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 hea- 'ven to view the wonderful fabric of 'the world, and the beauty of the ſtars, 'yet what would otherwiſe be rapture 'and extaſie, would be but a joy- 'leſs wonder 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 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 'tis 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 is one ſort who knowing nothing of geometry or mathematicks, will laugh at it as a whimſical and ridiculous undertaking. It is mere conjuration 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 is built upon ſuch a ſlippery foundation for the dreams of a fanciful head and a diſtempered 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 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 properer judges.

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 our conjectures againſt the word of God, and brcoah opinions directly oppoſite to

These conjectures do not contradict the holy Scriptures.

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 been answer'd so often, that I am almost asham'd to repeat it: That it is 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 would be to talk abſurdly. Since then the greateſt part of God's creation, that innumerable multitude of ſtars, is placed out of the reach of any man's eye; and many of them, it is likely, beyond the reach of the beſt glaſſes, ſo that they do not ſeem to belong to us; is it ſuch an unreaſonable opinion, that there are ſome reaſonable creatures who ſee and admire thoſe glorious bodies at a nearer diſtance?

This enquiry not over-curious.

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 knowledge: 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 enquiry 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 men's industry; just as if they had been of the privy council of Heaven: as if they knew the limits that God has fixed to knowledge: or as if men were able to pass those limits. 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 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 is 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 ad-

mit of a certain knowledge; I cannot 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 natural philosophy as far as it concerns itself in searching into the nature of things: in such noble and sublime studies as these, 'tis a glory to arrive at probability, and the search itself rewards the pains. But there are many degrees of probable, some nearer truth than others, in the

Conjectures not useless, because not certain.

determining of which lies the chief exercise of our judgment. 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 countries, we shall be better able to judge of what is 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 affecti-

These studies useful to religion.

ons 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 God the maker of thoſe ſtupendous works; 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 explained.

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.

P. 15.

Fig. 1

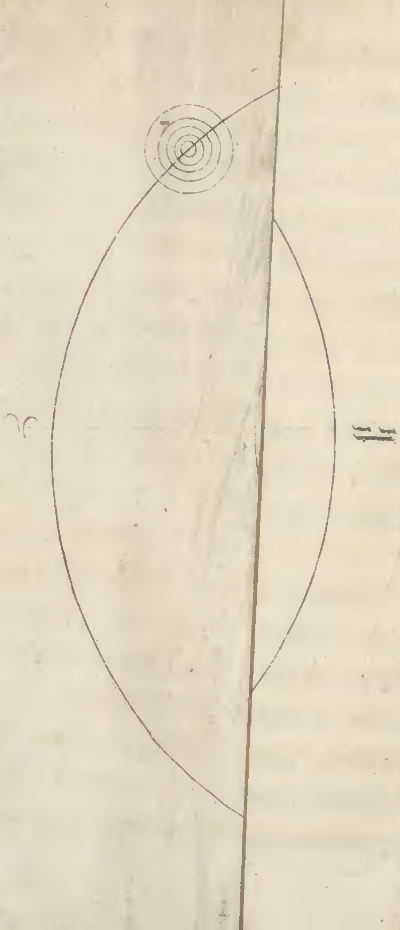
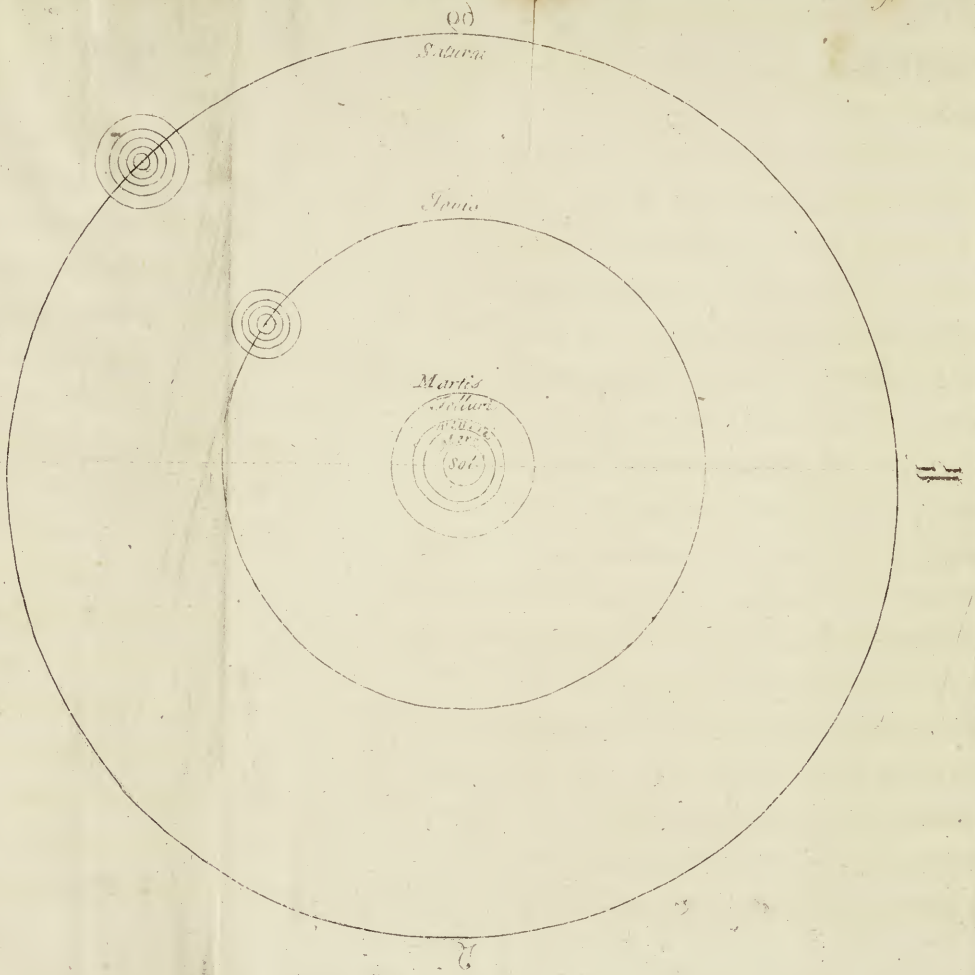


Fig. 1



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 often ſeen in my planetary clock. The ſecond ſhows the proportions of their magnitudes in reſpect of one another and of the 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 every one 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 keeping 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 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. 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 de-

Arguments for the truth of it.

monſtrated in this than either in that of Ptolomy 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 is 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 extremely absurd, and repugnant to the nature of all motion. Whereas nothing is easier with Copernicus than to give us satisfaction in this matter. Then he may impartially weigh those answers that Galilaeus, 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.

In the other figure you have the globes of the planets, and of the ſun, repreſented to your eyes as placed 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 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

The proportion of the magnitude of the planets, in reſpect of one another, and the ſun.

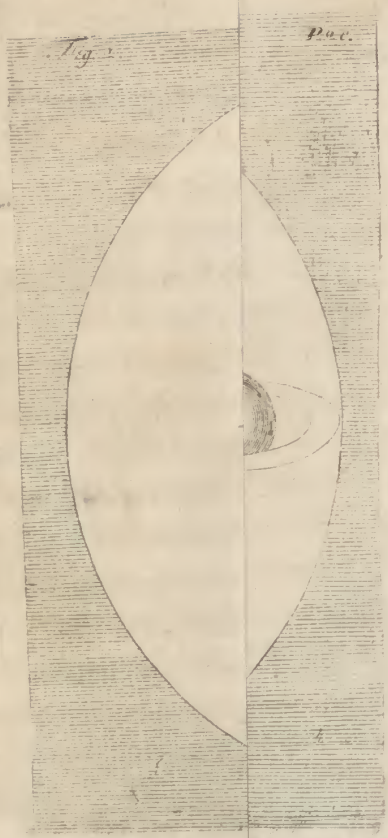


Fig. 2
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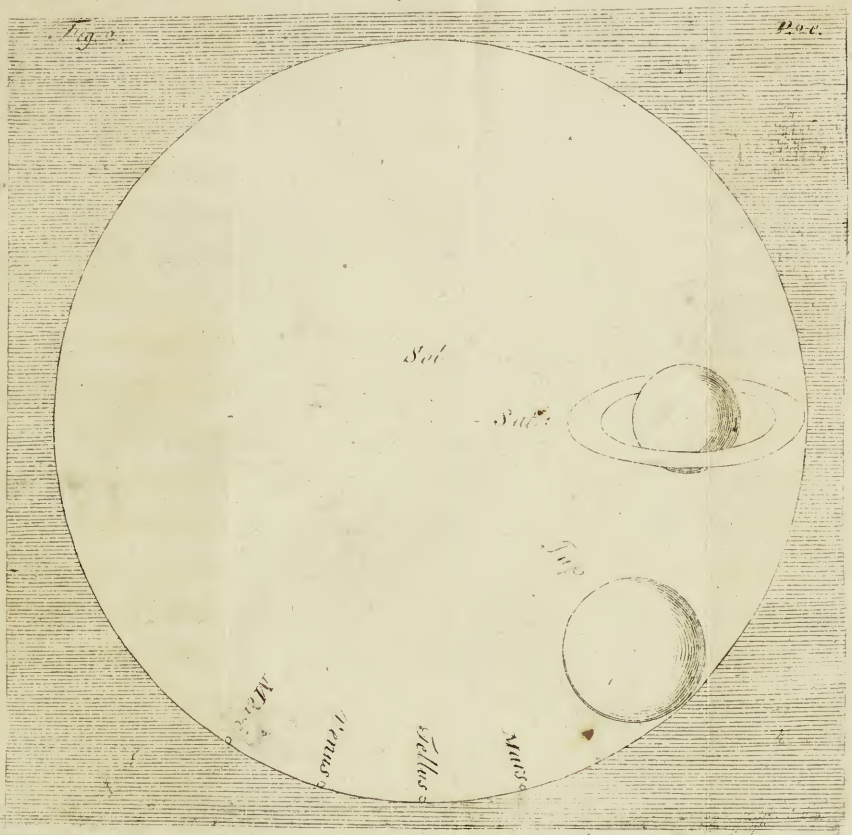
Fig. 1.

Pag.



Hevelius in the year 1661, but calculated by my self, and found to be as 1 to 290.

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 before-mentioned: 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 inventi-

The lamellae more convenient than micrometers.

on, are more convenient than the micrometers.

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, 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

The earth juſtly liken'd to the planets, and the planets to it.

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 inhabitants as the earth? or what ſhadow of reaſon can there be why they ſhould not?

If any one 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 thoroughly 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 judge of all others by? '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 can-

Arguments from their ſimilitude of no ſmall weight.

not, is no falſe logick. This muſt be our method in this treatiſe, 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 load-ſtone 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-a-days, 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.

But now to carry the search farther, let us see by what steps we must rise to the attaining some knowledge in the more private secrets concerning the state and furniture of these new earths. And, first, how likely is it 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

Have animals and planets.

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-pluſs'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 uſe, that they manifeſt an infinite wiſdom, and exquiſite knowledge in the laws of nature and geometry, as, to omit thoſe wonders in generation, we ſhall by and by ſhow; and make it an abſurdity even to think of their being thus fortuitouſly 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 bodies capable of moving themſelves, not at all inferior to ours (for why ſhould they?) and theſe are animals. Now for fear of ſtarving theſe 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,

Not to be imagin'd too unlike ours.

ſeeing they have the ſame ſun to warm and enliven them as ours have.

But perhaps ſome body may ſay, we conclude too faſt. They will not deny indeed but that there may be 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 examine, and whether it be not more likely that ſhe has not obſerv'd ſuch a va-

riety 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 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 exhibit-

ed 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 pro-

ceeds from ſome fluid principle. For 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: for whatſoever is dry and without moiſture, is without motion too; and without motion 'tis impoſſible there ſhould be any increaſe. But the parts of a fluid being in continual motion one with another, and inſinuating and winding 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, 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

theſe 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 Ju-

piter, as well becauſe even when 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. I can't ſay that they are exactly of the ſame nature with our water; but that they ſhould be fluid 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 tem-

But not juſt like ours.

per, 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.

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 faſtened 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 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

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

of their beauty or pleaſantneſs. Now what way can any one imagine for a continual production and ſucceſſion of theſe plants, but their bearing ſeed? A method ſo excellent that 'tis the only one that nature has here made uſe of, and ſo wonderful, that it ſeems to be deſign'd not for 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 fol-

low the ſame conſtant and fixt inſtitution of nature; all feed on herbs, or fruits, or the fleſh of other animals that fed 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 'tis 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 in-

vent 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 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 admirable na-

tural 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; either that they walk upon two feet or four; or like inſects, upon ſix, nay ſometimes hundreds; or that they fly in the air bear-

ing 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 tranſparency, be fitter for the volatile animals. There may be alſo 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 va-

riety 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 knowledge in the matter, or reach probability concerning the figures of theſe Planetary animals. Altho' conſidering theſe ways of motion we even now recounted, they may perhaps be no more different from ours than ours (thoſe of ours I mean that are moſt unlike) are from one another.

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-fiſh, the pourcontrel, the crocodile, the flying fiſh, the cramp fiſh, the crab, the oiſter, and the pur-

Great variety of animals in this earth.

ple 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. But be they never ſo many, there is no reaſon to think that the planets cannot 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.

And no leſs in the planets.

The more conſiderable

The ſame in plants.

differences in our plants ought to be thought on, as well as the other. As in trees, that between the fir and the oak, the palm, the vine, the fig, and the coco-nut tree, and that in the Indies, from whoſe boughs new roots ſpring, and grow downwards into the earth. In herbs, the difference is notable between graſs, poppy, colewort, ivy, pompions, and the Indian fig with thick leaves growing up without any ſtalk, and aloe. Between every one of which again there are many leſs differing plants not taken notice of. Then the different ways of raiſing them are remarkable, whether from ſeeds, or kernels, or roots, or by grafting or inoculating them. And yet in all theſe, whether we conſider the things themſelves, or the ways of their production,

I make no doubt but that the planetary worlds have as wonderful a variety as we.

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 ever ſo ſlightly touched on theſe matters, I don't find any that have ſcrupled to allow them their inhabitants: not men perhaps like ours, but 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 who 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

animals whatſoever: a creature that has ſomething divine within him, that knows, and underſtands, and embraces in his memory things innumerable; 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 to trust my reason, and must allow myself 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 any one say here, that there is so much villany and wickedness in this man that we have thus magnified, that it is 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 moſt beautiful and excellent ſubject. 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 is abſurd to ſay it happened againſt his will or knowledge) we muſt not think that thoſe different opinions, and that various multiplicity of minds were placed 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 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 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 which 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 esteem just and generous, in Jupiter or

Mars be thought unjuſt or wicked? This certainly is neither probable nor 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 are 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 different from ours, and ſuppoſing they may act by other principles in what belongs to friendſhip, and anger, hatred, honeſty, modeſty, and decorum, 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 is 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 rea-

ſon of any uſe. And I think it very probable, that all their animals, as well their beaſts as rational creatures, are like 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. Then if we conſider the wonderful nature of light, and the amazing artifice in the Sight.
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 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 'tis 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 colours 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 is impossible that light should represent objects to us at so vast a distance, except by such an intervening motion; and it is 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 is likely then, and credible, that in theſe things the planets have an exact correſpondence with us, and that their animals 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 to 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 beauty of colours, and the elegancy and beauty of forms: with them we read, we write, we contemplate the hea-

vens 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 immediately examine. But firſt I ſhall enquire whether now I have given them one, we may not venture upon the other four ſenſes, to make them as good men as ourſelves. And truly hearing almoſt perſuades me to give it a ſhare in the animals of thoſe new countries. For 'tis of great conſequence in defending us from ſudden accidents; and, eſpecially when ſeeing is of no uſe to us, it ſupplies 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,

Hearing.

tho' we do not 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 conveniencies of life? Or what can they have to recompenſe this want? 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 conveyance of ſound to our ears; and this

ſound for the conveyance of another man's thoughts to our minds: can we ever imagine that ſhe has left thoſe other worlds deſtitute of ſo vaſt advantages? That they do not 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.

A medium to convey ſound to the ear.

Touch. As for feeling, it ſeems to be given upon neceſſity to all creatures that are covered 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 is 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.

I know that it hath been a queſtion with many, whether there might not have been more ſenſes than thoſe five.

Their ſenſes not very different from ours.

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 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 con-

templation of beauteous ſhapes and colours; from the hearing in the ſweetneſs and harmony of ſounds; from the feeling in venery, unleſs you pleaſe to count that for a particular ſenſe by itſelf.

They have pleaſure ariſing from the ſenſes.

Since it is thus, I think it is but reaſonable to allow the inhabitants of the planets the 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 ourſelves, 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, where-

by 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 is 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 that there is ſuch a thing as pleaſure in the world, I cannot 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 is 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. Let us now see whether they may not have fire too: which is not so properly called an element, as a rapid 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

All the planets have fire.

is not ſo truly called 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, 'tis ſtrange if neither art ſhould have produced it, nor nature effected it there by one of theſe many means. Then how uſeful and neceſ-

ſary is it to us? By it we drive away cold, and ſupply the want of the ſun in thoſe countries where his oblique rays make a leſs vigorous impreſſion, and ſo keep a great part of the earth from being an uninhabited deſart: which is equally neceſſary in all the planets, whether we allow them ſucceſſion of ſeaſons, or a perpetual ſpring and equinox: 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 of 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.

But perhaps it may be 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, in reſpect of our pigmyſhips. 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 herſelf 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

The bigneſs of their creatures not rightly gueſt at by the bigneſs of the planets.

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 leſs 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 pigmies 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 us. For to paſs by thoſe who have hu-

man 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 forced 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 preferred to theirs, as being comprehenſive of innumerable things, indued with an infinite memory of what is paſt, and capable of providing againſt what is 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 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 is 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 is 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 reaſon that man has to boaſt of the pre-eminency 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 ho-

neſty, 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 have them go for nothing but clocks and engines of fleſh;

a thing which beasts so plainly confute by crying and running away from strokes, and all other actions, that I wonder how any one 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. 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

Men chiefly differ from beasts in the study of nature.

without knowledge what would be contemplation? 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 who with a learned niceneſs ſearches into their courſes; who underſtands wherein the fixt ſtars, as they are called, 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, and underſtands the whole fabric and architecture of their compoſition? If there-

fore 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 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,

They have aſtronomy.

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 produced. For ſuppoſing the earth, as we did, one of the planets of equal dignity and honour with the reſt, who would venture to ſay, that no where elſe were to be found any that enjoy'd the moſt beautiful and glorious ſight of Nature; 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 is a proof not ſo far fetch'd for the knowledge of aſtronomy in the planets, the ſame which we uſed

for their having rational creatures, and enjoying the other advantages we before talked 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 'tis 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 worlds, 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 theſe be made without metal, wood, or ſome ſuch ſolid body. Here is a neceſſity of allowing them the carpenter's 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. Again, theſe in-

Geometry and arithmetic.

ſtruments cannot be without a circle divided into equal parts, or a ſtreight line into unequal. Here is a neceſſity for introdu-

cing geometry and arithmetic. Then the neceſſity in ſuch obſerva- And writing.
tions 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 is no nation in the world but has ſome way or other of writing and marking down their thoughts: ſo that 'tis no wonder if the planetarians have been taught it by that great ſchool-miſtreſs Neceſſity, and ap-

ply 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.

But for all our large and liberal allowances to theſe gentlemen, they will ſtill be behind-hand with us. For we And optics. 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 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 compliment ourſelves 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 'tis 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 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 contrary to nature, ſince in the ſearch thereof they are employ'd: eſpecially if we conſi-

der the natural desire and love of knowledge, rooted in all men. For 'tis 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 foretell 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 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 diffi-

cult 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 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 itſelf 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 is no reaſon to think the planetarians leſs ingenious or happy than ourſelves; 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 arithmetic, 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. So that They have hands.

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 cities and houſes in their head, but they would never have been able to have built them. They would have had no ſubject of diſcourſe but

what belonged 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 exactly accommodated to all the design'd uses as the hands are? Shall we give them an elephant's 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 won-

derful compoſure of their neſts. But all this is nothing to thoſe conveniences the hand is ſo admirably ſuited 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? Either then the inhabitants 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.

That they have feet ſcarce any one can doubt, that does but conſider what we ſaid but juſt now of the different methods of progreſſion, which 'tis hard to imagine 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 which 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 thoſe worlds. And feet.

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 That they are upright.

planetarians 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 praise-worthy 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. 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

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

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 covering; 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 the 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, 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 human figure being the handsomest and most excellent of all others, when indeed 'tis nothing but a being accustomed to that

figure that makes us think ſo, and a conceit that we and all other animals naturally 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 hint-

ed that 'twas improbable they ſhould be leſs than we are. For 'tis 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 pre-eminence. Then ſeeing we have before 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 ne-

ceſſary to thoſe obſervations. Therefore we muſt ſuppoſe them larger than, or at leaſt equal to ourſelves, 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 fellowſhip with, and afford mutual aſſiſtances and helps to one another. Hereupon we muſt allow them a ſet-

tled, 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 governors, 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 nor deſire to ſteal from one another; perhaps they may be ſo juſt and good as to be at perpetual 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 is; and if ſo, they muſt be much happier than we. But ſtill 'tis more likely they have ſuch a medly as we, ſuch a mixture of good with bad, of wiſdom and folly, of war with peace, and want not that ſchoolmiſtreſs of arts, poverty. Becauſe from theſe things ſome utility proceeds; and tho' there did not, yet have we no reaſon to prefer their condition to ours.

They enjoy the pleaſures of ſociety.

What I am now going to ſay may ſeem ſomewhat

more bold, and yet is not improbable. For if these inhabitants of the planets live in society, as I have pretty well shewed they do, 'tis somewhat more than probable that they enjoy not only the profit, but the pleasures arising from such a society: such as the meetings and conversation of friends, loves, pleasant raillery, and public shows. 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 be without, and give ourselves such an advantage over them as reason will by no means admit of.

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 want not their ſhowers. For in Jupiter have been obſerv'd clouds, big no doubt with vapours 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 vapours drawn up by the heat of the ſun be diſpoſed of? and their winds, for they are cauſed only by vapours diſſolved by heat, and 'tis 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. For I dare not affront the

They have houſes to ſecure them from weather.

pride of men ſo much as to ſay, they are as good architects, have as noble houſes, and as ſtately palaces as ourſelves. 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 in building: and all others muſt be our inferiours in the knowledge 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 of 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

painting. If their globe is divided like ours, between ſea and land, as 'tis evident it is (elſe whence could all thoſe vapours in Jupiter proceed?) we have great reaſon to allow them the art of 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 knowledge that we are not maſters of, of the longitude of places. And how many 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 'tis 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.

They have navigation, and all arts ſubſervient.

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 im-

ploys 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, polygones, 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, about the circle, without admiration?

As geometry.

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 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 human 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 in their inventions as we ourſelves are.

They have muſic.

It is the ſame with muſic as with geometry, 'tis every where immutably the ſame, and always will be ſo. For all harmony conſiſts in concord, and concord is all the world over fix'd 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 muſic, 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 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

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 half-notes is ſo obvious, and the uſe of them 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 out-do us in conſorts of vocal and inſtrumental muſick, ſo artificially compos'd, that they ſhew their ſkill by the mixtures of diſcords and concords? and of this laſt ſort 'tis very likely the 5th and 3d are 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 poſ-

ſibly have a greater inſight into the theory of muſick than has yet been 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 exceſſive ſweetneſs which ariſes from the repetition of this pleaſing 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 bear 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 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 6, 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 proporti-

on 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. 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 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.

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 ourſelves 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, and make us the more value the good by comparing them with theſe. What

The advantages we reap from herbs and animals.

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 ourſelves, 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 fruits, milk,

eggs, hony, 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 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 pigeons 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 na-

tures, 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 filled with their encomiums. For even in the very inſects, who can but admire the ſix-cornered 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 ſhip-loads of ſoft delicate clothing. This is a ſhort ſummary of thoſe many profitable advantages the animal and herbal world ſerve us with.

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

in melting, refining, and tempering them? what ſkill and nicety in beating, drawing or diſſolving gold, ſo as with inconſiderable charges 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 'tis 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 eaſily guard our towns, by the wonderful ſtrength of that

And from metals.

invention, againſt all hoſtile invaſions: but now we find it has rather encouraged them, and at the ſame time been no ſmall occaſion of the decay of valour, by rendering it and ſtrength almoſt uſeleſs in war. Had the Grecian general who ſaid, valour 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 been 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 miſ-

chievous 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 ſufficient, without any labour of our own, to turn round our mills and engines; things which are of uſe to us in ſo many different imployments. For with them we grind our corn, and ſqueeze out our oil; with them we cut wood, and mill cloth, and with them we beat our ſtuff for paper. An incomparable invention! where mean 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 quick-ſilver over mirrors, unworthy of being mention'd, nor above all the admirable uſes that glaſſes have been put to in natural knowledge, ſince the invention 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 both which the world owes to my † inventions.

† The author invented the pendulum for clocks.

I might add much here of the late discoveries, most of them of this age, which have been 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 thro' 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 of the same kind; and that in the seed of the male are disco-

From the discoveries of our age.

ver'd, by the help of glaſſes, millions of ſprightly little animals, which 'tis probable are the very off-ſpring 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 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 ourſelves there, and enquire 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

knowledge of the incredible distance of the fix'd stars. But first after this long trouble we will give our reader a while to breath.

BOOK II.

'TWAS 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 me-

thoughts 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 philoſophize in this caſe, I don't care if I beſtow ſome few reflections upon that book.

Kircher's journey in ecſtacy examin'd.

That ingenious man ſuppoſing himſelf carried 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 allowed 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 carried, with a monſtrous ſwiftneſs, in twenty-four hours, round the earth. When moſt of theſe worlds are out of the reach 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 handſome, its light gentle, its waters ſweet and purling, and it ſelf beſet all about with ſhining cryſtals. In Jupiter he found wholſome 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 them handſome 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 is in 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 dar'd freely to ſpeak his mind, could have afforded us other gueſs 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 ventured to place ſpectators in the planets, let's take a journey to each of them, and ſee what their years, days, and aſtronomy are.

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, 'tis likely, have the ſame opinion of us that we have of Saturn, that we muſt 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 vi-

The ſyſtem of the planets in Mercury.

gour, 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 to 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 ourſelves, tho' they are ſo far more diſtant from the ſun. The aſtronomy of the Mercurians, 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 glorioufly 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 ſeven 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 been 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 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 attendant the moon. I have often wonder'd that when I have view'd 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 appeared 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 any one may ſatisfy himſelf, that from a very high mountain will 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 itſelf, and is at the ſame

time capable of ſending back the rays that it receives from the ſun? for 'tis 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 night, becauſe the vapours that ſurround the earth being then enlightened by the rays of the ſun, are an impediment to our proſpect.

But Mars, as I ſaid before, has ſome parts of him darker than others. By the conſtant returns of which his nights and days have been found to be of about the ſame length In Mars.

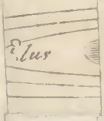
with ours. But the inhabitants have no perceivable difference between ſummer and winter, the axis of that planet having very little or no inclination to his orbit, as has been diſcover'd by the motion of his ſpots. Our earth muſt appear to them almoſt as Venus doth to us, and by the help of a teleſcope will be found to have its wane, increaſe, and full, like the moon: and never to remove from the ſun above 48 degrees, in whoſe disk 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 reflecting a weaker light than is proportionable to his diſtance from the

ſun. His body, as I obſerved 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 acknowlege himſelf our inferior. 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 pre-eminence of the forementioned planets, for having a moon to attend upon it, (for its magnitude can make but a ſmall difference) how much ſuperior 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, 'tis

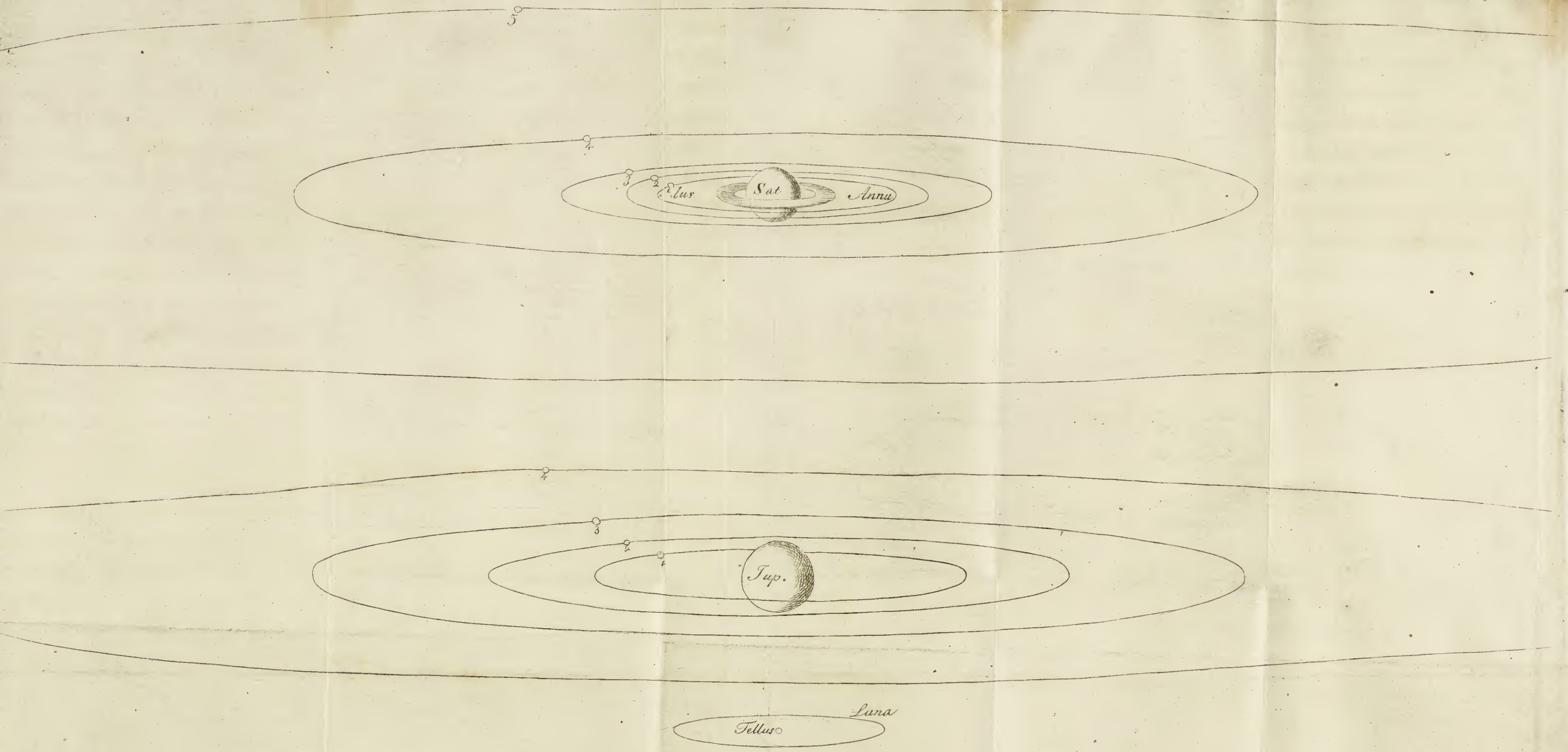
very probable that they are the chief, the primary planets in our ſyſtem, in compariſon with which the other four are nothing, and ſcarce worth mentioning. For the eaſier conception of their vaſt diſparity, I have thought fit to add a ſcheme of our earth, with the path of the moon about it, and the globe of the moon itſelf; and the ſyſtems of Jupiter and Saturn, where I have drawn every Fig. 3. 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 Galilaeo, 'tis well known: and any one 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



)thers: here for ought I know may

telescope not above 12 foot long,

Tab. 5.



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, shew'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 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 attendant; 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 ye 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 unwieldineſs, as for 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, & of the orbits 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

ſatellites is to that of the moon round the earth, as 8 and 1-half is to 1. And each of theſe moons, by the ſhadow they make upon Jupiter, cannot be leſs than our earth. 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, 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 the center of Jupiter is $2\frac{5}{6}$ of his diameters. That of the ſecond is four and a half: of the third 7 and one ſixth part: of the fourth 12 and two thirds, of the ſame diameters. The innermoſt of Saturn's

The periods of Jupiter's moons.

satellites 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 13 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 centre 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 three and a half; of the fifth 12, which were found with vast pains and labour. And Saturn's.

Now can any one look upon, and compare these systems together, without being amazed at the vast magnitude

and noble attendance of these 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 all 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 mortals?

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 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 5 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 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 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 1 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.

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, And in Saturn.

yet you 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 five hours.

But 'tis 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 planets. As the years and days in Jupiter are different from ours in this reſpect, ſo are the days in another; 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 been 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

Always of the ſame length.

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 ourſelves 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 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 been 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.

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 theſe 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 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 itſelf. 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 over-do the matter.

Fig. 4. Suppoſe then that to be the globe of Saturn, whoſe poles are A, B. GN is 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 there) never have a ſight of the ring. From all other

P. 102.

Fig. 4.

Luna
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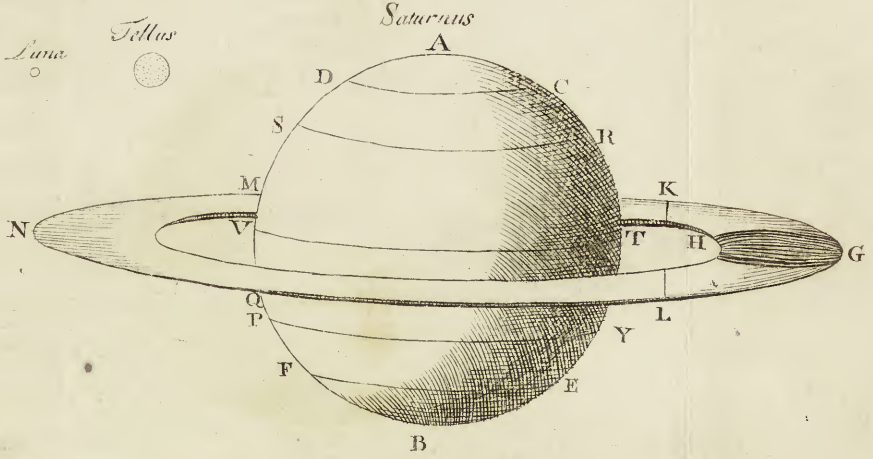
P. 168.

Fig. 4.



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 darkened 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

The appearances of the ring in Saturn.

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, 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 itſelf: 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 deprived 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 ſpace their moons are their only comfort. The other half of the year the hemiſphere TBV enjoys the ſame light that TAU before did, and then this undergoes thoſe long eclipſes which that before ſuffer'd. At the equinoxes, when the ſun is in the ſame plain 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 ſhowed 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 any one, I ſuppoſe, can frame to himſelf a picture of the night in Saturn, with two arches of the ring, and five moons ſhining 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 theſe 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.

The attendants 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 carried 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 be-

long to the attendants of Jupiter and Saturn, as having no reaſon to be at all inferior to that.

The ſurface of the moon then is 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 inhabitants. But I can't be of his mind, both for their incredible largeneſs, and that they might eaſily be occaſioned by natural cauſes. Nor can I find any thing

The moon hath mountains.

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 eſ-

But no ſea.

Nor rivers.

cape our ſight, eſpecially if they run between the hills as ours do. Nor have they any clouds to furniſh the rivers with water. For if they had, we ſhould ſometimes ſee one part of the moon darkened by them, and ſometimes another, whereas we have always the ſame proſpect of her.

Nor clouds.

'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 vapours of our atmoſphere conſiſt of water, and conſequently that where there are no ſeas or rivers, there

Nor air and water.

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 cannot imagine how any plants or animals, whose whole nourishment comes from fluid 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 weak 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 its axis, preſenting them ſometimes 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 condemned to the ſame uſeleſneſs? 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 to cauſe a miſt or dew, which may be very ſuitable to the

growth of their herbs. Which I remember is Plutarch's opinion, in his dialogue upon this ſubject. But in our earth a very little water drawn from the ſea into dew, and falling down again upon the herbs, would not be ſufficient for all our needs, without any rain or ſhowers. However 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 obſer-

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

vation 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, 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 towards 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 a 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. 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 itself, 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 undiscovered by us. They have it in its monthly wane and increase, they see it half, and horned,

The astronomy of the inhabitants of the moon.

and full, by turns, juſt as we do their planet. But the light 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 almoſt 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 Iceland and Nova Zembla are, in the ſummer time: who are in ſo little danger of being ſcorched, that in the middle of their ſummer, in their days of three months length, they ſuffer extreme cold. 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 in 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. All that I have ſaid belongs as well to Jupiter's and Saturn's as to our moon, in reſpect of the planets they move round. The length of their day and night is always equal to the time of their revolution: for example,

This may be applied to the moons about Jupiter and Saturn.

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 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 made up Fig. 1. in words. Going back then to the firſt ſcheme, ſuppoſe another like it, and proportionable, drawn upon a very large ſmooth plane; 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 Fig. 2. ring of Saturn of that bigneſs as the 2d figure ſhows you. Let all the other planets be ſuppoſed every one in his own orbit, and in the middle of all the ſun, of the ſame bigneſs which that figure repreſents, namely, about four inches in diameter. And then the orbit or circle in which the earth moves,

Fig: 5. *P. 189.*

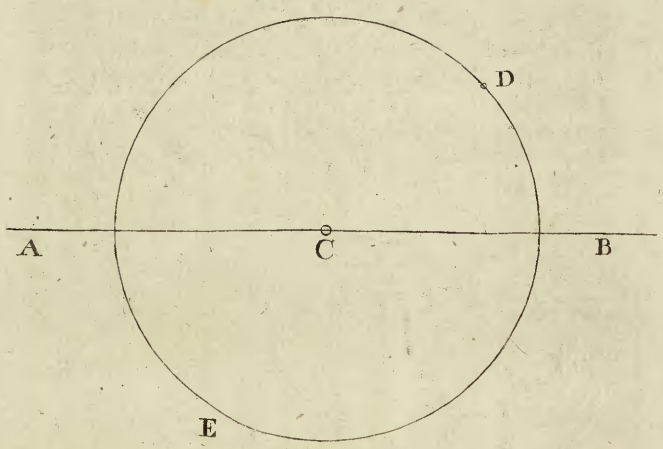


Fig: 5. P. 169.

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 Fig. 5. the line AB repreſents a ſmall portion of that circle which the earth moves in: 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.

The outermoſt of Saturn's moons moves 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 place, 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 mid way 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 perhaps in a moment, or pulſe of an artery, about an hundred

fathom, as is prov'd by thoſe experiments that Merſennus in a treatiſe of his relates; wherein the ſound was found to extend itſelf eighty hundredth parts in that time. 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 6538594 times ſix Paris feet, one degree being 57060 of that meaſure. This ſhows us how vaſt thoſe orbs muſt be, and how inconſiderable this earth, the theatre upon which all

The immenſe diſtance between the ſun and planets illuſtrated.

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 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 been 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

cómpact or fluid globe ; altho', if my account of light be true, upon that account I ſhould rather think him fluid: 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 vapours our atmoſphere is full of near the earth; which is likewiſe the cauſe of the ſtars twinkling.

The faculae in the ſun not eaſily ſeen.

Nor could I ever diſcern thoſe bright ſpots they ſpeak ſo much of being in the ſun, tho' the dark ones I have very often ſeen; ſo that with very good

reaſon I can doubt whether there's any ſuch thing. For, in all the more exact obſervators, 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. 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 a 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 ex-

By reaſon of its heat no inhabitants like ours can live in the ſun.

cellent 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 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 been made, if it had been only upon their account. For, as to 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, it seem'd to con-

tradict 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 every one of them that appeared any thing bright, muſt be larger than the path or orbit of the earth: which is very abſurd. This is the chief argument that Tycho Brahe ſet up againſt Copernicus. But when the teleſcopes ſhav'd them of their fictitious rays, and ſhow'd them 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 'tis 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. 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 'tis 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.

They are not all in the ſame ſphere.

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 of the heavens, 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 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 'tis 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 favour 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. 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 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. 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 ourſelves placed at an equal diſtance from the ſun and fix'd ſtars; we ſhould then perceive no difference between them. For, as to

The ſtars have planets about them like our ſun.

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 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 atten-

dance 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 requiſite for ſuch knowlege.

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 herbs, trees and animals, and adorn'd with ſo many ſeas and mountains! and how muſt our wonder and admiration be increaſed

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 compared 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 Bear's 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 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 been able perfectly to 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. 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 cloſed one end of my twelve-foot tube with a very thin plate, in the middle of which I made a hole not exceeding the twelfth part of a line, that is the hundred and forty fourth part of an inch. That end I turned 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-

A way of making a probable gueſs at the diſtance of the ſtars.

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 this diameter now was but $\frac{1}{152}$ part of that hundred and eighty-ſecond part of his whole diameter that I ſaw through the former hole. Multiplying $\frac{1}{152}$ and $\frac{1}{182}$ into one another, the product I found to

be $\frac{1}{27664}$. The ſun therefore being contracted into ſuch a compaſs, or being removed ſo far from us (for 'tis the ſame thing) as to make his diameter but the 27664 part of that we every day ſee, will ſend us juſt 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 $4'''$. 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 ſwift-

neſs, to travel from the ſun to us; then if we multiply the number 27664 by 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 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 theſe as theſe 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 been 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 even this number exceeds that of the fix'd ſtars? ſome of the antients, and Jordanus Brunus carried 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 contra-

ry can ever be made out. Indeed it ſeems to me certain, that the univerſe is infinitely extended; but what God has been 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, 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 every one 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 ethereal 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 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 cauſe which keeps the planets within the limits of their own orbits; 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 the planets muſt move

in elliptical orbits, as was discovered by Kepler. According to my notion of the gravitation 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 aether 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 planets, 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 whirlpools 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 at all intermix or communicate with one another; ſo in my opinion muſt the vortices of ſtars be plac'd as not to hinder one another's 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 Cartes's, when he was a ſhowing how a fix'd ſtar or ſun might be turned 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 u-

pon 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.