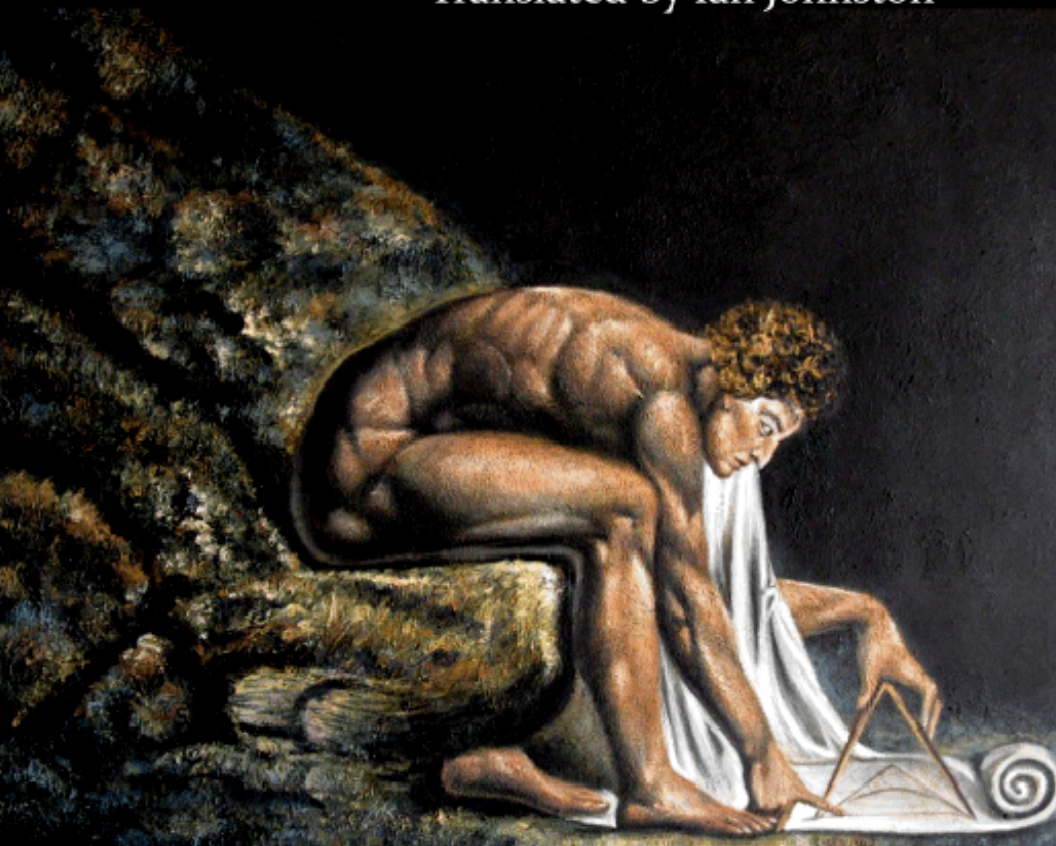
Immanuel Kant

Universal Natural History and Theory of the Heavens

Translated by Ian Johnston



Immanuel Kant

Universal Natural History and Theory of the Heavens
or
An Essay on the Constitution and the Mechanical Origin of the Entire Structure of the Universe Based on Newtonian Principles

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About the Cover Art: The cover art is a reproduction of William Blake's colour print of Isaac Newton (1785). Blake's vision in this work stresses the limitation of Newtonian scientific thinking, and yet the image has become the most famous artistic depiction of Newton and Newtonian ideas at work.

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Translator's Note

Immanuel Kant (1724-1804) published *The Universal Natural History and Theory of the Heavens* in 1755. This English translation, based on Georg Reimer's German edition of the complete works of Immanuel Kant (1905), was first completed and posted on the web in 1998. It has been considerably revised for this printed edition, mainly to improve the accuracy and fluency of the translation.

The footnotes in this translation come from Kant's original text except for those which are provided by the translator. The latter are prefaced by the comment *[Translator's Footnote]*. All footnotes without that initial phrase are Kant's. The initial Table of Contents is an addition to Kant's text.

In the English translation I have used the original lines from the works of Alexander Pope and Addison in those places where Kant quotes the often quite loose German versions of these English poets. The translations of the von Haller quotations are my own.

There are also occasional references to two earlier English versions of Kant's text: those by Stanley L. Jaki (Scottish Academic Press, 1981) and by William Hastie (first published in 1900, reprinted by University of Michigan Press, 1969). The translator of the present text would like to acknowledge the great help he has received from these two earlier translations. Anyone seeking a detailed contextual examination of Kant's scientific ideas in this essay should consult the Jaki edition, which is outstanding in this respect.

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September 2008

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Universal Natural History and Theory of the Heavens
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An Essay on the Constitution and the Mechanical Origin of the Entire Structure of the Universe Based on Newtonian Principles

To the most serene, the mightiest king and master
Frederick
King of Prussia
Margrave of Brandenburg
Lord Chamberlain and Elector of the Holy Roman Empire
Sovereign and Highest Lord of Silesia, etc. etc.
My most all-honoured King and Master,
Most serene and mighty king,
Most All-honoured King and Master,

The feeling of my own lack of worth and the radiance from the throne cannot make my foolishness so timid, when the honour which the most gracious monarch dispenses with equal magnanimity among all his subjects gives me grounds for hope that the boldness which I undertake will not be looked upon with ungracious eyes. In most submissive respect I here lay at the feet of your eternal kingly majesty one of the most trifling samples of that eager spirit with which your highness's schools, through the encouragement and the protection of their illustrious sovereign, strive to emulate other nations in the sciences. How happy I would be if the present endeavour could succeed in making the efforts with which the humblest and most respectful subject constantly tries to make himself in some way of service to the Fatherland win the highest possible feeling of goodwill of his king. With the utmost devotion until my dying day,

Your eternal majesty's most humble servant

The author

Königsberg
14 March, 1755

Preface

I have selected a subject which, both in view of its inherent difficulty and also with respect to religion, can right at the very start elicit an unfavourable judgment from a large section of readers. To discover the systematic arrangement linking large parts of creation in its entire infinite extent and to bring out by means of mechanical principles the development of the cosmic bodies themselves and the cause of their movements from the first state of nature, such insights seem to overstep by a long way the powers of human reason. From another perspective, religion threatens with a solemn accusation about the presumption that one is allowed to be so bold as to attribute to nature left to itself such consequences in which we rightly become aware of the immediate hand of the Highest Being and worries about encountering in the inquiry into such views a defence of the atheist. I do perceive all these difficulties, and yet I do not become fainthearted. I feel all the power of the obstacles ranged against me, and nevertheless I am not despondent. On the basis of a slight assumption I have undertaken a dangerous journey, and I already see the promontories of new lands. Those people who have the resolution to set forth on the undertaking will set foot on these lands and have the pleasure of designating them with their very own names.

I made no commitment to this endeavour until I considered myself secure from the point of view of religious duties. My enthusiasm has doubled as I witnessed at every step the dispersal of the clouds which behind their obscurity seemed to hide monsters and which, after they scattered, revealed the majesty of the Highest Being with the most vital radiance. Since I know that these efforts are free of all reproach, I will faithfully introduce what well-meaning or even weak-minded people could find shocking in my proposal and am candidly ready to submit it to the strict inspection of a council of true believers, which is the mark of an honest disposition. The champion of the faith, therefore, may be allowed to let his reasons be heard first.

If the planetary structure, with all its order and beauty, is only an effect of the universal laws of motion in matter left to itself, if the blind mechanism of natural forces knows how to develop itself out of chaos in such a marvellous way and to reach such perfection on its own, then the proof of the primordial Divine Author which we derive from a glance at the beauty of the cosmic structure is wholly discredited, nature is self-sufficient, the divine rule is unnecessary, Epicurus lives once again in the midst of Christendom, and an unholy philosophy treads underfoot the faith which proffers a bright light to illuminate it.

If I found this criticism had a firm basis, then the conviction which I have of the infallibility of divine truths is for me so empowering, that I would consider everything which contradicts it sufficiently refuted by that fact and would reject it. But the very agreement which I encounter between my system and religion raises my confidence in the face of all difficulties to an unshakable composure.

I recognize all the value of those proofs which people derive from the beauty and perfect organization of the cosmic structure to confirm the most eminently wise Author. If we do not obstinately deny all conviction, then we must agree with such incontrovertible reasons. But I maintain that the people who defend religion in this way, by using these reasons badly, perpetuate the conflict with the naturalists, because they present an unnecessarily weak case.

People are accustomed to take note of and to point out the harmonies, beauty, purposes, and a perfect interplay of means and ends in nature. But while they, on the one hand, extol nature, on the other hand, they seek to diminish it again. This fine arrangement, they say, is foreign to nature. Left alone to its universal laws, it would bring forth nothing but disorder. The harmonies demonstrate a foreign hand, which knew how to force material left without any regularity into a wise design. But I answer that if the universally efficient material laws were established equally as a result of the highest design, then they could presumably have no purposes except to strive to act on their own to

fulfill the plan which the Highest Wisdom has set out for Itself or, if this is not the case, should we not be drawn into the temptation of believing that at least matter and its general laws were independent and that the most eminently Wise Power, which knew how to make use of them so splendidly, may indeed be great, but not infinite, certainly powerful, but not totally self-sufficient?

The defender of religion fears that the harmony which can be explained by a natural tendency of matter would demonstrate the independence of nature from divine providence. He clearly confesses that if people can discover natural reasons for all the order in the cosmic structure, reasons which can bring this into existence from the most universal and essential characteristics of matter, then it may be unnecessary to invoke a highest Ruling Power. According to the natural scientist's calculations, he finds nothing to quarrel with in this claim. He acquires examples which establish the fertility of general natural laws for perfectly beautiful consequences and brings true believers into danger through reasons, which in their hands could become invincible weapons. I wish to cite examples. People have already often proposed, as one of the clearest proofs of a benevolent providence solicitous of human welfare, that in the hottest parts of the earth the sea winds, right at the very time when the heated soil most requires their cooling, spread over the land and refresh it, as if they had been summoned. For example, in the island of Jamaica, as soon as the sun has climbed sufficiently high to heat the soil most strongly, just after 9 in the morning, a wind begins to rise from the sea and blows from all sides over the land. Its strength increases proportionally with the elevation of the sun. Around 1 in the afternoon, when it naturally is the hottest, the wind is at its strongest. It gradually decreases again with the setting of the sun, so that in the evening the very same stillness reigns as at the start. Without this welcome arrangement, the island would be uninhabitable. All coastal lands lying in the hot places on the Earth enjoy this same benefit. Moreover, it is most essential for them, because, since they are the lowest places on dry land, they also

suffer the greatest heat. For the higher regions in the country, which this sea wind does not reach, are also in less need of it, because their higher location places them in a region of cooler air. Is not all this beautiful? Are there not clear purposes which have been realized by judiciously applied means? However, by way of a counterargument the natural scientist must find the natural causes of this in the most general characteristics of air, with no need to assume any special arrangements for the phenomenon. He observes correctly that these sea winds have to go through such periodic movements, even if no human beings lived on the island, thanks to no property other than the elasticity of air and gravity, without having any purposeful intention in the matter, even if it is indispensably necessary merely for the growth of plants. The sun's heat upsets the air's equilibrium by thinning out the air over the land, thus allowing the cooler sea air to rise from its position and take its place.

What benefits generally advantageous to our planet Earth do the winds not possess? And what uses does the keen intelligence of human beings not make of them? However, no other arrangements were necessary to create them except these same general properties of air and heat, which also had to occur on the Earth without reference to these purposes.

At this point the freethinker says: if you concede the point that when people can derive useful and purposeful arrangements from the most general and simplest natural laws, then we have no need for the special rule of a Highest Wisdom and thus you see here proofs which will catch you by your own admission. All nature, especially inorganic nature, is full of such proofs, which permit us to recognize that matter, which organizes itself through the mechanical operation of its own forces, has a certain correctness in its effects and without compulsion satisfactorily acts by rules of what it appropriate. When, in order to come to the rescue of the worthy cause of religion, a well-meaning person wishes to contest this capacity of general natural laws, then he will embarrass himself and by a poor defence give atheism a chance to triumph.

However, let us see how these reasons, which we fear in the hands of our opponents as injurious, are, by contrast, strong weapons to use in the fight against them. Matter, which organizes itself according to its most general laws, produces through its natural behaviour or, if we prefer, through a blind mechanical process, good consequences, which appear to be the design of a supremely High Wisdom. When we observe air, water, and heat left to themselves, they produce wind and clouds, rain, streams which moisten the lands, and all the useful consequences without which nature would have had to remain sad, empty, and barren. However, they produce these results not through mere chance or accident, which could just as readily have resulted in something detrimental. But we see that these consequences are limited by its natural laws so as to work only in this way. What should we then think of this harmony? How would it really be possible that things with different natures should strive to work in cooperation with one another for such perfect coordination and beauty, even with purposes in such matters which are to a certain extent beyond the range of lifeless material stuff, namely, for the benefit of human beings and animals, unless they recognized a common origin, that is, an Infinite Understanding, in which all things were designed with reference to their essential properties? If their natures were necessarily isolated and independent, what an astonishing contingency that would be, or rather, how impossible it would be that with their natural efforts they should mesh so exactly together, as if an overriding wise selection had united them.

Now, I confidently apply this concept to my present enterprise. I summon up the material stuff of all worlds in a universal confusion and create out of this a perfect chaos. According to the established laws of attraction, I see matter developing and modifying its motion through repulsion. Without the assistance of arbitrary fictions, I enjoy the pleasure of seeing a well-ordered totality emerge under the influence of the established laws of motion, something which looks so similar to the same planetary system which we see in front of us, that I cannot pre-

vent myself from believing that it is the same. This unanticipated unfolding of the order of nature on a grand scale I find at first suspicious, because it establishes such a well-coordinated and correct system on such a meagre and simple foundation. Finally, on the basis of the previously outlined observation, I advise myself that such a natural development is not something unheard of in nature but that its fundamental striving necessarily brings such things with it and that this is the most marvellous evidence of its dependence on that Primordial Essence which has within Itself the source of being and the first laws by which nature operates. This insight doubles my trust in the proposal I have made. The confidence increases with each step I take as I continue on, and my timidity disappears completely.

But the defence of your system, it will be said, is at the same time a defence of the opinions of Epicurus, to which it has the closest similarity.[1] I will not completely deny all agreement with him. Many people have become atheists through the apparent truth of such reasons which, with a more scrupulous consideration, could have convinced them as forcibly as possible of the certain existence of the Highest Being. The consequences which a perverse understanding infers from innocent basic principles are often very blameworthy. Although his theory was what one would expect from the keen intelligence of a great spirit, Epicurus's conclusions were also of this kind.

I will also not deny that the theory of Lucretius or of his predecessors (Epicurus, Leucippus, and Democritus) has much similarity to mine.[2]

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[1][*Translator's Note*: Epicurus (341 BC-270 BC), Greek philosopher, founder of the school of Epicureanism, who taught that natural phenomena are based on the motions and interactions of atoms in empty space].

[2][*Translator's Note*: Lucretius (99 BC-55 BC) Roman philosopher, author of *On the Nature of Things*, which developed the philosophical thinking of Epicurus and which attempted to combat superstition; Leucippus (c. 450 BC), Greek philosopher who promoted the idea that everything is made up of various indivisible elements called atoms; Democritus (460 BC-370 BC), Greek philosopher, who taught that all matter is made up of indivisible atoms].

Like those philosophers, I set out the first condition of nature as that state of the world consisting of a universal scattering of the primordial materials of all planetary bodies, or atoms, as they were called by these writers. Epicurus proposes a principle of heaviness which drives these elementary particles downwards, and this appears not very different from Newton's power of attraction, which I assume. He also assigned to these particles a certain deviation from the straight linear movement of their descent, although at the same time he had an absurd picture of the cause and consequences of this deviation, which comes about to some extent with the change in the straight linear descent, a change which we derive from the force of repulsion of the particles. Finally, came the eddies, which arose from the confused movement of the atoms, a major part of the theories of Leucippus and Democritus. We will meet them also in our theory. But such a close affinity with a theory which was the true theory of atheism in ancient times does not lead mine to be grouped in the company of their errors. Even with the most foolish opinions which can win popular applause, sometimes there is some truth to remark upon. A false basic assumption or a pair of unexamined coordinating principles lead people from the footpath of truth through unnoticed misdirections right into the abyss. Nonetheless, there remains, in spite of the above-mentioned similarity, a fundamental difference between the ancient cosmogony and the present one, so that one can derive from the latter totally opposite consequences.

The previously mentioned teachers of the mechanical development of the cosmic structure derived all order which can be observed in it from chance accident, which allowed the atoms to come together in such a fortunate way that they created a well-ordered totality. Epicurus was even so unconscionable that he demanded that the atoms swerved from their direct linear movement without any cause, so that they could run into each other. Collectively these writers pushed this absurdity so far, that they even attributed the origin of all living creatures to this blind collision and, in effect, derived reason from irrationality. In my theory,

by contrast, I find matter bound to certain necessary laws. I see a beautiful and orderly totality developing quite naturally in its complete dissolution and scattering. This does not happen through accident or chance. By contrast, we see that natural characteristics necessarily bring this condition with them. Hence, will we not be moved to inquire why matter had to have just such laws which aim at order and propriety? Was it really possible that many things, each of which has its own nature independent of the others, should on their own constitute themselves in such a way that a well-ordered totality thereby arises? And if they do this, is there not an undeniable proof of the commonality of their first primordial origin, which must be a self-sufficient Highest Reason, in which the natures of things were designed for harmonious purposes?

The material which is the primordial stuff for all things is thus bound to certain laws. Freely left subject to these laws, it must necessarily bring forth beautiful combinations. It has no freedom to deviate from this plan of perfection. Since it also finds itself subject to the loftiest wise purpose, it must of necessity be set in such harmonious relationships through a First Cause which rules over it. *There is a God for just this reason, that nature, even in a chaotic state, can develop only in an orderly and rule-governed manner.*

I have such a high opinion of the honest minds of those people who confer upon this proposal the honour of testing it, that I remain confident that, where the basic principles mentioned above will still not be able to get rid of all worries about the deleterious consequences of my system, nevertheless at least they place the sincerity of my intentions beyond doubt. If, in spite of this, there are malicious zealots who consider it a duty worthy of their holy calling to attach shameful explanations to the most innocent opinions, then I am sure that their judgment will have precisely the opposite effect among reasonable men. Besides, people will not deprive me of the right which Descartes enjoyed in his time among disinterested critics when he ventured to explain the development of world bodies from merely mechanical

laws.[1] I wish therefore to quote from the author of *Universal World History*:[2] "Thus we can do nothing other than believe that the attempt of this philosopher, who endeavoured to explain the development of the world in a certain time from confused matter simply through the continuation of a movement once impressed on it using a few easy and universal laws of motion, or of others *who since then have, with more approval, attempted the same thing through the primordial properties of matter, with which it is created, is far from being worthy of punishment or demeaning to God, as many have imagined, since in this way a higher idea of His infinite wisdom is far more likely to be brought about*."

I have sought to clear away the difficulties which seem, from a religious point of view, to threaten my propositions. There are some no less significant difficulties with respect to the subject matter itself. Even if it is true, people will say, that God has set in the forces of nature a hidden art of developing a perfect world order out of chaos on their own, will human understanding, which is so stupid in the commonest circumstances, be capable of investigating hidden properties in such a massive enterprise? Such an undertaking amounts to much the same thing as when people say: Give me only the material, and I will create a world out of it for you. Can the weakness of your insights, which are shamed by the most insignificant things which come into your mind daily and close by, not teach you that it is vain to discover the infinite and what was happening in nature even before there was a world? I demolish this difficulty, for I clearly show that of all the attempts which could be devised to learn about nature, this very endeavour may

[1] [*Translator's Note*: Rene Descartes (1596-1650), extremely important French philosopher who helped lay the foundations of modern science. As Jaki points out (p. 249) Descartes was sufficiently worried about what happened to Galileo to curtail his writings on mechanistic theory]

[2] Part Section 88. [*Translator's Note*: Jaki indicates (p. 249) that Kant is quoting from *An Universal History from the Earliest Time to the Present . . .*, by George Sale and others (London 1736) and that the italics were added by Kant]

be the one in which we can most easily and surely go right to the origin. Just as among all problems of research into nature, none will be resolved more correctly and certainly than the true constitution of the planetary structure on a large scale, the laws of motions, and the inner workings which drive all planetary orbits, in which Newtonian philosophy can provide such insights, that we find nothing like them in any other part of philosophy, in the same way I maintain that among all the natural phenomena whose first cause we are investigating, the origin of the planetary system and the production of the heavenly bodies, together with the causes of their movements, is the one which we may hope to consider reliably from first principles. The reason for this is easy to perceive. The heavenly bodies are round masses with the simplest development which a body whose origin we are exploring can ever have. Their movements are equally clear. They are nothing other than a free continuation of an impetus impressed upon them once, a motion which, combined with the force of attraction of the body at the mid-point, becomes circular. Moreover, the space in which they move is empty, the intermediate distances, which separate them from each other, are exceptionally large, and thus everything is laid out for undisturbed motion as well as for clear observation of them in as manifest a way as possible. In my view, we could say here with certain understanding and without presumption: Give me the material, and I will build a world out of it! That is, give me the material, and I will show you how a world is to come into being out of it. For if there is material present which is endowed with an inherent power of attraction, then it is not difficult to establish those causes which could have led to the arrangement of the planetary system, considered on a large scale. We know what is involved for a body to acquire a spherical shape. We grasp what is required for freely suspended spheres to take on a circular movement around the middle point towards which they are attracted. The position of the orbits relative to each other, the agreement in the direction, the eccentricity, everything can arise from the simplest mechanical causes, and we may hope with confidence to discover them, because they can be established with the easiest and clearest reasons.

However, can we boast of such advantages for the smallest plants or insects? Are we in a position to say, give me the material, and I will show you how a caterpillar could have developed? Do we not remain here on the bottom rung because of our ignorance of the true inner constitution of the object and of the development inherent in its multiple elements? Thus, people must not let themselves be disconcerted when I venture to say that we will be able to understand the development of all the cosmic bodies, the causes of their movements, in short, the origin of the entire present arrangement of the planetary system, before we completely and clearly understand the development of a single plant or caterpillar on mechanical principles.

These are the reasons on which I base my confidence that the physical part of natural philosophy gives us hope that in future it will indeed have the same perfection to which Newton raised the mathematical part of the subject. Next to the laws according to which the arrangement of the cosmic structure stands in its present state perhaps there are no others in the entire study of nature so capable of such mathematical accuracy as those laws by which it has developed, and without doubt the hand of an experienced surveyor would find work in these fields not unproductive.

Now that I have allowed myself to promote a favourable reception for what I am proposing in my examination, I will be permitted briefly to explain the way I have dealt with it. The first part is concerned with a new system for the structure of the cosmos on a large scale. Mr. Wright from Durham, whose essay I learned about in the *Freie Urteile* from Hamburg for the year 1751, first gave me the occasion to consider the fixed stars, not as a scattered teeming mass without perceptible order, but as one system with the closest similarity to a planetary system.[1] Thus, just as in the latter the planets are located very near to a common plane, the fixed stars in their positions are also related as closely as

[1] [*Translator's Note*: Thomas Wright (1711-1786), an English astronomer. Kant appears to have read a summary of Wright's book].

possible to a certain plane which must be imagined drawn through the entire heavens, and because of their densest accumulation toward this same plane they project that band of light called the Milky Way. I have become convinced that, since this zone illuminated by countless suns is very precisely structured in the orientation of an extremely large circle, our sun must similarly be located very near this large interconnecting plane. While I was exploring the causes of this structure, I have found it very probable that the so-called fixed or firm stars could really be slowly moving, wandering stars of a higher order. To endorse what will be found about this concept later in its own section, I wish only to cite here a passage from a text by Mr. Bradley concerning the movement of the fixed stars:[1] "If we wish to judge the result of a comparison between our best contemporary observations and earlier ones with tolerable accuracy, then it seems clear that some fixed stars really have changed position with respect to each other and, indeed, in such a way, that we see this is not the result of some movement in our planetary system, but can be ascribed only to a movement of the stars themselves. Arcturus readily provides strong proof of this point. For when we compare the present declination of Arcturus with its location as determined by Tycho as well as by Flamsteed, we will find that the difference is greater than we can assume to have arisen from the inaccuracy of their observations.[2] We have reason to suppose that other examples of a similar phenomenon must occur among the large number of visible stars, because their positions relative to each other could have altered for various reasons. For if we imagine that our own solar system changes its position in celestial space, then after a certain time has gone by, this will give rise to a perceptible change in the angular distance of the fixed stars. And because in such a case this would have a greater

[2][*Translator's Note*: James Bradley (1692-1762), professor of Astronomy at Oxford and Astronomer Royal. Kant offers the quotation in German].

[3][*Translator's Note*: Tycho Brahe (1546-1601), Danish astronomer famous for his accurate celestial observations made without a telescope; John Flamsteed (1646-1719), first Astronomer Royal].

effect on the positions of the nearest stars than on the positions of the ones far distant, then their positions would appear to change, although the stars themselves really remain immovable. And if, by contrast, our own planetary system stands still and some stars do, in fact, move, these will similarly change their apparent position, and the apparent movement will be greater the closer the stars are to us or the more the direction of their motion is arranged so that we can perceive it. Now, since the positions of the stars could thus be altered by so many different causes, when we consider the astonishing distances at which some of them are indubitably located, it will take the observations of several human lifetimes to determine the laws for the perceptible alterations of even a single star. Thus, it must be even more difficult to establish laws for all the most remarkable stars."

I cannot precisely determine the boundaries between Mr. Wright's system and my own, nor in what parts I have merely copied his design or developed it further. However, I had very good reasons to expand one aspect of the design considerably. I took into account the species of nebulous stars, which M. de Maupertuis considers in his treatment of the shape of the stars and which display more or less open elliptical shapes, and I easily convinced myself that they could only be an accumulation of many fixed stars.[1] The fact that these shapes, when

[1]Because I do not have available the treatise mentioned above I will here include what is relevant to this matter in a quotation from the *Ouvrages diverses* of M. de Maupertuis in *Actis Erud.* 1745: The first phenomena are those bright stars in the heavens which are called nebulous stars and which are considered a dense crowd of small fixed stars. But the astronomers, with the help of excellent telescopes, saw them only as large oval areas which were somewhat more luminous than the other part of the heavens. Huygens first came across one in Orion. In the *Anglical. Trans.* Halley recalls six such small areas: 1. in the sword of Orion, 2. in Sagittarius, 3. in the Centaur, 4. in front of the right foot of Antinous, 5. in Hercules, 6. in the girdle of Andromeda. Observing through an 8-foot reflecting telescope, people saw that only one fourth part of these can be considered a collection of stars. The remainder displayed only small white areas without significant difference, other than the fact that one is more circular in shape, another, by contrast, is more elongated. It also seems that in the first group the small stars visible through the telescope could not cause the white glow. Halley believes that from this appearance we can explain just what we meet at the start of the Mosaic creation story, namely, that

measured, were always round taught me that here there must be arranged an unimaginably numerous host of stars and, further, that they are around a common mid-point, because, if that were not the case, their free positioning in relation to each other would display wholly irregular shapes, not measurable figures. I also perceived that in the system in which they are brought together they must be for the most part limited to a single plane, because they are not circular but elliptical in shape, and that because of their pale light they are located incredibly far away from us. What I have concluded from these analogies the

light was created before the sun. Derham compares them to openings through which shines another immeasurable region and perhaps the fire of heaven. He maintains he has been able to observe that the stars seen near these small regions would be much closer to us than these bright stars. To this the author adds a catalogue of the nebulous stars taken from Hevelius. He thinks of these phenomena as huge bright masses, which through a powerful rotating motion have been flattened. If they were to have the same power of illumination as the remaining stars, the material which makes them up would have to have a massive size, so that when they are seen from a much greater distance than that of the stars, they could still appear through the telescope with a distinct shape and size. However, if they were approximately the same size as the rest of the fixed stars, they would have to be not only much closer to us, but also at the same time have a much weaker light, because at such a close distance and with such a discernible size they nevertheless display such a pale glow. It would be worth the trouble to discover their parallax, to the extent that they have one. For those who say they have no parallax perhaps came to that conclusion about all of them from only some of them. The small stars which we come across in the middle of these limited areas, as in Orion (or even more beautifully in the area in front of the right foot of Antinous, which looks just like a fixed star surrounded with a mist) would, if they were closer to us, be seen either as a sort of projection onto the area or would appear through that mass of stars, exactly as they do through the tail of a comet.

[*Translator's note*: Pierre Louis Moreau de Maupertuis, French mathematician, astronomer, and philosopher, who wrote on the stars and the solar system; Edmond Halley (1656-1742), English astronomer and mathematician and Astronomer Royal; William Derham (1657-1735), English clergyman and natural philosopher, who investigated astronomy to defend religious doctrine; Johannes Hevelius (1611-1687), Polish astronomer, whose a catalogue of stars was published in 1690. Kant's text does not include any quotation marks to indicate where borrowed quotations begin and end. Jaki (p. 90) puts quotation marks around everything from the phrase *Halley believes that* to the end of the footnote].

discussion will itself present for the unprejudiced reader's evaluation.

In the second part, which contains the proposal most germane to this treatise, I endeavour to develop the arrangement of the cosmic structure from the simplest condition of nature merely by mechanical laws. If, for those who are shocked at the daring of this undertaking, I may venture to propose a certain order in the manner with which they honour my ideas by testing them, I would request that they first read through the eighth section, which, I hope, will prepare their judgment for a correct insight. Meanwhile, when I invite the well-disposed reader to examine my opinions, I am justly concerned that, since hypotheses of this sort commonly are considered no better than philosophical dreams, it is a sour pleasure for a reader to resolve to undertake a careful investigation on his own into the histories of nature and patiently to follow the author through all the turns by which he moves around the difficulties which he runs into, so that at the end the reader perhaps laughs at his own credulity, like those who look at the London Market Crier.[1] However, I dare to promise that, if the reader will, as I hope, be convinced by the preparatory chapter placed at the start to undertake such a physical adventure based on such plausible assumptions, he will not meet, as he continues on his way, as many crooked diversions and impassable obstacles as he is perhaps worried about at the beginning.

In fact, I have rejected with the greatest care all arbitrary fictions. After I place the world in the simplest chaos, I have applied to it no forces other than the powers of attraction and repulsion, so as to develop the great order of nature. These two forces are both equally certain, equally simple, and at the same time equally primal and universal. Both are taken from Newtonian philosophy. The first is now an incontestably established law of nature. The second, which Newtonian science perhaps cannot establish with as much clarity as the first, I here assume only in the sense which no one disputes, that is, in connection with the

[1]See Gellert's fable , Hans Nord. [*Translator's Note*: Hans Nord was a fictional confidence trickster who collected money for a public display only to abscond with the money].

smallest distributed particles of matter, as, for example, in vapours. From such simple grounds as these, I have produced the system which follows in a natural manner, without imagining any consequences other than those which the reader's attentiveness must observe entirely on its own.

Finally, may I be permitted to provide a short explanation concerning the validity and the alleged value of those propositions which will appear in the following theory and according to which I hope to be assessed by reasonable judges. We evaluate an author fairly by the same stamp which he impresses on his own work. Thus, I hope people will demand from the different parts of this treatise no stronger validity for my opinions that what I myself establish for them in the scale of values. Generally, the greatest geometrical precision and mathematical certainty can never be demanded from a treatise of this sort. If the system is based upon analogies and harmonies in accordance with the rules of credibility and a correct way of thinking, then it has met every demand raised by its object. I believe I have reached this level of quality in some parts of this essay, as in the theory of the system of fixed stars, in the hypothesis about the composition of the nebulous stars, in the general design for the mechanical development of the cosmic structure, in the theory of Saturn's ring, and in some others. In certain particular parts the treatment will be somewhat less persuasive, as, for example, the determination of the relationships of the eccentricity, the comparison of the masses of the planets, the various deviations of comets, and some others.

Therefore, when in the seventh section I pursue the consequences of this theory as far as possible, attracted by the fecundity of the system and the pleasing nature of the greatest and most awesome subject imaginable, always guided by analogy and a reasonable credibility, although with a certain boldness, and when I propose to the power of imagination the infinite nature of the entire creation, the development of new worlds and the destruction of old ones, and the unlimited space of chaos, I hope that people will be sufficiently indulgent to the

attractive charm of the subject and the pleasure which one has in witnessing the harmony in one's theory pushed to its furthest limit not to judge it according to the strictest geometrical precision, which, in any case, does not occur in a theory of this sort. I await exactly the same fairness with respect to the third part. There people will constantly come across something more than merely arbitrary, although always something less than certain.

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this central point.

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Part One
Outline of a Systematic Arrangement of the Fixed Stars and of the Vast Number of Such Systems of Fixed Stars

Is the great chain, that draws all to agree,
And drawn supports, upheld by God, or thee?
(Pope)[1]

Short Outline of the Necessary Fundamental Principles of Newtonian Philosophy Required for an Understanding of the following Theory[2]

Six planets, including three with accompanying satellites, Mercury, Venus, Earth with its moon, Mars, Jupiter with four satellites, and Saturn with five, describe orbits around the sun as the mid-point and, together with the comets, which do the same thing from all sides in very long orbits, make up a system which we call the Solar System or the planetary world structure. The fact that the movement of all these bodies takes the form of a circle and returns back on itself presupposes two forces which are equally necessary for any sort of theory, namely, a projectile force, by which at every point of their curved linear movement the bodies would continue on a straight line and disappear into the infinite distance, unless another force, whatever it may be, constantly required them to leave this path and move on a curved track around the mid-point of the sun. This second force, as geometry itself has established with certainty, always aims at the sun and is therefore

[1][*Translator's Note*: The quotation comes from Alexander Pope, *Essay on Man*, Epistle 1. Kant offers the quotation in German].

[2]This short introduction, perhaps unnecessary for most readers, I wanted to set down first for those who are in some way insufficiently knowledgeable about Newtonian principles as a preparation to understand the following theory. [*Translator's Note*: As Hastie's footnote at this point reminds the reader, Uranus was discovered in 1781, Neptune in 1846, the moons of Mars in 1877, all subsequent to the time of Kant's essay].

called the sinking force, the centripetal force, or gravity.

If the orbits of the celestial bodies were exact circles, then the very simplest breakdown of the compounded curved movements would reveal that a continuous impulse towards the central point would be required for the arrangement. However, although the movements of all planets and comets are ellipses in which the sun is located at a common focal point, higher geometry with the help of Kepler's model (according to which the *radius vector* or the line drawn from the planet to the sun always cuts out on its elliptical path areas proportional to the times) similarly establishes with unequivocal certainty that a force must constantly draw the planet throughout its entire orbital path towards the mid point of the sun.[1] This sinking force, which governs throughout the whole space of the planetary system and directs itself to the sun, is thus an accepted natural phenomenon. Equally clearly demonstrated is the law according to which this force extends from the mid-point of the sun into the far distances. It always decreases inversely as the square roots of the distances from the centre increase. This rule is derived in an equally infallible way from the time which the planets need at different distances to complete their orbits. These times are always in a ratio to the square root of the cubes of their average distance from the sun. From this we deduce that the force which pulls these cosmic bodies to the mid-point of their orbits must decrease inversely as the square of the distance.

This very same law which governs among the planets in their movements around the sun occurs also in connection with small systems, namely, with those which are made up of moons moving about their main planet. Their orbital times are in exactly the same way proportional to the distances and establish a relationship of the force which causes sinking towards the planet, which is exactly the same as the one by which the planet is pulled towards the sun. All this, derived from

[1] [*Translator's Note*: Johannes Kepler (1571-1630), German mathematician and astronomer who established the mathematic laws for planetary motion].

the most infallible geometry and uncontested observations, has been placed forever beyond contradiction. From this now arises the notion that this sinking force may be exactly the same impetus which is called heaviness on the surface of the planet and which gradually diminishes with the distances from the surface, according to the above-mentioned law. We see this from the comparison of the quantity of heaviness on the surface of the earth with the force which pulls the moon to the mid-point of its orbit. These stand in relation to each other just as the force of attraction in the entire planetary system, namely, in inverse proportion to the square of the distances. Hence people also call this frequently reported central force gravity.

Moreover, because there is the highest degree of probability that if an effect occurs only in the presence of and in proportion to the distance to a certain body and if the direction of this effect is related as precisely as possible to this body, then it is credible that this body is the cause of the effect, however it occurs. Therefore, we have sufficient reason to think that this universal downward movement of the planets towards the sun can be attributed to the power of attraction of the sun and to ascribe the capacity for the power of attraction in general to all the celestial bodies.

Hence, if a body is left free to the influence of this impulse which drives it to sink toward the sun or some other planet, then it will fall towards it with a constantly accelerating motion and soon will be united with that same mass. However, if it gets a push directing it to the side, then, if that push is not powerful enough to achieve an exact equilibrium with the sinking force, the body will sink down to the central mass with a curved movement. And if, before the sinking body touches the outer surface of the central mass, the impulse impressed on it has grown at least strong enough to shift it from the vertical line about half the thickness of the body at the mid-point, then it will not touch this surface but, after it has swung closely around it, will, thanks to the velocity achieved in its fall, be raised up high again just as far as it fell, so as to continue its path in a constant circular movement.

Thus, the difference between the orbital paths of the comets and the planets consists in the sideways deviation in opposition to the force which drives them to fall. The more these two forces approach an equilibrium, the more the shape of the orbit will become circular; the more unequal they are, the weaker the projectile force in relation to the force pulling to the centre, then the longer the orbit, or, as we say, the more eccentric the orbit is, because the celestial body in one part of its path comes far closer to the sun than in another.

Because nothing in all nature is exactly balanced, no planet has an entirely circular motion. However, the comets deviate the most from a circular orbit, because at their first distance from the sun the impetus which was impressed on them towards the side was the least proportional to the force pulling them to the centre.

In this treatise I will very often use the expression a systematic arrangement of the cosmic structure. So that people will have no difficulty clearly imagining what this term is to mean, I will explain it briefly. Strictly speaking, all the planets and comets which belong to our cosmic structure already form a system by the fact that they rotate around a common central body. However, I take this term in an even narrower sense, because I consider the more precise relationships which have united them with each other in a regular and uniform way. The orbits of the planets are, in relation to each other, as nearly as possible on a common plane, namely, on the extended equatorial plane of the sun. The deviations from this rule occur only at the outermost borders of the system, where all movements gradually cease. When therefore a certain number of cosmic bodies, ordered around a common mid-point and moving around it are at the same time restricted to a certain plane, so that they have minimal freedom to deviate on both sides of this plane, and when the deviation occurs gradually only with those which are furthest distant from the mid-point and participate less in the interconnections than the others, then I say that these bodies are bound together in a systematic arrangement.

Natural History and Theory of the Heavens
Part One

On the Systematic Arrangement of the Fixed Stars

The theory of the general arrangement of the cosmic structure has not achieved any remarkable progress since the time of Huygens.[1] At this point we still know no more than we already knew then, namely, that six planets with ten companions, all of which have the circle of their orbit set almost on a single plane, and the eternal spheres of the comets, which run riot on all sides, make up a single system, whose mid-point is the sun, towards which everything sinks, around which their movements run, and from which they all are illuminated, warmed, and kept alive, and finally that the fixed stars are just so many suns, the mid-points of similar systems, in which everything may be set up in just as large and orderly a way as in our system and that infinite space teems with cosmic systems, whose number and excellence have a relationship to the infinite nature of their Creator.

The systematic arrangement which took place in the union of the planets which move around the sun disappeared in the crowd of fixed stars, and it seemed as if the rule-governed relationship encountered in miniature does not hold sway on a large scale among the links of all worlds. The fixed stars were subject to no law, by which their positions were confined relative to each other, and we saw all heaven and the heaven of all heavens filled without order and without design. Since human curiosity limited itself in this way, we did nothing further, other than to infer from this state the immensity of the One who had revealed Himself in such inconceivably huge works and to admire Him.

It was reserved for Mr. Wright, an Englishman from Durham, to take a happy step to an observation which he himself does not seem to have developed into anything insightful and whose useful application he did

[1] [*Translator's Note*: Christiaan Huygens (1629-1695) Dutch mathematician and astronomer, who discovered one of Saturn's moons and wrote about Saturn's ring].

not sufficiently note. He looked at the fixed stars not as a disorganized and scattered swarm without purpose but found a systematic arrangement in their totality and a general relationship of these stars with respect to a major plane of the space which they occupy.

We wish to improve the idea which he presented and to redirect it, so that it can generate important consequences. The complete confirmation of these is something we leave for future ages.

Anyone who gazes at the starry heavens on a clear night will notice that bright band which presents a steady light through the crowd of stars which have accumulated there more than elsewhere and which perceptibly lose themselves in the huge expanse. People have called this band the Milky Way. Because of the structure of this recognizably distinct area in the sky, it is remarkable that observers of the heavens were not long ago encouraged to derive from it strange conclusions about the locations of the fixed stars. For we see that the band has an immense circular orientation and, indeed, in a continuous arrangement taking up the entire heavens. These two factors possess such a precise determination and characteristics so recognizably different from uncertain approximations, that from them keen astronomers should long ago naturally have been motivated attentively to investigate the explanation for such a phenomenon.

The stars are not placed on the apparently hollow sphere of the heavens, but from our point of view stand at some distance from each other, some further than others, disappearing into the depths of the heavens. From this phenomenon it follows that, at those distances where they are located one behind the other in relation to us, they do not occur in an equal scattering in every direction, but must be arranged in particular relation to a certain plane which goes through our viewpoint and to which their locations are fixed as closely as possible.

This relationship is such an unambiguous phenomenon that even the remaining stars, which are not included in the white band of the Milky Way, are themselves observed to be that much closer together and

more dense, the nearer they are located to the circle of the Milky Way, so that of the 2000 stars which the naked eye perceives in the sky, we find the largest number in a relatively narrow area, the middle of which is taken up by the Milky Way.

Now, if we imagine a plane drawn through the starry heavens and extending an unlimited distance and assume that all the fixed stars and all the solar systems have a common spatial relationship to this plane, so that they are closer to it than to any other areas, then the eye which is located on this common plane, as it looks out into this field of stars, into the hollow spherical surface of the firmament, will see the thickest accumulation of stars in the direction of the drawn plane, in the form of an area illuminated with more lights. This band of light will sweep out in the direction of a huge circle, because the onlooker's viewpoint is on the plane itself. This area will be swarming with stars. Because of the undifferentiated smallness of bright points, a single one of which escapes the eye, and because of the apparent density of a uniform white gleam, it will look, in a word, like a Milky Way. The rest of the heavenly host, whose relationship with the drawn plane becomes less and less apparent or which are also located closer to the observer's position, will be seen as more scattered, although their accumulation will be related to this same plane. From this, finally, it follows that, because from our solar system we see this arrangement of fixed stars in the orientation of a very large circle, our solar system is located in precisely the same large plane and makes one system with the others.

In order that much better to penetrate the composition of the common interrelationship governing this cosmic structure, we wish to try to discover the cause which has arranged the locations of the fixed stars, relating them to a single common plane.

The Sun does not limit the extent of its powers of attraction to the narrow region of the planetary system. According to all appearance, this power extends an infinite distance. The comets which go very far above Saturn's orbit are forced by the sun's powers of attraction to turn

back again and to move in orbits. Whether it is more likely for the nature of a force apparently incorporated into the essence of matter to act without limits and whether, in addition, it will be really recognized as such by those who assume Newton's principles, we wish only to have it conceded that this power of attraction of the sun extends approximately to the nearest fixed star and that the fixed stars act on each other as just so many suns to the same extent. Thus, it follows that the entire host of fixed stars strives to come closer together through this power of attraction, so that all the world systems are in a situation where sooner or later they fall into one clump, through this reciprocal moving closer together, which is continuous and unhindered, unless these systems are saved from this disaster by forces which pull away from the central point, as with the spheres in our planetary system. These forces bend the heavenly bodies away from falling in a straight line and, working together with the forces of attraction, bring about the timeless orbits. Thus the structure of creation is preserved from collapse and has been skilfully created to last eternally.

Hence, all the suns in the firmament have orbiting motions, either around one common central point or around many. But with them, we can everywhere apply the analogy of what we observe about the orbital paths of our solar system, namely, that just as that very cause which has imparted to the planets a force moving them away from the centre, through which they maintain their orbits, has directed their orbital paths so that they are all related to a single plane, so also the cause, whatever it might be, which has given the suns of the higher world as well as so many wandering stars of the higher world structure the force of their orbit has at the same time brought their orbits as much as possible into one plane and has worked to limit deviation from this plane.

According to this conception, we can picture the system of fixed stars to a certain extent by means of the planetary system, if we magnify the latter infinitely. For if instead of six planets with their ten satellites we assume many thousands of similar bodies, and instead of the twenty-eight or thirty comets which we have observed, we assume a hundred

or a thousand times more of them, and if we think of these particular bodies as generating their own light, then to the eye of the observer who looks out at them from the Earth there would appear exactly the same light as appears from the fixed stars of the Milky Way. For the planets we have imagined, because of their close relationship to the same common plane in which we find ourselves with our Earth, would display a densely lit area made up of countless stars, whose direction went in a very large circle. This band of light would have a sufficient number of stars everywhere, although, according to this hypothesis, as moving stars, they are not fixed to a single spot, for, because of their movement, there would always be enough stars on anyone side, even though other stars had moved from that location.

The width of this illuminated zone, which projects a sort of zodiac, will be set by the different levels of deviation of designated erratic stars from their reference plane and by the inclination of their orbits in relation to this same plane. Since most of them are near this plane, their number will appear more scattered depending on the extent they are distant from it. However, the comets, which occupy all regions without distinction, will cover the field of the heavens on both sides.

The shape of the heaven of fixed stars thus has no cause other than the same systematic arrangement on a grand scale as the cosmic structure of the planetary system on a small scale, since all the suns make up one system, whose common interconnecting plane is the Milky Way. Those which are the least related to this plane will be seen to the side; for that very reason, however, they are less dense, more widely scattered, and less frequent. They are, so to speak, comets among the suns.

This new theory, however, attributes a forward motion to the suns, and yet everyone acknowledges that they are motionless and that they have been fixed in their positions from the start. The name which the fixed stars have acquired from this seems confirmed and unambiguous because of all the centuries of observation. This difficulty, if soundly based, would destroy the proposed theory. But this lack of movement,

according to all appearances, is only something apparent. It is either merely an exceeding slowness, caused by the enormous distance of their orbits from the common mid-point or the impossibility of seeing them brought about by the distant location of the observer. Let us estimate the plausibility of this notion by calculating the movement which one of the fixed stars located close to our sun would have, assuming that our sun is the mid-point of its orbit. If, following Huygens, we assume that the distance of this star is more than 21000 times greater than the distance of the sun from the Earth, it then follows from the established law of the time of orbiting bodies, which is proportional to the square root of the cube of the distances from the mid-point, that the time which this star must take to complete its circle once around the sun would be more than one and a half million years and that in 4000 years this would have established a shift in its position of only about one degree. Now, because perhaps only a very few fixed stars are as close to the sun as Huygens assumed for Sirius, and because the distance of the rest of the heavenly host perhaps exceeds by far the distance of Sirius, therefore they would require a far longer time for such periodic orbits. Moreover, it is also more probable that the motion of the suns in the celestial stars goes around a common mid-point whose distance away is extraordinarily far, and the forward motion of the stars can hence be exceedingly slow. Consequently, we can probably assume from this that all the time since human beings have been keeping records of celestial observations has perhaps still not been sufficient for them to notice the change which has taken place in these stellar positions. We must meanwhile not yet give up hope that we will discover this change in time. To achieve that will require subtle and careful observers, together with a comparison of observations far distant from each other. We must direct these observations especially at the stars of the Milky Way, the main plane of all movement.[1] Mr.

[1]Especially at those accumulations of stars which occur in great numbers together in a small area, as, for example, the seven stars [*Translator's Note*: the Pleiades] which perhaps among themselves make up a small system in the midst of the greater one.

Bradley has observed the almost imperceptible movement of the stars. The ancients marked stars in particular places in the sky, and we see new ones in other places. Who knows that these are not the latter which have merely changed position? The excellence of the instruments and the perfecting of our knowledge of the stars give us ground to hope for the discovery of such remarkable and important observations.[1] The plausibility of the matter itself, based on nature and analogy, supports this hope so well, that it can stimulate the attentive work of scientists to bring it to completion.

The Milky Way is, so to speak, also the zodiac of new stars, alternately appearing and disappearing in this region in a way hardly matched in any other celestial region. If this alteration in their visibility proceeds from their periodic moving further away and closer to us, it seems clear from the proposed systematic arrangement of the stars that such a phenomenon must mainly be seen only in the region of the Milky Way. For there are stars there moving in very elongated orbits around other fixed stars, as satellites move around their main planets. Thus, the analogy with our planetary system, in which only heavenly bodies near the common plane of movement have a companion moving around them, requires that only the stars in the Milky Way will have suns orbiting around them.

I am coming to that part of the proposed theory which makes it most particularly attractive because of the sublime picture it presents of creation's plan. The series of ideas which has led me to it is short and natural. It consists of the following. If a system of fixed stars, all spatially related to a common plane, just as we have sketched out the Milky Way, is so far distant from us that all perception of individual stars making up the system is no longer possible, even with a telescope,

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[2]De La Hire observes in the *Memoires* of the Paris Academy for the year 1693, that he has confirmed from his own observations as well as from a comparison of them with those of Ricciolus a significant change in the positions of the stars in the Pleiades. [*Translator's Note*: Philippe de la Hire (1640-1718), French mathematician and astronomer; Baptista Ricciolus (1598-1671), Italian astronomer].

if the distance of this system has exactly the same relationship to the distance of the stars in the Milky Way as the latter have to the distance of the sun from us, in short, if such a world of fixed stars is seen at such an immeasurable distance from the eye of the observer located outside this world, then this world will appear in a small angle as a tiny and weakly lit area, with a circular shape if its plane is oriented directly in the line of sight and elliptical if it is viewed from the side. The weakness of the light, the shape, and the recognizable extent of its diameter will clearly distinguish such a phenomenon, when present, from all the stars which are seen individually.

We do not need to search a long time for this phenomenon among the observations of the astronomers. It has been clearly confirmed by different observers. People have wondered about its strangeness, have made assumptions, and have subscribed sometimes to odd imaginary images and sometimes to plausible ideas, which, however, just like the former, had no basis. We are talking about the nebulous stars or, rather, a type of them, which M. de Maupertuis wrote about as follows:[1] "There are small places whose light is somewhat more than the darkness of empty celestial space, which all are alike in the fact that they display more or less open ellipses, but their light is much weaker than any other that we are aware of in the heavens." The author of the *Astrotheology* imagined that these were openings in the firmament through which he believed he saw heavenly fire.[2] A philosopher of illuminating insights, the above-mentioned M. de Maupertuis, in thinking about the shape and the recognizable diameter of these stars, considers that they are astonishingly large celestial bodies, which display an elliptical shape because of the large flattening caused by the impetus of their rotation, when viewed from the side.

It is easy to be convinced that this last explanation also cannot hold.

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[1] *Treatise on the Shape of the Stars.*

[1][Translator's Note: *Asterotheology* was written by the English cleric William Derham (1657-1735)].

Because this kind of nebulous stars must undoubtedly be at least as far away from us as the other fixed stars, not only would their size be astonishing (for in this respect they would have to exceed by a factor of many thousands the largest stars), but the strangest point of all would be that with this extraordinary size, made up of self-illuminating bodies and suns, these stars should display the dimmest and weakest light.

Much more natural and comprehensible is the idea that there are no such individual huge stars but systems of many stars, whose distance makes them appear in such a narrow space, that the light, which cannot be seen for each individual star, because of the countless crowd of them, comes out in a uniform pale glow. The analogy with the system of stars in which we find ourselves, their shape, which is exactly as it must be according to our theory, the weakness of the light, which this previously mentioned infinite distance requires, all these endorse perfectly the idea that these elliptical figures should be taken as exactly the same world systems and, so to speak, as Milky Ways, whose structure we have just gone through. And if suppositions in which analogy and observation are in full agreement and support each other have precisely the same value as formal proofs, then we must take the certainty of this system as demonstrated.

Now the attentiveness of those who observe the heavens has sufficient motivation to concern itself with this undertaking. The fixed stars, as we know, are all connected to a common plane and thus create a coordinated totality, a world of worlds. We see that in the immeasurable distances there are more such star systems and that creation in the entirely of its infinite extent is everywhere systematic and mutually interconnected.

We could further suppose that these particular higher world orders are not unconnected to each other and through this mutual relationship establish once again an even more immeasurably great system. In fact, we see that the elliptical shapes of these sorts of nebulous stars, which

M. de Maupertuis mentions, have a very close relationship to the plane of the Milky Way. Here a wide field stands open to discoveries, for which observation must provide the key. The properly named nebulous stars and those about which there is a dispute whether we should call them nebulous must be investigated and tested according to the guidelines of this theory. If we view the parts of nature according to a design and a plan we have discovered, then certain characteristics reveal themselves which are otherwise overlooked and remain hidden, when observation squanders its time on all objects without any guidance.

The theory which we have proposed opens up for us a view of the infinite field of creation and offers an idea of the work of God appropriate to the infinite nature of the Great Master Builder. If the size of a planetary system in which the Earth is hardly seen as a grain of sand fills the understanding with astonishment, how delightfully astounded we will be when we examine the infinite crowd of worlds and systems which fill the totality of the Milky Way. But how much greater this wonder when we know that all these immeasurable arrangements of stars once again create a numbered unity, whose end we do not know and which is perhaps, like the previous one, inconceivably large and yet, once again, only a unit in a new numbered system. We see the first links of a progressive relationship of worlds and systems, and the first part of this unending progression already allows us to recognize what we are to assume about the totality. Here there is no end, but an abyss of a true infinity, in which all capacity of human thought sinks, even when it is uplifted with the help of mathematics. The wisdom, goodness, and power which has revealed itself is limitless and, to exactly the same extent, fruitful and busy. The plan of its revelation must, therefore, be, just like it, infinite and without borders.

However, there are important discoveries to be made, and not just in large things, which serve to expand the idea we can formulate about the magnitude of creation. In smaller things there is no less undiscovered, and we see even in our solar system the links of a system which stand immeasurably far from one another and between which

we have not yet found the intermediate parts. Saturn is the outermost of the wandering stars which we know about. Are there to be no more planets between Saturn and the least eccentric comet which comes down to us from a distance perhaps ten or more times removed, no planet whose orbit could approach more closely a comet's orbit than Saturn does? And should not other planets be gradually changing into comets by means of a series of intermediate types approximating the composition of comets and linking together the family of planets with the family of comets?

The law according to which the eccentricity of the planetary orbits is directly related to their distance from the sun supports this assumption.[1] The eccentricity in the movements of the planets increases with the distance of the planet from the sun, and the furthest planets, therefore, come closer to the condition of comets. We can thus assume that there are still other planets beyond Saturn which are even more eccentric and hence even more closely akin to comets, thanks to a continual gradation which finally turns planets into comets. The eccentricity of Venus is 1/126th of the semi-axis of its elliptical orbit; in the case of Earth, the eccentricity is 1/58th; in the case of Jupiter, it is 1/20th, and in the case of Saturn 1/17th. Thus, the eccentricity evidently increases with the distances. It is true that Mercury and Mars are exceptions to this law, because their eccentricity is much greater than the measurement of their distance from the sun permits. But we will learn in what follows that the very same cause which gave some planets in their development a small mass also deprived them of the impulse required for a circular path, with the result that they were pulled into an eccentric movement, thus leaving them incomplete in two respects.

Is it not a probable consequence that the increase in the eccentricity of

[1] [*Translator's Note*: Kant's text reads "inverse relationship" (*Gegenhaltung*). This seems a careless error, since from the sentence it is clear that the relationship is a direct proportion rather than an inverse one].

the cosmic bodies located immediately beyond Saturn will be approximately proportional to the ones beneath, and that the planets are related to the family of comets through a less abrupt gap?[1] For it is certain that this very eccentricity is the basic difference between the comets and the planets. The comet's tail and its misty spheres are only consequences of eccentricity. Similarly, the particular cause, whatever it may be, which has given the celestial bodies their orbital paths, because of the greater distances not only was weaker in making the circular impulse equal to the downward force, thereby allowing eccentric movements, but also for this very reason was less capable of bringing the orbits of these spheres into the common plane on which the lower bodies move. Thus was produced the deviation of the comets to all regions.

According to this hypothesis, we would still perhaps hope for the discovery of new planets beyond Saturn, which would be more eccentric than Saturn and thus closer to the characteristics of comets. But for this very reason we would be able to see them only for a short time, that is, when they approach the sun. This factor, together with the smaller extent of their approach and the weakness of their light ,has hindered their discovery up to now and must make that difficult in future. If we wanted, we could call the last planet and the first comet the one whose eccentricity was so large that in its approach to the sun it intersected the orbit of the nearest planet to it, and perhaps Saturn's, as well.

[1] [*Translator's Note*: Kant's text has "decrease" (*Abnahme*) rather than "increase." Here again (as in the previous note) there seems to be a careless error in the wording describing the relationship of distance from the sun and eccentricity.]

Part Two

Concerning the first condition of Nature, the development of the celestial bodies, the causes of their movement and their systematic interrelationship both with the structure of planets in particular and also with the entire creation.

See plastic Nature working to this end,
The single atoms each to other tend,
Attract, attracted to, the next in place
Form'd and impell'd, its neighbour to embrace.
See Matter next, with various life endu'd
Press to one centre still, the gen'ral Good.
(Pope)[1]

Section One

Concerning the Origin of the Planetary World Structure in General and the Causes of Its Movements

So far as concerns the reciprocal relationships which the parts of the cosmic structure have among themselves and through which they reveal the cause which brought them about, observation of this arrangement displays two aspects, both of which are equally probable and worthy of consideration. On the one hand, if we think of the fact that six planets with ten companions describe orbits around the sun at their mid-point, that all move in one direction, in fact, the same direction as the axial rotational of the sun itself, which governs all their orbits though the power of attraction, that their orbits do not deviate far from a common plane, namely, the extrapolated equatorial plane of the sun, that among the furthest celestial bodies belonging to the solar system, in the region where the common cause of movement was, according to the hypothesis, not so strong as in the region close to the

[1] [*Translator's Note*: Alexander Pope, *Essay on Man*, Epistle III. Kant quotes the German version].

mid-point, deviations from the precision of these conditions occur, which are sufficiently related to the lack of impressed motion, if, I say, we consider all this interconnection, then we will come to believe that one cause, whatever it may be, had a pervasive influence throughout the entire extent of the system and that the conformity in the direction and position of the planetary orbits is a consequence of the coordinated agreement which they must have had with that material cause through which they were set in motion.

On the other hand, if we consider the space in which the planets of our system orbit, then we find it is completely empty and deprived of all material stuff which could have subjected these celestial bodies to a common set of influences and brought with it coordination among their movements.[1] This fact has been established with more perfect certainty and its probability is, where possible, greater than the probability of the previous claim. Swayed by this reason, Newton could not point to any material cause which, by its extension into the space of the planetary system, should maintain the commonality of movements. He maintained that the immediate hand of God had set up this order without the use of natural forces.

Considering the matter impartially, we see that the reasons here on both sides are equally strong. And they have an equal value as completely certain. However, it is also just as clear that there must be a concept which could and should unite these two apparently conflicting reasons and that in this concept we are to seek the true system. We wish briefly to announce that concept. In the present arrangement of space, in which the spheres of all the planetary worlds move around, there is no material cause present which could impress itself on or direct their movements. This space is completely empty, or at least as good as empty. Thus, in earlier times it must have been differently con-

[1] I am not investigating here whether this space can, strictly speaking, be called empty. For at this point it is sufficient to observe that all the material which one might come across in this space is much too incapable of exercising an influence with respect to the masses in motion which are the concern here.

stituted and full of matter sufficiently capable of conferring movement on all the celestial bodies located there and of bringing them into harmony with its motion and, as a consequence, into harmony with each other. When the power of attraction unified the above-mentioned space and collected all the scattered matter in particular clusters, the planets must have from then on freely and unchangingly continued the orbital movement, once impressed upon them, in an unresisting space. The reasons for the first-mentioned probability absolutely require this notion. And since there is no third possibility between the two, we look upon this idea with approval as an excellent one, an approval which raises it above the plausibility of a hypothesis. If we wished to be long winded, we could, with a series of successive inferences in the manner of a mathematical demonstration, with all the display which this involves and with an even greater plausibility than its introduction in physical subjects customarily elicits, finally arrive at the proposal itself, which I will set down, concerning the origin of the cosmic structure. But I would rather present my opinions in the form of a hypothesis and leave it to the reader's insight to put its value to the test, than render its validity suspect because of the appearance of a devious demonstration, something which might thus captivate the ignorant but lose the approval of those who understand.

I assume that all the matter making up the spheres belonging to our solar system, all the planets and comets, at the origin of all things was broken down into its elementary basic material and filled the entire space of the cosmic structure in which these developed bodies now move around. If we consider this state of nature in and of itself, without reference to a system, it seems to be merely the simplest which can follow upon nothingness. At that time nothing had yet developed. The incorporation of heavenly bodies located separate from one another, their distance from each other controlled according to the powers of attraction, and their shape, arising from the equilibrium of the collected materials, are a later condition. Nature, on the immediate edge of creation, was as raw and undeveloped as possible. Only in the funda-

mental properties of the elements which make up the chaos can we perceive the sign of that perfection which nature has from its origin, since its being is a consequence arising from the eternal idea of the Divine Understanding. The simplest, most universal characteristics, apparently designed without purpose, the material, which seems merely passive and in need of forms and structures, has in its simplest condition a tendency to build itself up by a natural development to a more perfect arrangement. The difference in the types of elements by itself was the most important factor contributing to the movement of nature and to the development of chaos, so that the tranquillity which would have ruled in a state of universal equality among the scattered elements would be lifted, and the chaos begin to develop itself at points where the particles have a stronger power of attraction. The types of this basic material are undoubtedly infinitely different, to match the immensity which nature displays in every respect. Given the equal distribution in planetary space, the materials with the greatest specific density and power of attraction, which in and of themselves take up less room and are also rarer, therefore become more scattered than the lighter varieties of material. Elements with a specific heaviness one thousand times greater are a thousand, perhaps a million, times more scattered than those which are lighter in this proportion. And since these differences must be imagined as infinite as possible, then, just as there can be one sort of physical component which exceeds another in its measured density, as a sphere drawn with the radius of the planetary system exceeds another sphere with the diameter of the thousandth part of a line, so the heavier type of scattered elements are separated from each other by a much greater distance than the lighter kinds.

The universal tranquillity in space replete in this way lasts only for an instant. The elements have essential forces which set each other in motion and are, indeed, themselves an origin of life. The material is under an immediate impulse to develop. The denser type of scattered materials, thanks to the power of attraction, collect from a spherical area around them all the material with a lesser specific weight. But

they themselves, together with the material which they have united with them, converge in the points where the small pieces of an even denser type are located, and these again to even denser points, and so on. When we consider this idea of a self-developing nature throughout the entire extent of chaos, we will easily see that all the consequences of this process will finally consist of the assembling of different clusters, which, after the completion of their development, would be calm and eternally motionless because of the equality in the force of attraction.

But nature has still other forces in store, which manifest themselves especially when the material is dispersed in fine particles, so that these particles repel each other and by their conflict with the power of attraction induce that movement, which is, as it were, an enduring life of nature. Because of this force of repulsion, which reveals itself in the elastic nature of fumes, in the diffusion from strong-smelling bodies, and the spreading of all gaseous materials and which is an uncontested phenomenon of nature, the elements sinking towards their points of attraction will shift each other sideways from their vertical movement, and the straight linear descent will end up in orbital movements which surround the mid-point towards which they were sinking at the centre. In order clearly to grasp the development of the cosmic structure, we want to limit our observation of the infinite essence of nature to a particular system, like the one to which our sun belongs. Once we have explored the development of this system, then we will be able to proceed in a similar way to the origin of the higher world structures and bring together into one theory the infinite nature of the entire creation.

Thus, if a point is found in a very large space where the power of attraction of the elements located there exerts a stronger influence than at any other points around it, then the basic material stuff of elementary particles spread out in all the surrounding area will sink toward this point. The first effect of this general sinking is the development of a body at this mid-point of the attraction which, so to speak, proceeds to grow from an infinitely small seed in rapid stages. But as this mass

increases, it will, in exactly the same proportion, with its more powerful force move the surrounding particles to unite with it. When the mass of this central body has grown so extensive that the velocity with which it draws the small particles to itself from great distances is diverted sideways by the weak level of the force of repulsion with which these particles interfere with one another, it produces lateral movements, which, thanks to the centrifugal force *[Centerfliehkraft]*, are such that they can move in a circle around the central body. Thus, large vortexes of small particles develop, each of which, because of the combination of the force of attraction and the force leading to a sideways rotation describes its own curving path. These sorts of circles all intersect each other, something which their large scattering in this space leaves room for. Meanwhile, these movements, in various ways in conflict with each other, strive naturally to bring one another into equilibrium, that is, into a single state where the movement of one hinders the movement of another as little as possible. This occurs, first, because the particles restrict the movement of other particles for as long as it takes until they all are moving forward in one direction, and second, because the particles restrict their vertical movement, thanks to which they approach the centre of the attraction, until the time when they are all moving horizontally, that is, in circles running parallel around the sun at their mid-point, no longer intersecting with one another, and, thanks to the equilibrium between the centrifugal force *[Schwungskraft]* and the force drawing them downwards, maintaining constant free circular orbits at the heights where they are suspended, so that finally only those particles remain suspended in the volume of space which have attained through their fall a velocity and through the resistance of other particles a direction by means of which they can continue a free circular movement. In this condition, where all the particles run around the central body in one direction and in circles arranged in parallel, namely, in free circular movements by means of the required centrifugal force, the conflict and the collision of the elements disappear, and everything is in the condition of the smallest reciprocal interaction. This result always occurs naturally with mate-

rials subject to conflicting movements. It is thus clear that from the scattered mass of particles a large number must, on account of the resistance through which they seek to bring each other to this state, succeed in attaining such an exact arrangement, although a much greater number do not reach this condition and serve only to increase the cluster of the central body, into which they sink, since they cannot hold their position freely at the height where they are suspended, but intersect the circles of the lower particles and eventually, because of the resistance, lose all their movement. This body at the middle point of the force of attraction, which, on account of the large amount of its assembled material, has accordingly become the main piece of the planetary structure, is the sun, although at this time it does not yet immediately have that flaming glow, which breaks out on its surface when its development is fully complete.

We must still note that while all the elements of self-developing nature, as demonstrated, thus move in one direction around the sun as the mid-point, in the case of such orbits which are set up in a single direction and which occur, so to speak, around a common axis, the rotation of fine material cannot remain in this way, because, according to the laws of central motion, all orbital movements must intersect the mid-point of the force of attraction with the plane of their rotation. Among all these orbits moving in one direction around a common axis, however, there is only one which intersects the mid-point of the sun. Therefore, all the material from both sides of this imagined axis moves quickly to that circle which goes directly through the axis of rotation right at the central point of the common downward movement. This circle is the plane which establishes a relationship for all the elements hovering around; as much as possible they accumulate around it and, by contrast, leave the regions far away from this plane empty. For those elements which cannot approach so closely to this plane towards which everything is drawn will not be able to maintain themselves indefinitely in those places where they are suspended, but, as they collide with the elements floating around, will bring about their own final fall

toward the sun.

Thus, if we consider this fundamental material of the planets hovering around in a state where it develops itself through the power of attraction and the mechanical consequence of the general law of repulsion, then we see a region which is contained between two planes standing not far from each other. In the middle of these two is located the common interconnecting plane, extending from the mid-point of the sun out to an unknown distance. All the particles we can think of carry out mathematically precise circular movements in free orbits on this common plane, each proportional to the extent of its distance and to the force of attraction which governs there. Because in such an arrangement they interfere with each other as little as possible, they would remain in this form for ever, if the force of attraction of these particles of basic matter did not then start to exercise its effect and in this way to cause new developments, the seeds of planets which are to arise. For since the elements moving around the sun in parallel circles and positioned where the distance from the sun is not very different are almost calm relative to each other, because of the equality in the parallel movements, then the force of attraction of elements located there with an excessive specific attraction initiates at once a significant effect, collecting the nearest particles to start the development of a body. In proportion to the growth of its cluster, the power of attraction of this body expands, and elements from a wide area move to combine with it.[1]

In this system, the development of the planets has this advantage over any other theoretical possibility: the cause of the masses provides

[1]The start of the self-developing planets is not to be looked for only in the Newtonian power of attraction. In the case of a small particle of such exceptional fineness, this force would be just too slow and weak. We would rather say that in this space the first development happens through the collision of some elements which unite through the normal laws of combination, until those clusters which develop out of the process gradually grow sufficiently large that the Newtonian power of attraction in them becomes capable of constantly increasing the size of the cluster through its effect at a distance.

simultaneously the cause of the motions and the position of the orbits. Indeed, even the deviations from the greatest precision in this arrangement, as well as the harmonies themselves, are illuminated in an instant. The planets are developed out of particles, which, at the heights where they are suspended, have precise movements in circular orbits. Thus, the masses formed by their combination will continue exactly the same movements at precisely the same level and in exactly the same direction. This is sufficient to understand why the movement of the planets is approximately circular and why their orbits are on a single plane. Moreover, they would be exactly circular if the distance from which they gather the elements for their development were very small and thus if the difference in their movements were very insignificant.[1] But because the development of a thick planetary cluster involves a wider surrounding area, throughout which the fine basic stuff is scattered so much in celestial space, the difference in the distances of these elements from the sun and thus also the difference in their velocities are no longer insignificant. As a result, given this difference in the movements, it would be necessary, in order to maintain on the planet an equilibrium between the central forces and the circular velocity, for the particles which collide with the planet from different distances and with different motions to offset each other's aberrations exactly. Although this, in fact, occurs fairly accurately, nonetheless, this compensation falls somewhat short of perfection and brings the deviations from circular movement and eccentricity with it.[2]

[2]This measured circular movement is essentially relevant only to the planets near the sun. For where great distances are concerned, where only the furthest planets or even the comets have developed, it is easy to assume that because the sinking movement of the basic material there is much weaker and the spatial expanse where they are scattered is also larger, the elements in and of themselves already deviate from circular movement and thus must be the cause of the bodies which develop from them.

[1]For the particles from the regions near the sun, which have a larger orbital velocity than is required for circular movement in the place where they collect together on the planet offset the deficiency in velocity of the particles from a longer distance away from the sun, which are incorporated into the very same body, so as to run in a circular orbit at the distance of the planet from the sun.

It is just as easy to shed light on the fact that although the orbits of all planets should properly be in one plane, nevertheless in this part we also come across a small deviation, because, as already discussed, the elementary particles which find themselves as close as possible to the general plane of their movements nevertheless take up some space on either side of it. It would be only too fortunate a coincidence if all the planets were to begin to develop exactly in the middle between these two sides on the plane connecting them, something which would already cause some inclination of their orbits towards each other, although the impulse of the particles from both sides would restrict this deviation as much as possible, allowing it only within narrow limits. Thus, we must not be surprised about the fact that here, too, we rarely come across the most precise accuracy in the arrangements, as is the case with all things in nature, because generally the multiplicity of circumstances involved in every natural condition does not permit an exact regularity.

Part Two
Section Two

Concerning the Different Densities of the Planets and the Relationship of Their Masses

We have shown that the particles of the elementary basic material, distributed equally by themselves in cosmic space, through their sinking downward towards the sun remain suspended in the places where the velocity which they attained in their descent reaches a precise equilibrium in relation to the force of attraction and that their direction would be altered so as to be perpendicular to the radius of the circle, as should be the case with circular movements. However, if we now think of the particles of different specific density at the same distance from the sun, then the ones with a greater specific heaviness drive more deeply through the resistance of the other particles toward the sun and will not be diverted from their path as soon as the lighter ones. Thus, their movement will form a circular orbit only at a closer distance to the sun. On the other hand, the elements of the lighter type are diverted from a straight vertical fall earlier and take on circular movements before they are driven so deep toward the centre. Thus, they remain suspended at greater distances away. Moreover, they are not able to drive so deeply downward through the space filled with the elements, without the resistance of these elements decreasing their motion, and they will not be able to attain the high level of velocity required for a circular movement closer to the mid-point. Hence, according to the required equilibrium in the movements, the specifically lighter particles will orbit at distances further from the sun; the heavier ones occur, however, at closer distances. The planets which are built out of these elements will therefore be of a denser variety when they are nearer the sun than when they are formed from the combination of these atoms further away from the sun.

Thus, there is a sort of statistical law which establishes for the material of cosmic space an inverse relationship between its distance from the

centre and its density. Nonetheless, it is just easy to grasp that it is not essential that each distance contain only particles of the same specific density. Of the particles of a certain specific type, some remain hovering at greater distances from the sun and attain the permanent circular motion appropriate to their fall at a greater distance. These have moved down toward the sun from further away. On the other hand, those whose original location in the universal distribution of the materials in Chaos was nearer the sun, regardless of the fact that their density is no greater than the former group, will attain a circular orbit closer to the sun. Since the locations of the materials in relation to the mid-point of their descent is determined not only by the specific heaviness of the material but also by its original place in the first calm state of nature, it is therefore easy to see that very different types of material will combine at every distance from the sun, so as to remain suspended there and that, nevertheless, generally we will find the denser material more frequently closer to the mid-point than further away and thus that, notwithstanding the fact that the planets will be a mixture of very different materials, nonetheless, in general, their masses must be denser in proportion to their closeness to the sun and less dense when their distances away are greater.

In the matter of this law governing planetary densities, our system manifests an advantageous comprehensiveness in comparison with all those ideas which people have come up with or even could come up with about its cause. Newton, who established the density of some planets by calculation, thought that the cause of this relationship set according to the distance was to be found in the appropriateness of God's choice and in the fundamental motives of His final purpose, since the planets closer to the sun must endure more solar heat and those further away are to manage with a lower level of heat, something which would not seem to be possible, unless the planets near the sun were composed of a denser kind of material and those further away of a lighter material. But to perceive the inadequacy of such an explanation does not really require much reflection. A planet, for example,

our Earth, is composed of types of material very different from each other. Of these, it was necessary only that the lighter varieties, which will be more deeply penetrated and affected by the same solar working and whose composition has a relationship to the heat through which the sun's rays work, be spread out on the planet's outer surface. But the fact that the mixture of the remaining material in the total cluster must have this relationship sheds light on nothing at all, because the sun has no effect on the inside of the planets. Newton was afraid that if the Earth had been in a lower position in the proximity of Mercury, then in the sun's rays it would probably have to burn up like a comet, and the Earth's materials would have insufficient protection against fire not to become scattered by this heat. But, by contrast, it is the sun's own material stuff, which is four times lighter than the material making up the Earth, which would have to be destroyed by this blazing heat. Or why is the Moon twice as dense as the Earth, yet still suspended at the very same distance away from the sun as the Earth? Thus, we cannot attribute the proportional densities to the relationship with the sun's heat, without entangling ourselves in the greatest contradictions. Instead we recognize that a cause which allocates the locations of the planets according to the density of their clusters must have had a relationship to the inner material and not to the material on the surface. This cause would have to determine this relationship with the density only according to the total composition, still permitting a differentiation in the materials in one and the same celestial body, without regard to the consequences which it established. Whether some statistical law other than the one presented in our theory can achieve this satisfactorily I leave to the insight of the reader to judge.

The relationship of the planetary densities brings with it one more circumstance which corroborates the validity of our theory by completely endorsing the previously proposed explanation. The celestial body standing at the mid-point of other spheres orbiting around it is commonly of a lighter sort than the bodies orbiting most closely round it. The Earth with respect to the Moon and the Sun with respect to the

Earth manifest such a relationship vis-à-vis their densities. According to the proposal we have laid out, such a relationship is necessary. For the lower planets were built up mainly from the excess elementary material which, thanks to the advantage of its density, could have driven with the required degree of velocity right to an area close by the mid-point. By contrast, the body at the very mid-point was put together out of the material of all varieties present, without distinction, which did not attain the velocity required by the law. Since among these, the lighter materials make up the greatest portion, it is easy to see that, because the celestial body orbiting closest to the mid-point or the ones nearest to it has within it, as it were, a selection of the denser forms of material but the central body has a mixture of all types, without differentiation, then the former will be a substance of a denser sort than the latter. In fact, the moon has twice the density of the Earth, and the Earth is four times denser than the sun, which, according to all assumptions, will be exceeded by the planets even closer to the sun, Venus and Mercury, with an even higher degree of density.

We now turn our attention to the relationship which, according to our theory, the masses of the celestial bodies should have in comparison to their distances from the sun, in order to test the results of our system against Newton's infallible calculations. It does not require many words to make people understand that the central body must always be the major part of its system and thus that the sun must be preponderantly greater than the planets collectively, just as the same point will hold for Jupiter and Saturn in relation to their nearby planets. The central body is developed from the downward sinking from the entire extent of the sphere of its power of attraction of all particles incapable of attaining the most precisely established circular movement and a close relationship to the common plane. The number of these must undoubtedly be extraordinarily greater than the number of those which attain orbital movement. To apply this observation in particular to the sun: if we wish to estimate the spatial extent in which particles with a circular

orbit which have served as basic material for the planets have deviated furthest from the common plane, then we can assume that it is, as an approximation, somewhat larger than the width of the greatest deviation of the planetary orbits from each other. Now, while they deviate from the common plane on both sides, their greatest angular difference with respect to each other is hardly 7.5 degrees. Thus, we can picture all the material out of which the planets were developed as having been distributed in that space which we imagine between two planes extending out from the mid-point of the sun and enclosing an angle of 7.5 degrees. However, a zone 7.5 degrees wide extending in the direction of the largest circle is a bit more than the seventeenth part of the spherical surface. Thus, the physical space between the two planes, which cut out a part of planetary space in the width of the above mentioned angle, is somewhat more than a 17th part of the physical contents of the entire sphere. Hence, according to this hypothesis, all material used for planetary development would comprise approximately the seventeenth part of the material which the sun assembled for its composition on both sides out as far as the furthermost planet is located. But this cluster of the central body has a preponderance over the combined content of all the planets which is not 17 to 1 but 650 to 1, as Newton's calculations have established. However, it is easy to see that in the higher regions beyond Saturn, where planetary development either ceases or is rare, where only a few comet bodies have arisen, and especially where the movements of the basic material, because in that location it is not rapid enough to attain the equilibrium with the centripetal force as required by law, as happens in the regions close to the centre, ended up in an almost universal sinking toward the mid-point and increased the size of the sun with all the material from such a vast expanse of space, it is easy, I say, to see that for these reasons the sun would have to acquire such a preponderantly large mass.

However, in order to compare the planets with each other with respect to their masses, we first observe that, in accordance with the method

of development I have indicated, the quantity of material which combines in the composition of a planet depends particularly on the extent of its distance from the sun, for the following reasons: (1) Because of its power of attraction, the sun limits the sphere of the planet's power of attraction; however, in the same circumstances, it does not restrict the more distant planets so narrowly as the close ones. (2) The circle from which all the particles have come together to make a more distant planet will be described with a larger radius and thus contain more basic material than the smaller circles. (3) For the very reasons just mentioned, the width between the two planes of the greatest deviation at a constant angle is greater at a greater distance than at a small distance. On the other hand, this advantage for the more distant planets over the ones lower down will be limited by the fact that the particles nearer the sun will be of a denser type and, everything considered, will also be less scattered than at a greater distance away. But we can easily estimate that for the development of large masses the first advantage far exceeds the limitation just mentioned and that, in general, the planets which develop far distant from the sun would have to acquire larger masses than the ones close to the sun. This happens insofar as we imagine a planet's development with only the sun present. But if we admit the development of several planets at different distances, then one planet will restrict the extent of the power of attraction of another planet through the sphere of its own force of attraction. This brings about an exception to the previous principle. For the planet which is near another one of exception mass will lose a very great deal from the sphere of its development and thus will become unusually smaller than the relationship of its solar distance by itself requires. On the whole, the planets have a greater mass as they are further from the sun, just as Saturn and Jupiter, in general, the two main parts of our system, are thus the biggest because they are furthest from the sun. However, deviations from this analogy do occur. But in them the mark of their common development is always manifest: the principle which we maintain concerning the heavenly bodies, namely, that a planet of exceptional size takes away from the nearest ones on both sides the

mass appropriate to them, given their distance from the sun. For it attracts to itself a portion of the material which should go into the development of both of them. In fact, because of its location, Mars should be bigger than the Earth. But Mars has a diminished mass on account of the force of attraction from Jupiter, which is so large and close by. And although Saturn itself has an immediate advantage over Mars because of its distance from the sun, nevertheless Saturn has not been entirely free from suffering a considerable loss thanks to Jupiter's power of attraction. And it seems to me that Mercury owes its exceptionally small mass not only to the force of attraction of the powerful sun, which is so close to it, but also to the fact that Venus is a neighbouring planet. If we compare the presumed density of Venus with its size, Venus must be a planet of considerable mass.

Everything agrees as splendidly as we might wish in order to confirm the adequacy of a mechanical theory for the origin of the cosmic structure and the celestial bodies. Now, as we estimate the space in which the material stuff of the planets was distributed before their development, we wish to consider how diffuse the material was which filled this middle space at that time and how free or unrestricted the particles suspended all around were to establish their rule-governed motions in it. If the space holding in itself all the planetary material was contained in that part of the sphere of Saturn which was between two imaginary planes subtended at an angle of about 7 degrees to each other from the mid-point of the sun out into the full reaches of space (and which therefore comprised one seventeenth of the entire sphere which we can describe with a radius equal to the distance of Saturn), then in order to calculate the diffusion of the basic planetary material filling this space, we wish to set the distance of Saturn at 100,000 Earth diameters. Thus, the entire sphere of Saturn's orbit will exceed the volume of Earth's globe by a factor of 1000 billion.[1] If we take instead of the seventeenth part only the twentieth part of the space in which the elementary basic

[1] [*Translator's Note*: Jaki points out (p. 262) that Kant is referring to an English billion, that is, 10^{12}, rather than to a North American billion, 10^{9}].

stuff was suspended, this still must exceed the volume of Earth's sphere by a factor of 50 billion. Now, if, following Newton, we set the mass of all the planets along with their satellites at only 1/650 of the mass of the cluster of the sun, then the Earth, which is only 1/169282 of this mass, will be related to the collective mass of all the planetary material in the ratio of 1 to 276.5. And if we then made all this material the same specific density as the Earth, we would produce a body which would take up a space 276.5 times greater than the Earth.[1] Assuming that the density of the entire cluster of the Earth is not much greater than the density of the firm material which we encounter under Earth's outermost layer, as is required by the characteristics of the shape of the Earth, and assuming that this outer material is about 4 or 5 times denser than water and that water is 1000 time heavier than air, then, if all the planetary material were expanded to the density of air, it would take up a space almost 1,400,000 times larger than Earth's sphere. If we compare this space with the space in which, according to our theory, all planetary material was spread out, it is 30 million times smaller. Thus, the scattering of the planetary material in this space is much more thinly distributed than the particles of our atmosphere. In fact, the thin density of this scattered distribution, as inconceivable as it may appear, was nonetheless neither unnecessary nor unnatural. It had to be as thin as possible, in order to permit the suspended particles all freedom of movement, almost as in an empty space, and infinitely to reduce the resistance which they could have created for each other. They could, however, have assumed such a thinly distributed state on their own. We cannot doubt this point if we know a little about the diffusion which matter undergoes when it is transformed into vapour or when, to stay on the subject of the heavens, we consider the thinning out of the material in the tail of a comet, whose diameter, of an unheard of thickness, exceeds the diameter of the earth by a factor of

[2] [*Translator's Note*: Kant's original text states 277.5 times greater than the Earth, a figure which is different from the number he has just given and which, as Jaki observes, indicates Kant's carelessness in checking his manuscript.

well over a hundred, and yet it is so transparent that the small stars can be seen through it, something which our air, when it is illuminated by the sun at a height many thousand times smaller, does not allow.

I conclude this section by bringing out an analogy which in and of itself can raise the present theory of the mechanical development of the celestial bodies above the probability of a hypothesis to a formal certainty. If the sun is composed of particles of the same basic material from which the planets have developed and if the difference between them consists only in the fact that in the sun undifferentiated material of all sorts accumulated, while in the planets the density of their types was distributed according to the different distances, then if we consider the material of all the planets as a collective unity, from their complete intermixing the result would have to be a density almost equal to the density of the sun. Now, this necessary consequence of our system finds happy confirmation in the comparison which M. de Buffon, that justly celebrated philosopher, set out between the densities of the total aggregate of planetary material and the material of the sun.[1] He found a similarity between the two in the ratio of 640 to 650. When unbiased and necessary consequences of a theoretical conception encounter such happy confirmations in true natural relationships, can we really then believe that mere contingency has brought about this agreement between theory and observation?

[1] [*Translator's Note*: Georges Leclerc, Comte de Buffon (1707-1788), one of France's best known, greatest, and most influential natural scientists in the eighteenth century].

Part Two
Section Three

Concerning the Eccentricity of the Planetary Orbits and the Origin of Comets

We cannot make the comets a special class of celestial bodies entirely different from the family of planets. Here, as elsewhere, nature works by imperceptible stages and, while going through all the series of changes, links together distant qualities with ones close at hand, thanks to a chain of intermediate rungs. The eccentricity in the case of the planets is the result of a lack of that impetus by which nature strives to make the movement of planets precisely circular, something which, however, she can never perfectly attain because of the intervening influence of various causes. However, the deviation from circular motion is greater at the larger distances from the sun than close by.

This condition goes through a constant scale with all possible levels of eccentricity from the planets right up finally to the comets. True, this interconnection seems to be severed in the case of Saturn because of a large gap which completely separates the family of comets from the planets. But in the first part we have remarked that there may well be still other planets beyond Saturn which are more like comets because of a greater deviation from circularity in their orbital path and that it is only through a lack of observations (or also the difficulty involved in such observations) that this affinity was not long ago revealed as clearly to eye as to the understanding.

In the first section of this part we have already referred to a cause which can render eccentric the orbit of a cosmic body developing out of the basic material suspended all around, if we also assume that this body in all its locations has carefully balanced forces moving it directly in a circular motion. Because the planet collects materials from places at a considerable distance from each other, where the orbital velocities are different, the materials collectively reach the planet with different

degrees of inherent orbital velocity. These deviate from the velocity appropriate to the distance of the planet from the sun and thus induce an eccentricity for the planet insofar as these different impressions of the particles fail to offset each other's deviation completely.

If the eccentricity had no other cause, it would be moderate everywhere. Also it would be less significant with the small planets far from the sun than with the closer and larger planets, that is, if we assumed that previously the particles of the basic material really did have a precise circular movement. Now, these estimates do not agree with observation, since, as has already been mentioned, the eccentricity increases with the distance from the sun, and the small size of the masses appears instead to create an exception to an increase in eccentricity, as we see with Mars. Thus, we are forced to limit the hypothesis about the precise circular movement of the particulate basic materials, so that, while they very nearly attain the determined precision in the regions near the sun, they nevertheless admit wider deviations from that precision the further the elementary particles hovered from the sun. Such an adjustment of the basic principle of the free circular movement of the basic material is more naturally appropriate. For regardless of the spatial diffusion, which seems to leave them free to limit each other at the point of completely balanced equilibrium of the central forces, no less considerable are the causes which hinder the attainment of this natural goal. The further the dispersed parts of the original material are from the sun, the weaker the force which induces them to sink down. The resistance of the particles below, which should bend their fall sideways and force them to assume a direction perpendicular to the radius of the circle, is proportionally diminished as these particles sink down under it either to be incorporated into the sun or to assume an orbit in a region closer to the sun. The fact that this more distant material has a predominant specific lightness does not permit it to acquire the downward movement, which is the basis for everything, with the force necessary to move the resisting particles aside, and perhaps these distant particles still restrict each other in

order finally to attain this uniformity after a long time. Thus, among these distant particles small masses have already developed as the starting point of so many celestial bodies, which, because they are assembled from weakly moving material, possess only an eccentric movement with which they sink toward the sun and on the way are increasingly diverted from a perpendicular fall by taking on more quickly moving pieces. Finally, however, they remain comets if those spaces in which they developed have, through the sinking down toward the sun or through the assembling in particular clusters, become cleansed and empty. This is the reason why the eccentricity of the planets and those celestial bodies called comets increases with the distance from the sun. Comets have their name for the very reason that in this characteristic they far exceed the planets.[1] There are, it is true, two exceptions which violate the law concerning the increase in eccentricity with the increasing distance from the sun. We see them in the two smallest planets of our system, Mars and Mercury. But with the first the cause is presumably the vicinity of a planet as large as Jupiter, which through its power of attraction on its side of Mars deprives it of particles for its development and thus only allows Mars a special area in the direction of the sun in which to extend itself. This brings with it an excessive central force and eccentricity. So far as Mercury, the lowest but also the most eccentric of the planets, is concerned, it is easy to believe that, because the sun's axial rotation does not yet by a long way equal Mercury's velocity, not only does the resistance which the sun presents to the material in the space surrounding it deprive the nearest particles of their central movement but also this resistance could easily extend right out to Mercury, and its orbital velocity would on this account have been considerably diminished.

Eccentricity is the most notable characteristic differentiating the

[1] [*Translator's Note*: Jaki observes (p. 263) that Kant seems to overlook that the word comet comes from the Greek *kome*, meaning *hair*, a clear reference to the tail of the comet, its best-known distinguishing feature].

comets. Their atmosphere and tail, which expand through the heat of their close approach to the sun, are only consequences of the eccentricity, although they have always served in times of ignorance as uncommon images of horror, announcing to the common folk imaginary destinies. Astronomers, who pay more attention to the laws of motion than to the strangeness in the shape, notice a second characteristic distinguishing the family of comets from planets, namely, unlike planets, comets do not confine themselves to the zone of the zodiac, but establish their orbits in all celestial regions without restriction. This peculiarity has exactly the same cause as the eccentricity. The planets have confined their orbits to the narrow region of the zodiac because the elementary material in the vicinity of the sun acquires circular movements which in each revolution try to intersect the interrelated plane and do not allow a body, once developed, to deviate from this surface towards which all the material from both sides presses. Thus, basic material from the spaces far from the mid-point, which, weakly moved by the force of attraction, cannot attain free orbital movement for the very reason which produces eccentricity, is not capable of accumulating at this height on the plane interconnecting all planetary movement, so as to maintain the bodies developed there primarily on this track. Since it is not limited to a particular region, as is the case with the lower planets, the scattered basic material will instead develop on its own into celestial bodies equally easily on both sides, far from the interconnecting plane just as often as it will near to it. Hence, comets will be fully free to descend toward us from all regions. However, those which first developed in a place not far above the planetary orbits will manifest less deviation from the limitations of their paths as well as less eccentricity. With the increasing distances from the mid-point of the system, this lawless freedom of the comets in relation to their deviations increases and loses itself in the depths of the heavens in a total lack of orbital movement. This leaves the bodies developing in the outer regions free to fall toward the sun and establishes the last frontiers of the systematic arrangement.

In this outline of the comet's movements, I assume that, so far as their direction is concerned, for the most part they have one in common with the planets. It seems to me that in the case of the comets close by this is undoubtedly true. Also this similarity of form cannot get lost in the depths of the heavens before the point where the elementary basic stuff in the least energetic state of motion establishes the rotation which arises in all directions from the downward sinking, for, on account of the commonality of the movements lower down, the time required to align them in a common direction is, given the large distance, too long for them to be able to extend themselves far enough for the natural development in the lower region to occur. Hence, there will perhaps be comets which will establish their orbits in the opposite direction, namely, from east to west, although I might equally well almost persuade myself, for reasons which I am reluctant to cite here, that of the nineteen comets in which we have observed this peculiarity, in some of them an optical illusion may have given rise to this observation.

I must still note something about the masses of the comets and the density of their material. For the reasons mentioned in the previous section, according to the rules, the development of these celestial bodies in the upper regions should proceed always according to the principle that, as the distance increases, their masses get larger. And we can believe that a few comets are larger than Saturn and Jupiter. But it is just not credible that this quantity of the masses always increases in this manner. The scattering of the basic materials and the specific lightness of their particles make the development in the furthest region of cosmic space slow. The uncertain diffusion of this material in the entire infinite expanse of this space without any tendency to accumulate in the direction of a certain plane permits several smaller developments in place of a single considerable one. And the lack of central force draws the largest portion of the particles down to the sun, without their having assembled themselves into masses.

The specific density of the stuff out of which the comets develop is

more worthy of attention than the size of their masses. Presumably, since they develop in the uppermost reaches of the cosmic structure, the particles which compose them are of the lightest sort. We cannot doubt that this is the major cause of the vapour sphere and the tail, which distinguish them from the other celestial bodies. We cannot attribute this dispersal of the comet's material in a vapour mainly to the effect of solar heat. A few comets in their approach to the sun hardly reach the depth of the Earth's orbit. Many remain between the orbits of Earth and Venus and then turn back. If such a moderate level of heat dissolves and thins out the material on the surface of these bodies to this extent, then they would have to consist of the lightest material which undergoes, under the influence of heat, more thinning out than any material whatsoever in all nature.

Moreover, it is not possible to attribute the vapours which arise so frequently from the comet to the heat which its body has left over from the earlier approaches to the sun. For indeed we may suppose that at the time of its development a comet has gone through quite a few orbits with greater eccentricity and that these were reduced only gradually. But the other planets, for which we could assume the very same, do not manifest this phenomenon. However, they would inherently display it, if the varieties of the lightest material included in the composition of the planets were present just as much as they are with the comets.

The Earth has something in itself which we can compare with the dispersal of the comet's vapours and their tails.[1] The finest particles which the effect of the sun draws from Earth's outer surface pile up around one of the poles, when the sun directs the semi-circle of its orbit into the opposite hemisphere. The finest and most energetic particles, which arise in the hot equatorial regions, having attained a certain atmospheric altitude, are compelled by the effect of the sun's rays to move away to and accumulate in those regions which at that

[1]These are the Northern Lights.

period are directed away from the sun and buried in a long night. These particles compensate the inhabitants of the icy regions for the absence of the great light, which even at this distance sends them the effects of its heat. Just this same power of the sun's rays, which creates the Northern Lights, would bring out a vapour circle with a tail, if the finest and volatile particles on the Earth were encountered just as frequently on the Earth as on the comets.

Part Two
Section Four

Concerning the Origin of Moons and the Axial Rotation of the Planets

The attempt of a planet to develop from the range of basic materials is at the same time the cause of its axial rotation and produces the moons which are to orbit around it. What the sun with its planets is on a large scale a planet with a sphere of attraction extending far out is on a small scale, namely, the major part of a system whose pieces have been set in motion through the force of attraction of the central body. Since the developing planet activates for its process of growth the particles of the basic material from the total sphere of its power of attraction, it will produce from all these sinking motions, thanks to their reciprocally interacting effects, circular movements, and will, in fact, finally produce movements which settle upon a single common direction. Some of these motions will get moderated appropriately for free circular movement and in this limited area will be located close to a common plane. In this space, as with the main planets around the sun, the moons also will develop around the planets, when the extent of the power of attraction of such cosmic bodies offers favourable conditions for their production. Incidentally, what was said in connection with the origin of the solar system can be applied equally well to the system of Jupiter and of Saturn. The moons will have arranged their orbital circles in one direction almost in a single plane and this, in fact, for the same reasons as those in the large-scale analogy. But why do these satellites in their common orientation move far more in the direction in which the planets move than in any other? The moons' orbits are not produced through the circular movements of the planet. They acknowledge as cause only the power of attraction of the main planet, and, so far as this force is concerned, all directions are equally good. Mere contingency will select the direction out of all possible directions, according to which the sinking movement of the material changes into

circles. In fact, the circular path of the main planet does nothing at all to impress orbital motion around the planet upon the material out of which the moons are to develop. All the particles surrounding the planet move with it in the same motion around the sun and are thus, in relation to the planet, respectively at rest. The power of attraction of the planet achieves everything by itself. But since, as far as direction is concerned, this power is in and of itself indifferent to them all, the orbital movement which is to arise out of that requires only a small external stimulus to deflect it more to one side than to the others. This small degree of steering the orbital movement acquires from the forward movement of the elementary particles which run simultaneously around the sun but at a higher velocity and reach the sphere of the planet's power of attraction. For this requires the particles closer to the sun, which orbit at a faster momentum, to abandon the direction of their path when they are already at a considerable distance and to move up over the planet in an extended curve. Because these particles have a higher degree of velocity than the planet itself has, when they are drawn down by the planet's power of attraction, they produce in their perpendicular descent and also in the descent of the other particles a curved deviation from west to east. It requires only this slight steering to see to it that the orbital movement in which the descent, initiated by the power of attraction, finishes up takes on this direction rather than any other. For this reason, all the moons will coordinate their direction with the direction of the orbit of the main planets. However, the plane of their path also cannot deviate far from the plane of the planetary orbits, because the material out of which they develop, for the very reason which we have referred to concerning orbital direction in general, is also guided according to this most precise arrangement, namely, coordinating itself with the plane of the principal orbits.

From all this we clearly see what the circumstances are in which a planet may be able to acquire satellites. The power of attraction of the planet must be large and, as a result, the extent of the sphere in which

this power is effective must extend far out, so that not only are the particles which move to the planet through a long descent, without regard to the effects of resistance, at length able to attain the velocity for a free orbital momentum, but also there must be present sufficient material for the development of moons in this region, something which cannot occur with a slight power of attraction. Therefore, only planets with large masses and at a great distance from the sun are endowed with satellites. Jupiter and Saturn, the two largest and also most distant of the planets have the most moons. The Earth, much smaller than those planets, is assigned only one. And Mars, which on account of its distance might have merited some share of this advantage, goes without because its mass is so small.

We observe with pleasure how the same force of attraction of the planet, which brought the material for building moons and at the same time determined its movement, extends to the very body of the planet itself, in giving it an axial rotation, by means of exactly the same action through which the planet develops, in the common direction from west to east. The particles of the descending basic material, which, as mentioned, acquire a common rotational movement from west to east, fall for the most part onto the surface of the planet and are mixed into its cluster, because they do not have the appropriate velocity to maintain themselves in freely suspended orbital motion. Since they now come into the composition of the planet, they must, as parts of it, continue just the same rotational movement and in exactly the same direction which they had before they were united with the planet. And because, in general, we can see from the foregoing that the number of particles which the lack of necessary movement drives down to the central body must be very much greater than the number of those others capable of attaining the appropriate degree of velocity, then we can easily grasp why this central body will in its axial rotation be a long way from possessing the velocity to achieve an equilibrium between the gravity on its surface and the centrifugal force. Nevertheless, the axial rotation of planets with a larger mass and at a considerable distance

from the sun will be much faster than with the small ones close to the sun. In fact, Jupiter has the fastest axial rotation that we are aware of, and I do not know what system would enable us to reconcile this fact with a body whose cluster exceeds all the others, unless we could see that its movements are themselves the effect of that power of attraction which this celestial body exerts in accordance with the mass of this very cluster. If the axial rotation were an effect of an external cause, then Mars would have to have a more rapid axial rotation than Jupiter, for the very same power of movement affects a smaller body more than a larger one. We would quite correctly be surprised at this, since all the orbital movements diminish with distance from the midpoint, but the speeds of the rotations increase with the distance. With Jupiter the rotational movement could be even three and a half times faster than its annual motion around the sun.

Thus, we must recognize in the daily rotations of the planets the very same cause which is, in general, the common origin of movement in nature, namely, the force of attraction. This style of explanation, therefore, will successfully prove its truth through the natural quality of its basic concept and through the natural consequences of that.

But if the development of a body itself produces the axial rotation, then it is reasonable that all the spheres of the cosmic structure must possess it. Why, then, does the moon not have it? It does seem, although the idea is false, to have reached a kind of rotation, because it always has the same side turned towards the earth, but this comes far more from a kind of overbalancing of one hemisphere than from a true rotating momentum. Must the moon really have rotated on its axis at an earlier period more quickly and through some unknown cause or other have gradually reduced this movement until it was brought to this slight and measured remainder? We need to resolve this question only in connection with one of the planets. Then the application to all planets will follow of itself. I am postponing this solution to another occasion, since it has a necessary connection to the assignment which the Royal Academy of Sciences in Berlin has established for the prize

in the year 1754.

The theory which is to explain the cause of the axial rotations must also be able to produce from exactly the same causes the orientation of the planetary axes in relation to their orbital plane. We have reason to be surprised why the equator of the daily rotation is not in the same plane as the one in which the moons orbit as they move around the same planets. For this same movement which directs the orbit of a satellite, through its extension to the body of the planet, produced its axial rotation, and it should give it exactly the same determinate direction and orientation. Celestial bodies which have no planets orbiting closely around them, nevertheless, because of exactly the same movement of the particles which served them as material and the same law which limited each one to the plane of its periodic orbit, settle into an axial rotation which, for the same reasons, had to coincide with the direction of their orbital plane. As a result of this cause, it is reasonable that the axes of all celestial bodies would have had to be oriented perpendicular to the common interconnecting plane of the planetary system, which does not deviate far from the ecliptic.[1] But the axes are perpendicular only with the two most important parts of this cosmic structure, with Jupiter and the sun. With the others whose rotation we know, the axes are at an angle in relation to the plane of their orbits, Saturn more than the others, but the Earth more than Mars, whose axis is also almost perpendicular to the ecliptic. The equator of Saturn (insofar as we are able to ascertain it from the direction of its ring) is inclined at an angle of 31 degrees to the plane of its orbit. However, the Earth is inclined towards its plane at an angle of only 23.5 degrees. We can perhaps attribute the cause of this deviation to the inequality in the movements of the material which came together to build the planet. The preponderant movement of the particles was

[1] [*Translator's Note*: The ecliptic is the large circle described by the sun's apparent movement during the year. As Jaki notes (p. 266), the common plane of reference, which is perpendicular to the sun's axial rotation, makes an angle of about 7 degrees with the ecliptic].

around the planet's mid-point in the direction of the plane of its orbit. And there the interconnecting plane was in place around which the elementary particles accumulated to make the movement there circular, where possible, and to pile up material for the development of the satellites, which for this reason never deviate far from the plane of the planet's orbit. If the planet developed for the most part only out of these particles, then its axial rotation in its first growth would be as little offset from that plane as the satellites which orbit around it. But the planet develops, as the theory has established, more from particles which sank down on both sides and whose number or velocity appears not to have been totally balanced, so that one hemisphere would be able to acquire a small excess of movement with respect to the other and thus cause some displacement of the axis.

Setting these reasons aside, I consider this explanation only as a supposition which I do not have the confidence to establish. My true view is as follows. The axial rotation of the planets in the original state of their first development was quite accurately aligned with the plane of their annual rotation, and causes were present which pushed these axes out of their first position. A celestial body which is moving out of its first volatile state into a firm condition undergoes, when it develops completely in this way, a large change in the regularity of its outer surface, which becomes firm and hardens while the deeper material has not yet sufficiently sunk down according to the measure of its specific gravity. The lighter types of material intermixed in its cluster, after separating out from the rest, finally move under the outermost crust, which has become firm, and create large holes. The largest and widest of these holes, for reasons which would take too long to discuss here, occur under or near the equator. The above-mentioned crust finally sinks down into these depressions and produces various inequalities, mountains and rifts. Now, since in something like this manner, as must apparently have happened with the Earth, the Moon, and Venus, the outer crust became uneven, the planet could not achieve an equilibrium any more on all sides in the circle of its axial rotation. A few

prominent sections of considerable mass, which had nothing equal to them on the opposite side, which could act as an effective counterweight to the momentum, must have then shifted the axial rotation and sought to place it in a position around which the material was equally poised. Thus, exactly the same cause as in the complete development of the celestial body changes its outer crust from a horizontal state into broken up inequalities. This general cause has made it necessary to change somewhat the original orientation of the planet's axis. We perceive this to be the case with all the celestial bodies which the telescope can reveal sufficiently clearly. But this change has its limits, so that the deviation is not excessive. The inequalities, as already mentioned, show up more near the equator of an orbiting celestial body than at a distance from it. In the region of the poles they disappear almost entirely. The discussion of the causes of this I am reserving for another time. Thus, the most prominent masses rising above the even surface will be found near the equatorial circle. Since the masses strive to bring themselves close to this circle because of the major influence of their momentum, they will be able to raise the axis of the celestial body at the most only a few degrees out of its perpendicular orientation with its orbital plane. As a consequence, a celestial body which has not yet fully developed will still have this orientation of its axis perpendicular to its orbital path. The angle will perhaps be altered only with the long succession of centuries. Jupiter appears to be still in this condition. The preponderance of its mass and size and the lightness of its material meant that it had to assume a firm and calm condition a few centuries later than other celestial bodies. Perhaps the inside of its cluster is still in motion, as the parts composing it sink toward the centre according to the determination of their heaviness, and through the separation of the thinner varieties from the heavy ones it is developing a firm state. According to such an account, Jupiter cannot yet appear calm on its outer surface. Collapses and ruin govern there. The telescope itself has confirmed that for us. The shape of this planet is constantly changing, while the Moon, Venus, and the Earth remain unaltered. Indeed, we can also with justice estimate that the comple-

tion of the developmental period is several centuries later in the case of a celestial body which exceeds our Earth in size by a factor of more than twenty thousand and which has a smaller density by a factor of four. When its outer surface reaches a tranquil composition, then undoubtedly much larger inequalities, like the ones which cover the surface of the Earth, combined with the velocity of its rotational impulse, will in a relatively short period give its axial rotation the constant orientation which the equilibrium of its forces will require.

Saturn, which is three times smaller than Jupiter, because of its greater distance from the sun can perhaps have the advantage of a faster development than Jupiter. At least Saturn's much quicker axial rotation and the large ratio of its centrifugal force to the gravity on its outer surface (which is to be presented in the following section) see to it that the inequalities which have thus presumably developed there have very quickly given it a shift toward the side of the excess weight through a displacement of the axis. I freely concede that this part of my system concerning the position of the planetary axes is still incomplete and quite far from being subject to geometrical calculation. I preferred to reveal this candidly rather than through all sorts of devious but apparently competent reasons damage the rest of the theory and give it a weak part. The section which follows can provide confirmation of the credibility of the entire hypothesis. There we wish to explain the movements of the cosmic structure.

Part Two
Section Five

Concerning the Origin of Saturn's Ring and the Calculation of the Daily Rotation of the Planet from the Relationships to this Ring

Thanks to the systematic arrangement in the cosmic structure, its parts are linked together by a ladder of alterations in their characteristics, and we can assume that a planet located in the remotest region of the world will have approximately the same characteristics which the nearest comet would take on, if through a diminution of its eccentricity, it were raised into the family of planets. With this in mind, we wish to examine Saturn as if it had gone through several orbits with a greater eccentricity, in a manner similar to the motion of a comet, and had been gradually brought into a path more similar to a circle.[1] The heat which the planet incorporated in its approach to the sun raised the light material from its outer surface. As we know from previous sections, this material, in the case of the most distant celestial bodies, is excessively thinly distributed and with low levels of heat undergoes diffusion. Meanwhile, after the planet was brought in several orbits to the distance where it is now suspended, in such a moderate climate it gradually lost the heat it had absorbed, and the vapours, which still constantly spread around it from its outer layer, gradually stopped moving up into tails. New materials did not shift upward any longer with the same frequency to supplement the old ones. In short, the vapours already going around Saturn remained, for reasons which we will refer to presently, suspended in a permanent ring around the planet and kept the reminder of its previous comet-like nature, while Saturn's body exuded the heat and finally became a calm and cleansed planet. Now we wish to point out the secret which in this celestial body could have held the vapours which had come up from it in free sus-

[1]Or, what is more probable, with its comet-like nature, which still has its inherent eccentricity, before the lightest material of its outer layer has been completely scattered, the planet had an extended a comet-like atmosphere.

pension, indeed, which changed these vapours from an atmosphere spread out around the planet into the form of a ring standing completely apart from it everywhere. I assume that Saturn had an axial rotation. Nothing more than this is required to reveal the entire secret. No mechanism other than this single one produced for the planet the phenomenon mentioned above, as an immediate mechanical result. I am sufficiently confident to assert that in all of nature only a few things can be brought to such a comprehensible origin as this special feature of the heavens can be derived from the raw state of the planet's first development.

The vapours rising up from Saturn had their own inherent movement and established themselves freely at the altitude to which they rose. This motion they acquired as parts of the planet from its axial rotation. The particles which moved up from close to the equator of the planet must have had the fastest motions, and those further away right up to the poles that much slower motions, according to the higher latitude of the place from which they arose. The relationship to the specific heaviness determined the different heights to which the particles rose. But the only particles which could maintain their locations at their distance away in a constant free circular momentum were the ones set at those distances which demanded a central force similar to the velocity which these particles had made their own thanks to the axial rotation. The remaining particles, to the extent that the interaction with the others could not bring them this precise velocity, must either through their excess motion leave the planetary sphere or through their lack of motion necessarily sink back onto the planet. The particles scattered throughout the total extent of the vapour sphere, thanks to the very same central law, in the motion of their curved swing, would strive to intersect the extended equatorial plane of the planet from both sides. And in coming together on this plane from both hemispheres, they would stop each other and accumulate there. Since I assume that the above-mentioned vapours are the very ones which the planet in its cooling last sent back up, all the scattered vapour material

will collect close to this plane in an area not particularly wide and leave the space on both sides empty. In this new and changed orientation, however, the materials will nonetheless continue exactly the same movement which they maintained while suspended in free concentric circular orbits. In such a manner, the circle of vapour now alters its shape, which was a full sphere, into the form of an extended surface coinciding precisely with Saturn's equator. But this surface must also, for exactly the same mechanical reasons, finally assume the form of a ring, whose outer edge will be determined by the effect of the sun's rays, which, by means of their force, scatter and disperse those particles which have distanced themselves a certain way from the mid-point of the planet, as they do with comets, and in this way designate the outer limit of their circle of vapours. The inner edge of this emerging ring will be set by the relationship to the velocity of the planet under its equator. For that distance away from its mid-point where this velocity attains an equilibrium with the power of attraction for that location is the closest approach to the planet where the particles which have arisen from its body are able to describe circular orbits thanks to their own movement acquired from the planet's axial rotation. Because the particles closer than that require a higher velocity for such an orbit, which they cannot have because the movement even on the equator of the planet is not faster, they will maintain eccentric orbits which intersect each other, weaken each other's motions, and finally will all fall back down onto the planet from which they arose. Now, there we see an amazingly strange phenomenon, the sight of which since its discovery has always astonished astronomers and whose cause we could not ever entertain even a probable hope of discovering, come about in an easy mechanical way, free of all hypotheses. What happened to Saturn, as can easily be seen from this, would happen just as regularly to any comet with a sufficient axial rotation, if it were set at a constant height in which its body could gradually cool down. Nature, left to its own forces, is fertile in excellent results, even in chaos, and the development following from this produces such wonderful relationships and harmonies for a creature's

common needs that it even enables us to recognize with unanimous certainty in the eternal and unchanging laws of their fundamental characteristics that Great Being in whom they are all united, thanks to their common dependency in a collective harmony. Saturn derives important advantages from its ring. It lengthens its day and under so many moons illuminates its night to such an extent, that the absence of the sun is easily forgotten. But must we then, on that account, deny that the common development of material through mechanical laws, without the need for anything other than their universal regulations, could have produced relationships which create advantages for reasoning creatures? All beings have a common dependency on a single cause: the Divine Understanding. They can therefore produce no other consequences after them except those which bring with them an image of the perfection of exactly the same Divine Idea.

Now we wish to calculate the time of the axial rotation of this celestial body from the relationships of its ring, according to the hypothesis of its development mentioned above. Because all the movement of the ring's particles is a motion absorbed from the axial rotation of Saturn, on whose outer surface they were located, the fastest movement which these particles possess among themselves will be the same as the fastest rotation which occurs on Saturn's outer surface. In other words, the velocity at which the particles of the ring orbit on its inner edge is equal to the velocity of the planet at its equator. But we can easily find that when we look for it in the velocity of one of Saturn's satellites, for we assume that it is proportional to the square root of the distances from the mid-point of the planet. From the velocity we have discovered, the time of Saturn's axial rotation is immediately given: it is six hours, twenty-three minutes, and fifty-three seconds. This mathematical calculation of an unknown movement for a celestial body, which is perhaps the only prediction of its kind in the real theory of nature, awaits confirmation from the observations of future ages. The telescopes known up to this time do not enlarge Saturn sufficiently, so that we can discover the spots (which we can assume are on its outer

surface) in order to be able to perceive its axial rotation through their forward displacement. But the telescopes have perhaps not yet reached that perfection which we can hope from them and which the hard work and skill of the craftsmen seem to promise us. If we once succeed in providing visible confirmation of our conjectures, how certain the theory of Saturn would be and what an overwhelming credibility the entire system which is built upon the same principles would derive from that. The time of Saturn's daily rotation establishes the relationship of the centrifugal force away from the mid-point at its equator to the force of gravity on its outer layer. The former is to the latter as 20 is to 32. Thus, the force of gravity is only around 3/5 greater than the centrifugal force. Such a large proportion as this brings about necessarily a very observable difference in the diameters of this planet. And we could anticipate that this difference must have developed to such an extent that the observation of this planet, although it is only enlarged a little by the telescopes, would have to make it all too clearly visible. But in truth this does not happen, and the theory could thus suffer a disadvantageous blow. A thorough proof completely removes this difficulty. According to Huygens' hypothesis, which assumes that the gravitational force inside a planet is the same throughout, the difference in the diameters is proportional to the diameter at the equator in a ratio twice as small as the proportion of the centrifugal force to the gravitational force at the poles.[1] For example, in the case of the Earth, the force moving away from the mid-point at the equator is 1/289 of the gravitational force at the poles. Thus, in Huygens' hypothesis, the diameter of the equatorial plane is 1/578th greater than the earth's axis. The cause is as follows: the gravitational force, according to what has been assumed, inside the Earth's cluster in all regions close to the mid-point is as great as it is on the outer surface, but the centrifugal force diminishes as one moves close to the mid-point. Thus, the centrifugal

[1] [*Translator's Note*: the "difference in the diameters" Kant refers to is the difference between the diameter at the equator and the diameter at the poles. If the latter is smaller than the former, the planet will take on the appearance of a flattened sphere].

force is not always 1/289th of the gravitational force. For these reasons, the entire loss in weight of a liquid column on the plane of the equator amounts, not to 1/289th but to half of that, i.e., to 1/578th. On the other hand, according to Newton's hypothesis, the centrifugal force, which initiated the axial rotation, has the same relationship to the gravitational force at a specific location on the entire equatorial plane right to the mid-point, because the gravitational force inside the planet, assuming the planet has the same density throughout, decreases with the distance from the mid-point in the same proportion as the centrifugal force decreases, so that the latter is always 1/289th of the former. This creates a lightening of the liquid column at the equatorial plane and also a rise in it of 1/289th. This difference of the diameters in this theory is increased even more by the fact that the shortening of the axis involves bringing the parts closer to the mid-point, and with that an increase in the gravitational force; but the increase in length of the equatorial diameter involves moving parts further from the very same mid-point and thus lessening the gravitational force. For this reason, the flattening of the Newtonian spheroid increases to the point where the difference in the diameters increases from 1/289 to 1/230.

According to these reasons, the diameters of Saturn would have to be in an even larger ratio to each other than 20 to 32. They would have to reach a proportion almost equal to 1 to 2, a difference which is so large that the slightest attentiveness would not miss it, no matter how small Saturn might appear through the telescopes. But from this one can only conclude that the assumption of the uniform density, which seems to be quite correctly applied to the case of the Earth's body, in the case of Saturn deviates far too widely from the reality. This is already inherently probable in the case of a planet whose cluster consists, for the greatest part of its content, of the lightest materials and which leaves the heavier sorts of materials much freer to settle down toward the mid-point, according to their gravitational make up, than do those celestial bodies whose much denser stuff delays the settling down of the material and allows it to harden before this settling can occur.

When we also assume in the case of Saturn that the density of its material in the interior increases as one moves closer to the centre, then the gravitational force no longer declines in this ratio, but the growing density compensates for the deficiency in those parts which are set at heights above the point located in the planet and which contribute nothing by their power of attraction to the planet's gravitational power there.[1] When this preponderant density of the deepest material is very large, thanks to the laws of attraction, the density changes the gravitational force which in the interior declines toward the centre into something almost uniform and establishes the ratio of the diameters close to Huygens' proportion, which is always half the ratio between the centrifugal force and the gravitational force. Thus, since with respect to each other, these were as 2 to 3, then the difference in the diameters of Saturn will not be 1/3, but 1/6 of the equatorial diameter. Finally, this difference will still be concealed because Saturn, whose axis makes a constant angle of 31 degrees with its orbital plane, never orients the position of its axis perpendicular to its equator, as happens with Jupiter, something which diminishes the appearance of the previous difference by almost one third. Under such circumstances, and especially given Saturn's great distance away, we can easily believe that the flattened shape of its body will not be so readily visible as we would think. However, astronomy, whose progress depends particularly on the perfecting of the instruments, with their help will perhaps be in a position to discover such a remarkable characteristic, if I do not flatter myself excessively.

What I say about the shape of Saturn can, to some extent, serve as a general remark about the natural theory of the heavens. According to

[1]For, according to the Newtonian laws of attraction, a body located inside a sphere will be attracted only by that part of the ball which can be drawn in a sphere around it with a radius equal to the distance which that body stands from the centre. The concentric part located beyond this distance, because of the equilibrium of its forces of attraction, which cancel each other out, has no effect on this, not moving the part either towards or away from the centre.

an exact calculation, Jupiter has a ratio of the gravitational force to the centrifugal force at its equator of at least 9.25 to 1. If its cluster were of uniform density throughout, in accordance with Newton's theories, this planet should show a difference between its axis and the equatorial diameter even greater than 1/9. But Cassini found it to be only 1/16, Pound 1/12 and sometimes 1/14.[1] At least all these various observations, which in their difference confirm the difficulty of this measurement, agree in that they establish the difference as much smaller than it should be in Newton's system, or rather, according to his hypothesis of uniform density. And if we therefore change the assumption about the uniform density, which permits such a wide discrepancy between theory and observation, into the much more probably assumption that the density of the planetary cluster is arranged so that it increases towards the centre of the planet, then we will validate the observations not only of Jupiter but also of Saturn, a planet much harder to measure, so as to be able to understand clearly the cause of the smaller flattening of its spherical body.

From the development of Saturn's ring, we have taken the opportunity to venture on the bold step of determining through calculation the time of its axial rotation, something which the telescopes are not capable of discovering. Let us add to this attempt at a physical prediction yet another concerning the very same planet, a claim whose validity we can expect to be witnessed by more perfect instruments of future ages.

According to our assumption that Saturn's ring is an accumulation of particles which, after they arose as vapours from the outer surface of this celestial body, maintain themselves, thanks to the impetus they receive and continue from the planet's axial rotation at the altitude of their distance away in free circular movement, these particles do not have the same periodic orbital times at all their distances from the mid-

[1] [*Translator's Note*: Jean Dominique Cassini (1625-1712), a prominent French astronomer; James Pound, an English cleric and member of the Royal Society].

point. The times are, by contrast, determined according to the square root of the cube of their distance from the planet, if the particles are to keep themselves suspended according to the laws of the central forces. Now, the time in which, according to this hypothesis, the particles of the inner edge complete their orbit is about ten hours, and the orbital time for the particles on the outer edge is, according to the appropriate calculations, fifteen hours. Thus, when the lowest parts of the ring have completed three orbits, the furthest parts have completed only two. Even if we estimate that the interference which the particles create for each other in the plane of the ring through their great dispersal is as insignificant as we like, it is nevertheless probable that the slower movement of the particles further away in each of their orbits gradually delays and retards the more quickly moving lower parts. On the other hand, the lower parts would have to impart to the upper parts some of their motion, so as to create a more rapid rotation. If this reciprocal interaction were not finally interrupted, this process would last until such a time as all the particles in the ring, both the low ones and those further away, were brought to rotate in the same time, in which state they would be at rest relative to each other and would have no effect in displacing one another. But such a condition, if the movement of the ring ended up like this, would destroy it completely. For if we take the middle of the plane of the ring and establish that the movement there remain what it was before and what it must be to be capable of achieving free orbital movement, the lower particles would not hold themselves suspended at their altitude, because they would be held back considerably, but would intersect each other in oblique and eccentric motions. The more distant particles, however, through the impulse of a motion greater than it should be for the central force at their distance from the planet, would move away from Saturn further than the outer boundary of the ring set by the effect of the sun and would, of necessity, be scattered behind the planet by the sun's effect and carried away.

But we need not fear all this disorder. The mechanism of the developing motion of the ring involves an arrangement which, thanks to the

very causes which should destroy it, establish it in a secure state by means of which it is divided up into several concentric circular bands which, because of the intervening gaps which separate them, have no more common interaction with each other. For while the particles orbiting on the inner edge of the ring with their faster motion push forward the particles above somewhat and accelerate their orbit, the higher level in velocity provides these particles with an excess of centrifugal force and moves them further away from the place where they were suspended. But if we assume that while these particles strive to separate themselves from the lower ones, they have to overcome a certain interconnection which, whether it is because they are scattered vapours, nevertheless appears to be not entirely insignificant for them, then this increased level of momentum seeks to overcome the inter-relationship mentioned above, but will not do so by itself, so long as the excess in the centrifugal force causing them to move around in the same orbital time as the lowest particles does not exceed the central force of their position and their interconnectedness. And for this reason the interconnectedness must remain in a stripe of a certain breadth of this ring, although because its parts perform their orbits in the same time, the upper particles must make an effort to pull themselves away from the lower ones, but not in a larger width, because, while the velocity of these particles orbiting in equal times increases with the distances more than it should according to the central laws, when it has gone beyond the level which can sustain the interconnection of the vapour particles, they must tear themselves away from it and take up a distance away from the planet appropriate to the excess impulse of the orbital forces over the centripetal force at that location. In this way, the intervening space will be set up, which keeps the first band of the ring away from the rest. And in the same way, the accelerated motion of the particles above, through the rapid rotation of those below, and their interconnection with them, which seeks to hinder the separation, will make a second concentric ring, from which the third arises around a moderate intervening gap. We could calculate the number of these circular bands and the width of the intervals between them, if we knew

the extent of the interconnection linking the particles to each other. But we can be satisfied that we have, in general, found out with a good degree of probability the composition of Saturn's ring, which prevents its destruction and keeps it suspended through free movements.

The conjecture gives me no little satisfaction thanks to the hope of seeing it confirmed some day through effective observations. A few years ago there was a report from London that when people observed Saturn with a new Newtonian telescope, an improved model by Mr. Bradley, its ring seemed to be essentially a combination of many concentric rings, separated by intervening spaces. This report has not been taken further since that time.[1] The observational instruments have opened up for our understanding the knowledge of the most distant boundaries of the cosmic structure. If now it is particularly up to them to undertake new steps in this business, from the attentiveness of our time to all those things which can expand human ideas we really can have probable grounds for hoping that they will turn particularly in a direction which presents them with the greatest expectation of important discoveries.

However, if Saturn has been so fortunate as to make a ring for itself,

[1]After I set down this remark, I found in the *Mémoires* of the Royal Academy of Sciences in Paris for the year 1705, in a discussion by M. Cassini of Saturn's satellites and its ring (on page 571 of the second part in the von Steinwehr translation) a confirmation of this conjecture, which leaves hardly a doubt any more about its validity. M Cassini presents an idea which could have been to some extent a small approximation of the truth which we have produced, although at the same time that is inherently unlikely, namely, that perhaps this ring might be a swarm of small satellites, which from Saturn appear just as the Milky Way does from the Earth. This idea can stand if we take for these small satellites the vapour particles which move around the planet with exactly the same motion. Then he goes on to say the following: "This idea was confirmed by the observations which people have made in the years when Saturn's ring appeared wider and more open. For people saw the width of the ring divided into two parts by a dark elliptical line. The part closest to the sphere was brighter than the part furthest away. This line marked, so to speak, a small intervening space between the two parts, just as the width of the space between the sphere and the ring is shown by the greatest darkness between the two."

why then has no other planet shared this advantage? The reason is clear. The ring is to arise from the ascending vapours of a planet, which it gives off in its raw condition, and the planet's axial rotation must give these vapours their impetus which they only have to continue when they have reached the altitude where they can attain an exact equilibrium between the planet's gravitational power and the motion imparted to them. Thus, we can easily determine by calculation the altitude to which the vapours from a planet must rise, if they are to maintain themselves in a free circular movement by means of the motion which they had at the planet's equator, provided we know the diameter of the planet, the period of its axial rotation, and the gravitational force on its outer surface. According to the law of central movement, the distance of a body which can go freely in circles around a planet at a velocity equal to the planet's axial rotation is in exactly the same ratio to the semi-diameter of the planet as the centrifugal force away from the centre at the equator is to the gravitational force. Given these reasons, the distance of the inner edge of Saturn's ring is equal to 8, when we assume that the half-diameter of the planet is 5. These two numbers are in the same ratio as 32 to 20, which, as we have previously noted, expresses the ratio of the gravitational force to the centrifugal force at the equator. For the same reasons, if we establish that Jupiter is to have a ring developed in this way, its smallest half-diameter would exceed the half-diameter of Jupiter by a factor of 10. That would exactly match the distance where its most remote satellite orbits around it. For these reasons and also because the vapours rising up from a planet cannot expand so far out from it, it is impossible for Jupiter to develop a ring. If we wanted to know why the Earth has acquired no ring, we will find the answer in the size of the half diameter which the inner edge of the ring alone would have to have had. This would have to have been 289 Earth semi-diameters. With the slower moving planets the possibility for the development of a ring gets even more remote. Thus, there is no example left where a planet could have acquired a ring in the manner which we have explained, other than the example of the planet which really has one. This is not an insignificant confirmation of the plausib-

ility of our manner of explanation.

But what makes me almost certain that the ring going around Saturn has not come about in the common way and was not built up through the universal laws of development governing throughout the entire system of planets, which also produced Saturn's satellites, and certain, I say, that no external material provided the material for this ring, but that it is a creation of the planet itself, which moved its most volatile parts upward up by heat and gave them a rotational impulse from its own axial rotation, is this fact: unlike the other satellites of this planet and, in general, all orbiting bodies which accompany a main planet, the ring is not oriented on the common interrelated plane of planetary motions, but deviates from it considerably. This is a certain proof that it did not develop from the common basic material and acquire its motion from the sinking down of this material, but arose from the planet long after its complete development and, through the orbital force implanted in it, as the planet's separated part, acquired from the planet's axial rotation a related motion and direction.

The pleasure of having grasped one of the strangest peculiarities of the heavens in the full extent of its nature and development has involved us in an extensive discussion. With the permission of our indulgent readers, let us keep going wherever we like, all the way to excess, so that after we have permitted ourselves a pleasant sort of arbitrary opinion with a kind of freedom from restraint, we will turn back to the truth once more with that much more caution and care.

Could we not imagine that the Earth, exactly like Saturn, once had a ring? It might have arisen from its outer layer precisely as Saturn's did and have maintained itself a long time, since the Earth had gone from a much faster rotation than the present one to the existing rate, for who knows what reasons. Or we could attribute the building of it to the common basic material sinking down according to the rules which we explained above, which we must not take so strictly if we want to indulge in our liking for the unusual. But what a supply of beautiful

explanations and consequences such an idea offers us! A ring around the Earth! How beautiful the sight for those who were made to live on Earth as a paradise. How much comfort for those whom nature was to greet with a smile on all sides! But this is still nothing in comparison to the confirmation which such a hypothesis can derive from the ancient lore of the story of creation, no small recommendation for approval among those people who believe they are not dishonouring revelation but endorsing it when they use it to ennoble the excess displays of their wit. The waters of the firmament, which the Mosaic account talks of, have already caused interpreters no small problem. Would it not be possible for us to use this ring to assist ourselves out of this difficulty? This ring undoubtedly consisted of vapours rich in water. And in addition to the advantage which it could provide for the first inhabitants on the earth, we have the fact that it was, when necessary, capable of breaking apart in order to punish the world, which had made itself unworthy of such beauty, with deluges. Either a comet, whose power of attraction brought the rule-bound motions of ring's parts into total confusion, or the cooling in the region where it was positioned united its scattered vapour particles and hurled them down upon the ground in the most horrifying of all inundations. We understand readily what the consequences of this were. The whole world went under water and absorbed, in addition to the foreign and volatile vapours of this unnatural rain, that slow poison which brought all creatures closer to death and destruction. From now on the shape of a pale light bow vanished from the horizon, and the new world, which could never remember what this looked like without experiencing terror before this fearful instrument of the divine revenge, saw perhaps with no less dismay in the first rainfall that coloured bow which seems to develop its shape like the first one, but which through the covenant of a forgiving heaven was to be a sign of grace and a memorial to the lasting establishment of the now changed surface of the Earth. The similarity in the form of this memorial sign to the event I have described could make such a hypothesis appealing for those people who follow the prevailing inclination to bring the wonders of revelation

into one system with the orderly laws of nature. I find it more advisable completely to sacrifice the transitory approval which such agreement can arouse for the true pleasure which comes from the perception of regular interconnections when physical analogies reinforce each other in the designation of physical truths.

Part Two
Section Six

Concerning the Lights of the Zodiac

The sun is surrounded by a subtle and vaporous essence going around it at the level of its equatorial plane up to a great altitude, with only a small extension on both sides. So far as this is concerned, we cannot be certain whether, as M. de Mairan pictures it, it makes contact with the outer surface of the sun in the shape of an uneven polished lens (*figura lenticulari*) or, like Saturn's ring, is always located at a distance away.[1] It may be either of these. But sufficient similarity remains to establish a comparison of this phenomenon with Saturn's ring and to infer a common origin. If this spread out material is something flowing out from the sun, and it is most probable to consider it in that manner, then we cannot miss the cause which has brought it to the common plane of the sun's equator. The lightest and most volatile material, which the sun's fire raises and has for a long time already raised from its outer surface will through the same process expand far over it and remain suspended at a distance, according to how light it is, where the forward driving effect of its rays comes into an equilibrium with the gravitational power of these vapour particles, or they will be reinforced by the stream of newer particles which continuously come up to them from below. Now, because the sun, as it rotates on its axis, imparts to these vapours torn away from its outer surface their regular motion, the latter maintain a certain orbital impetus by which, in accordance with the central laws, they are driven from both sides in their circular motion to intersect the sun's extrapolated equatorial plane. And thus, because they are driven down to this in equal quantities from both hemispheres, they pile up there with equal forces and form an extended flat surface on the designated solar equatorial plane.

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[1] [*Translator's Note*: Jean Jacques de Mairan (1678-1771), French scientist and author of a book on the Aurora Borealis. The phrase *figura lenticulari*, Jaki observes, means *in the shape of a lentil*].

But regardless of this similarity with Saturn's ring, there remains a fundamental difference, which causes the phenomenon of the zodiac light to differ considerably from Saturn's ring. The particles of Saturn's ring maintain themselves in freely suspended circular orbits through the implanted rotating motion; but the particles of the zodiacal light are kept at their altitude by the power of the sun's rays, without which their inherent motion from the axial rotation of the sun would be far from sufficient to hold them in free orbits and to prevent their falling down. For since the centrifugal force of the axial rotation on the surface of the sun is not even 1/40000 of the power of attraction, these vapours which have moved upward would have to be 40000 semi-solar diameters away from it in order to find at such a distance a power of gravitation which could for the first time achieve an equilibrium with their allotted motion. Thus, we are certain that this solar phenomenon is not given to it in the same way as Saturn's ring.

Nevertheless, there remains a not insignificant probability that this solar necklace perhaps acknowledges the same cause which nature collectively acknowledges, namely, the development out of the universal basic material, whose parts, since they were suspended all around the highest regions of the solar world, first moved down to the sun in a late descent only after the full and complete development of the entire system, with weaker curved motion, but still from west to east, and, thanks to this type of orbital path, intersected the extrapolated solar equatorial plane. By their accumulation there on both sides, once this motion stopped, they occupied a plane stretching out in this location, where they now maintain themselves always at the same altitude, in part through the power of repulsion of the sun's rays, in part through the real orbital motion they have attained. The present explanation has no value other than what one gives to an assumption and makes no demand other than for an arbitrary acceptance. The judgment of the reader may direct itself to that option which seems to him most worthy of adopting.

Part Two
Section Seven

Concerning Creation in the Total Extent of its Infinity Both in Space and Time

With its immeasurable size and its infinite multiplicity and beauty radiating out in all directions around it, the cosmic structure presents a silent wonder. If the picture of all this perfection now stirs the imaginative power, from a different perspective the understanding derives another type of delight, when it observes how so much splendour, such an enormous greatness, flows out from one single universal rule in an eternal and justified order. The planetary structure in which the sun at the centre makes the spheres found in its system orbit in eternal circles by means of its powerful force of attraction is entirely developed, as we have seen, from the originally distributed basic stuff of all planetary material. All the fixed stars which the eye discovers in the high recesses of the heavens and which appear to display a kind of extravagance are suns and central points of similar systems. The analogy permits us here no doubt that these were built and developed in the same manner as the one in which we find ourselves, from the smallest particles of elementary materials which filled empty space, this infinite extension of the Divine Presence.

Now, if all planets and planetary systems acknowledge the same sort of origin, if the power of attraction is unlimited and universal, if the power of repulsion of the elements is similarly continuously at work, and if, in comparison with the Infinite, the large and the small are both small, should not the cosmic structures have acquired in a like manner an interconnecting relationship and a systematic coordination among themselves, as the celestial bodies of our solar system have on a small scale, like Saturn, Jupiter, and the Earth, which are special systems on their own and yet are linked together amongst themselves as parts in an even greater system? If we take one point in the infinite space in which all the suns of the Milky Way were developed, a point around

which, for some unknown reason, the first development of nature out of chaos began, then at that location the largest mass and a body of the most exceptional power of attraction will have arisen, which thus would have become capable of forcing everything in a huge sphere around it in the process of developing systems to move down towards it as their central point and to build around it on a large scale a system like the one which the same elementary basic material which developed the planets created around the sun on a small scale. Observation makes this supposition almost indubitable. The army of stars, through its orientation in relation to a common plane, makes up a system just as much as the planets of our solar system do around the sun. The Milky Way is the zodiac of these higher world orders, which deviate from its zone as little as possible. Its band is always illuminated by their lights, just as the zodiac of planets is illuminated here and there by the shining of these spheres, although only in a very few points. Each one of these suns, along with its orbiting planets, makes up a particular system of its own, but this does not prevent them from being parts of an even greater system, just as Jupiter or Saturn, in spite of their own satellites, are confined in the systematic arrangement of an even greater cosmic structure. Can we not acknowledge with such a precise harmony in the arrangement the same cause and manner of production?

Now, if the fixed stars make up a system whose extent is determined by the sphere of attraction of the body located at the centre, will not more solar systems and, so to speak, more Milky Ways have arisen, which were produced in the limitless field of space? With astonishment we have seen figures in the heavens which are nothing other than such systems of fixed stars restricted to a common plane, such Milky Ways, if I may express myself in this way, which present themselves to our eyes in different positions with a weakly glimmering elliptical shape appropriate to their infinite distance away. They are systems, so to speak, of infinitely more infinite diameter than the diameter of our solar system, but without doubt they arose in the same way, are organized and arranged by the same causes, and maintain themselves

by the same dynamics as our system in its arrangement.

If we see these systems of stars once more as links on collective nature's great chain, we have just as many reasons as before to think of them in a mutual relationship and in combinations which, thanks to the laws governing throughout all nature, constitute the first development of a new and even greater system, controlled by the force of attraction of a body with incomparably more forceful attractive power than were all former systems, from the centre of their rule-bound positions. The force of attraction, the cause of the systematic arrangement among the fixed stars of the Milky Way, still works, even at the distance of these very cosmic structures, to bring them out of their positions and to bury the world in an unavoidable impending chaos, if the allotted rule-bound forces of motion did not develop a counterweight to the force of attraction and produce from the combination of the two of them that relationship which is the basis of the systematic arrangement. The force of attraction is without doubt a characteristic of matter as widely extensive as the coexistence which creates space, because it unites substances through a mutual dependency, or, to speak more precisely, the power of attraction is just this common relationship which unites the parts of nature in space. Thus, it expands through the total extent of space right into all its infinite distances. If the light from these remote systems, which is only an impressed movement, reaches us, must not the power of attraction, this primordial origin of motion, which antedates all motion, which requires no foreign cause, and which cannot be halted by any barrier, because it works in the innermost core of matter in the universal calm of nature without any external impulse, must not the force of attraction, I say, have set in motion these systems of fixed stars with their material in an undeveloped scattering in the first movements of nature, regardless of their immeasurable distances away, a motion which, as we have seen on a small scale, is the very origin of the systematic union and the enduring permanence of its links, the factor which keeps them secure from collapse?

But then what will finally be the end of the systematic arrangements? Where will creation itself cease? We well note that to think of creation in relation to the power of the Infinite Being means it must have no boundaries at all. We come no nearer to the infinity of the creative power of God if we enclose the space of its revelation in a sphere described with the radius of the Milky Way than if we enclose it in a ball with a diameter an inch long. Everything finite which has its limits and a determined relationship to unity is equally far away way from infinity. Now, it would be absurd to set the Divine into effective action with an infinitely small part of His creative capacity and to imagine His infinite power, the treasure house of a true infinity of natures and worlds, incapacitated and locked into an eternal deficiency in practice. Is it not much more appropriate or, to express the matter better, is it not necessary to present the embodiment of creation as something which cannot be measured by any standard, which is how it must be, in order to bear witness to that power? For this reason the field of the revelation of divine properties is just as infinite as these properties themselves.[1] Eternity is not sufficient to bear witness to the Highest

[1]The idea of an infinite extension of the world has opponents among those who know something about metaphysics and has recently found one in Mr. M. Weitenkampf. If, because of the alleged impossibility of a crowd without number and limits, these gentlemen cannot feel comfortable with this idea, then for the time being I wish merely to ask whether the future consequence of eternity will not contain with it a real infinity of multiple options and changes and whether this endless sequence is not entirely present once and for all in the Divine Understanding. Now, if it was possible that God can effectively create the idea of infinity, which to His mind actually presents everything at once in a successive series, why should He not be able to present the idea of another infinity in a spatially united interconnection and thus make the extent of the world limitless? Since people will seek out an answer to this question, I will avail myself of the opportunity which will present itself to remove the alleged difficulty through an explanation taken from the nature of numbers, where we can perceive with a more precise consideration the following still as a question in need of discussion: whether something which a power accompanied by the highest wisdom *has produced* to reveal itself, is related as a differential amount to something it *could produce*.

[*Translator's Note*: Johann Weitenkampf (1726 -1758), German theologian who defended the idea of a finite universe].

Essence where it is not united with spatial infinity. It is true that attraction, shape, beauty, and perfection are relationships of the basic elements and of the substance making up the material of the cosmic structure. And we notice it in the arrangement which the wisdom of God still effects at all times. It is also most appropriate to the wisdom of God that these develop themselves as an unforced consequence of the universal laws implanted in them. And therefore we can with good reason establish that the order and arrangement of the cosmic structure take place gradually from the supply of created natural matter in a temporal succession. But the basic material itself, whose properties and forces form the basis for all changes, is an immediate result of the Diving Being and itself must be simultaneously so rich and so perfect that the development of its compositions could in the flow of eternity extend over a plan enclosing in itself everything which can be, a plan which has no dimensions, which is, in short, infinite.

Now, if creation is spatially infinite or at least was really already that from the beginning as far as its material is concerned or according to its form or development is prepared to become so, cosmic space will become active with worlds without number and without end. Will that systematic union, which we have previously mentioned in particular among all the particles, now extend to the totality and the universe collectively, the All of nature, be tied together in a single system through the union of the power of attraction and the centrifugal force? I say yes. If nothing but separate cosmic structures without having among themselves any unifying relationship to a totality were the only things present, then, if we were to assume this chain of links as truly endless, we could imagine that a precise equality in the power of attraction in its parts on all sides could keep this system secure from destruction which the inner reciprocal force of attraction threatens them with. But this condition needs to be determined with such precise measurement of the distances carefully weighed against the power of attraction that the slightest displacement would bring destruction to the universe and would deliver it over to collapse. The

time would be long, but finally it would have to come to an end. A cosmic arrangement which did not keep itself going in the absence of a miracle does not have the mark of permanence which is the sign of God's choice. Thus, we find it much more appropriate if we make of creation collectively a single system creating all worlds and world structures, which fill all infinite space and which are made with reference to a single central point. A scattered confusion of cosmic structures, which might be separated from each other by distances as great as you like, would have an unhindered tendency to rush to dissolution and destruction, unless there were in place a certain arrangement in relation to a common mid-point, the centre of the power of attraction in the universe and, because of systematic movements, the foundation point of all nature.

Around this universal central point of downward movement in all nature, both developed and raw, at which is undoubtedly located the cluster with the most extensive power of attraction, encompassing in its sphere of attraction all worlds and ordered systems which time has produced and eternity will produce, we can probably assume that nature initiated its development and also that there the systems have accumulated in the greatest density but that further away from that mid-point, the systems are lost in ever increasing stages of disorder in the infinity of space. We could assume this principle from the analogy to our solar system, and this arrangement can, in any case, serve to show that at great distances not only the common central body but also all the systems moving in close proximity to it collectively combine their power of attraction and, so to speak, out of a single cluster exercise their effect on systems even further away. This will then help us to grasp all nature in the entire infinity of its extent in one single system.

Now, in order to trace the foundation of this universal system of nature from the mechanical laws of matter striving to develop, in the endless space of the dispersed elementary basic material some point or other of this matter must have accumulated with the greatest density, so as to

have assembled through the development going on there more than anywhere else a mass which serves as the foundation point. It is indeed the case that in an infinite space no point can really justifiably be called the centre. But thanks to a certain relationship based upon the inherent levels of density of the primordial stuff, according to which at the time of creation this material had accumulated more densely particularly at one certain location and its density had grown increasingly scattered with the distance away from this point, such a place can have the privilege of being called the centre. And it truly does become that through the development of the central mass because of the strongest power of attraction in it. It becomes the point to which all the remaining basic material incorporated in particular developments moves down, and thus, no matter how far unfolding nature may extend, it creates out of the entire totality only a single system in the infinite sphere of creation.

However, what is important and what, provided that it wins approval, is worthy of the greatest attention is the fact that, as a consequence of the ordering of nature in this system of ours, creation or, rather, the development of nature, first begins with this central point and with constantly progressive steps extends itself gradually out into all the further distances, in order to fill limitless space with worlds and order in the progress of eternity. Let us contemplate this picture with quiet pleasure for a moment. I find nothing which can elevate the human spirit to a more noble astonishment than this part of the theory concerning the successive completion of creation, as it opens up for humanity a glimpse into the unending field of the Almighty. If people grant me that the matter which is the building stuff of all worlds is not homogeneous in the entire infinite space of the Divine Presence but was distributed in accordance with a certain law which perhaps concerned itself with the density of the particles and according to which with the increasing distance from a certain point, like the location of the densest accumulation, the scattering in this primordial material increases, then in the original movement of nature the

development will have started in the region next to this centre and then, in a progressive temporal sequence, the more remote space will have gradually developed worlds and planetary structures in a systematic arrangement linked to this centre. Any one finite period, whose duration is connected to the magnitude of the completed work, will, in its development, always produce a sphere only a finite distance from this central point. The remaining infinite part will meanwhile still be combatting confusion and chaos and will be that much further from a condition of complete development, the further away it is located from the sphere of already developed nature. As a consequence of this, although from the place where we reside we have a view into, as it seems, a fully completed world and, so to speak, into an infinite host of planetary structures which are systematically united, nevertheless we find ourselves in reality only in proximity to the mid-point of all nature, where it has already developed out of chaos and attained its appropriate completion. If we could step over to a certain sphere, we would there witness chaos and the scattering of the elements, which, in proportion to their proximity to the central point partly leave their raw condition and are closer to the completion of their development. But with the degrees of distance away they gradually are lost in a total scattering. We would see how the limitless space of the Divine Presence, in which we find the store of all possible natural developments, buried in a quiet night, full of matter to serve as the stuff of worlds to be produced in the future and full of the initiating energies to bring it into motion. With a weak stimulus these begin those movements with which immeasurable nature of this barren space is yet still to be activated. Perhaps a succession of millions of years and centuries is to flow by before the sphere of developed nature in which we find ourselves grows to the perfection now inherent in it. And perhaps an even longer period will elapse before nature will take such a wide step into chaos. But the sphere of developed nature is ceaselessly occupied with expanding itself. Creation is not the work of a moment. After creation made a beginning by producing an infinity of substances and materials, it is efficacious with constantly increasing degrees of

fecundity throughout the total succession of eternity. Millions and whole mountains of millions of centuries will pass, during which new worlds and new world systems will constantly develop and reach completion, one after the other, in the expanses far from the central point of nature. Regardless of the systematic arrangement among their parts, they will have a common relationship to the central point, which became the initial point of development and the centre of creation through the capacity of the power of attraction of its preponderant mass. The infinity of the future temporal succession, for which eternity is inexhaustible, will thoroughly activate all the spaces of God's presence and gradually set it into rule-bound regularity, appropriate to the excellence of its design. And if, in a daring picture, we could, so to speak, sum up all eternity in a single idea, then we would be able to see the entire infinite space filled with world systems and a completed creation. However, because, in fact, in the temporal sequence of eternity the part to come is always infinite and the part gone by is finite, the sphere of developed nature is always only an infinitely small part of that being which has in it the seeds of future worlds and strives to develop itself out of the raw condition of chaos in long or short periods of time. Creation is never complete. True, it once began, but it will never cease. It is always busy bringing forth new natural phenomena, new things, and new worlds. The work which it brings into being has a relationship to the time nature expends on it. It needs no less than an eternity to bring the entire limitless extent of infinite spaces alive with numberless worlds without end. We can say about creation what the noblest of the German poets writes about eternity.

> Eternity! Who knows you?
> For you worlds are days and humans moments.
> Perhaps the thousandth sun is now turning
> And thousands still remain behind.
> Like a clock animated by a weight,
> A sun rushes by, moved by the power of God.
> Its impulse comes to an end, and another throbs.

But you remain and do not count them.
(von Haller)[1]

There is no small pleasure in letting one's imagination roam over the limits of completed creation into the space of chaos and to see half raw nature in the vicinity of the sphere of the developed world losing itself gradually through all the stages and shades of incompleteness in the whole of undeveloped space. But is that not a culpable daring, people will say, to throw down a hypothesis and to praise it as a design for the delight of the understanding, a plan which is perhaps merely too arbitrary when we claim that nature is only developed to an infinitely small extent and limitless spaces are still at strife with chaos, so that they will display in the succession of future times entire hosts of worlds and world systems in all appropriate order and beauty? I am not so devoted to the consequences which my theory offers that I should not acknowledge how the conjecture about the successive expansion of creation through endless spaces containing material for that purpose cannot fully counter the objection that it is beyond proof. Meanwhile, however, I hope from those who are in a position to appreciate levels of probability, that such a map of infinity, although it touches on a plan that seems destined to be concealed forever from human understanding, will not for that reason immediately be seen as a fantasy, especially when we take the analogy as an aid which must always show us the way in such cases where the understanding lacks the guiding threads of indubitable proofs.

However, we can still support the analogy with reasons worthy of consideration. The insight of the reader who, I may flatter myself, will approve will perhaps be able to multiply these reasons with even more important ones. For when we consider that creation does not bring with it a characteristic stability, insofar as it does not establish for the

[1] [*Translator's Note*: The quotation, like the later ones from von Haller is from the poem "Unvollkommene Ode über die Ewigkeit" by Albrecht von Haller (1708-1777), a German physiologist and poet].

common striving of the power of attraction, which works through all its parts, such a precise universal modification which can sufficiently withstand the tendency of this power to bring destruction and disorder, unless creation allotted the orbital forces which, in combination with the central tendency, fixes in place a systematic arrangement, then we will be required to assume a common central point for the entire totality of worlds, a point which holds all the parts of this totality together in a united relationship and makes only one system out of the entire essence of nature. If, in addition to this, we pursue the idea of the development of world bodies out of scattered elementary matter, as we have outlined the subject previously, but do not limit the idea here to one particular system, and instead extend it to all nature, then we will have to imagine such a distribution of the basic matter in the space of primordial chaos which naturally involves a central point of all creation, so that in the latter the effective mass which encompasses all nature collectively in its sphere of attraction brings the material together and makes the general relationship work, so that all worlds make up only one single structure. However, in limitless space a sort of distribution of the primordial basic material can hardly be imagined which is to establish a true central point towards which collective nature is to sink down, other than one in which the distribution is arranged according to a law of increasing disorder from this point out everywhere into all the far distances. This law, however, at the same time establishes a difference in the time which a system requires in the different regions of limitless space to come to its mature development. This period is shorter, the closer the location of the development of a world system is to the centre of creation, because in the closer region the elements of matter have accumulated more thickly; by contrast, the further the distance away from this centre, the longer the time required, because the particles there are more scattered and are later in coming together in order to develop.

If people consider the entire hypothesis that I have drawn up to the full extent of what I have said, as well as what I will still actually present,

they will at least not think that the boldness of its claims cannot be excused. We can estimate the inevitable tendency which each world system brought to completion has to move gradually towards its destruction among the reasons which can establish that the universe, in contrast to that destruction, will be fertile with worlds in other regions, to make up for the deficiency which it has suffered in one location. Although the entire part of nature that we know about is only equivalent to an atom in comparison with what remains hidden over or under our horizons, it nevertheless confirms this fertility of nature, which is without limit, because it is nothing other than the working out of the Divine Omnipotence itself. Numberless animals and plants are destroyed every day and are a sacrifice to mortality. But nature, with its inexhaustible productive capacity, creates just as many over again in other places and fills up the emptiness. Considerable parts of the earth's surface which we inhabit are being buried once again in the sea out of which they were pulled at a favourable time. But in other places, nature makes up for the loss and produces other areas which were hidden deep under water, in order to extend over these areas new riches from her fertile store. In the same way, worlds and world systems go under and are swallowed up in the abyss of eternity. But, on the other hand, creation is always busy organizing new developments in other regions of the heavens and making up for the loss with advantage.

We should not be amazed to admit mortality even in the greatness of God's work. Everything finite, with a starting point and a cause, has within itself the mark of its limited nature. It must die and have an end. On account of the excellence of its arrangements, the duration of a world system has a inherent permanence which, according to our ideas, comes close to a limitless time span. Perhaps a thousand, perhaps millions of centuries will not destroy it. But because vanity, which adheres to finite natures, works continuously for their destruction, so eternity will hold in itself all possible periods, in order finally to bring about through a gradual decay the moment of its collapse. Newton, this

great admirer of the attributes of God in the perfection of His works, the one who with the deepest insight into the excellence of nature combined the greatest devotion for the revelation of Divine Omnipotence, saw himself compelled to predict the decay of nature through the natural tendency which the mechanics of movement had to bring it about. If a systematic arrangement comes close to a state of confusion as the essential result of its fallibility over a long period of time, even in the very smallest part that we can imagine, then in the endless current of eternity there must be a moment in time when this gradual diminution exhausts all movement.

However, we must not lament the destruction of a cosmic structure as a real loss for nature. It demonstrates its richness with a kind of dissipation which, while a few parts pay tribute to mortality, maintains it undamaged in the full extent of nature's perfection with numberless new productions. What a countless number of flowers and insects a single cold day destroys. But how little we miss them, regardless of the fact that they are beautifully natural works of art and proofs of Divine Omnipotence! In another place, this death will be made up once again with excess. Humanity, which appears to be the masterpiece of creation, is itself no exception to this principle. Nature shows that it is just as rich and just as inexhaustible in the production of the most excellent of creatures as it is of the most insignificant and that even their destruction is a necessary shadow amid the multiplicity of its suns, because producing humanity cost nature nothing. The harmful effects of infected air, earthquakes, and inundations wipe out entire peoples from the surface of the earth, but it does not appear that nature has suffered any damage because of this.

In the same way, entire worlds and systems leave the stage when they have played out their roles. The infinite nature of creation is large enough that it looks upon a world or a Milky Way of worlds in comparison with it as we look upon a flower or an insect in comparison with the Earth. In the meantime, while nature beautifies eternity with changing scenes, God remains busy with a ceaseless creation, forming

material for the development of even greater worlds.

> Who sees with equal eye, as God of all,
> A hero perish, or a sparrow fall,
> Atoms or systems into ruin hurl'd,
> And now a bubble burst, and now a world.
>
> (Pope)[1]

Let us therefore get our eyes used to these terrifying collapses as the customary methods of providence and look at them with even a kind of pleasure. In fact, nothing is more appropriate to the richness of nature than this. For when a world system in the long sequence of its duration exhausts all the multiplicity which its organization can contain, when it has now become an expendable link in the chain of being, then nothing is more fitting than that it play the last role in the drama of the passing changes of the universe, which is part of every finite thing, namely, it gives up what it owes to mortality. Nature demonstrates, as mentioned, even in the small parts of its being this rule of its processes, which eternal fate has prescribed for it on a large scale. And I repeat that the magnitude of what is to pass away is in this matter not the slightest obstacle, for everything large becomes small. Yes, it becomes, so to speak, just a point, if we compare it with the infinity which creation will present throughout the succession of eternity in limitless space.

It appears that for worlds, as for all natural things, this fatal ending is subject to a certain law whose consideration gives the theory a new appropriate feature. According to this principle, the fatal ending originates among those celestial bodies located closest to the central point of the universe, just as the production and development first began close to this mid-point. From there the decay and destruction gradually work their way outward into the further distances, in order to bury all

[1] [*Translator's note*: The quotation comes from Alexander Pope's *Essay on Man*, Epistle I. Kant quotes the German and comments in the bracket that it comes from Brocke's translation].

the world which has gone through its time, by means of a gradual decline in its motions, finally in a single chaos. On the other hand, nature is ceaselessly busy on the borders opposite to the developed world producing worlds from the raw material of the scattered elements, and while nature on one side close to the mid-point is aging, so on the other side it is young and fertile in new generations. The developed world, according to this, finds itself in a limited space in the middle, between the ruins of what has been destroyed and the chaos of undeveloped nature. And if we imagine, as is probable, that a world already growing to completion could last a longer time than it required to become developed, then the extent of the universe will in general increase, regardless of all the destruction which mortality ceaselessly brings about.

However, if we are still willing to allow an idea which is just as probable as the arrangement of the divine works is appropriate, then the satisfaction aroused by such a description of nature's changes will be raised to the highest level of delight. Can we not believe that nature, which was capable of setting itself up out of chaos into a rule-bound order and a finely tuned system, is equally in a position just as easily to organize itself once more out of the new chaos, into which the diminution of its motions has lowered it, and to renew the first unity? Might the springs which brought the scattered material stuff into motion and order not be able once more to be made effective by extended forces after the motionlessness of the machine has rendered them inert and, through the very same universal principles, be harmoniously restricted in the way in which the original development was produced? We will not examine the matter very long before conceding this, if we consider that, after the final exhaustion of the orbital motions in the cosmic structure has thrown the planets and comets together down onto the sun, the sun's fire must increase immeasurably through the mixing of so many large bodies, especially since the distant spheres of the solar system, as a consequence of the theory we have previously established, contain the lightest and most effective fuel in

all nature. This fire, given the highest intensity by the new fuel and the most volatile materials, will without doubt not only break down everything into the smallest elements once more but will also in this way spread them out with an expansive force appropriate to the heat and at a velocity which is not weakened by any resistance in the middle region. It will scatter and spread them out once again in the same wide space which they occupied before the first development of nature, so that, after the intensity of the central fire is damped down by the almost total destruction of the sun's mass, through the combination of the forces of attraction and repulsion the old generations, together with their systematically interrelated movements, will be repeated with no less regularity and will present a new cosmic structure. Thus, when a particular planetary system suffers destruction in this way and has been re-established by the fundamental forces, when indeed this play repeats itself again as before, then finally the period approaches when, in the same manner, the large system of which the fixed stars are links will collectively experience chaos through the lessening of it motions. We will have even fewer doubts here that the uniting of such an endless number of rich fiery storehouses as these burning suns, together with their attendant planets, will scatter the material making up their masses, which has been dissolved by the indescribable inferno, in the old space of the sphere in which they developed, and there the materials will provide for new developments through the same mechanical laws. As a result of this, the barren space can become active with worlds and systems once more. When we follow this phoenix of nature, which is only burned up in order to live again, renewed once more from its ashes, through all infinity of times and spaces, when we see how it progresses, even in the region where it decays and grows old, inexhaustible in new phenomena and, on another border of creation, in the space of undeveloped raw matter, with constant strides to unfold the plans of the divine revelation in order to fill eternity as well as all spaces with its wonders, then the spirit which thinks about all this is lost in deep astonishment. But still dissatisfied with such great events as these, whose mortality cannot adequately satisfy the soul, he wishes

to learn at close hand about that Being whose understanding and whose greatness are the fountain of that light which extends itself over all nature, as it were, from a central point. With what kind of awe must the soul not contemplate its very own essence, when it observes that it is to survive even all these changes. It can say to itself what the philosophical poet says concerning eternity:

> When then a second night will bury this world,
> When from everything nothing remains but the place,
> When still many other heavens bright with other stars
> Will have completed their course,
> You will be as young as now, just as far from death
> As eternally alive as now.
>
> (von Haller)

O how happy the soul, when among the tumult of the elements and the ruins of nature, it is at any time set on a height from which it can see rushing past, as it were, below its feet the devastation which the frailty of worldly things brings about! A blessedness which the understanding is never permitted to dare to expect teaches us to hope with conviction for the revelation. For when the bindings which keep us tied to the vanity of living creatures fall away in the moment established for the transformation of our being, then the immortal soul, freed from its dependency on finite things, will find in the companionship with the infinite essence the enjoyment of true blessedness. All nature, which has a universal harmonious relationship to the pleasure of the Deity, can fill that reasoning creature with nothing but eternal satisfaction, which finds itself united with this original fountain of all perfection. Nature seen from this central point will show on all side nothing but security, nothing but propriety. The changing natural scenes are not able to upset the calm bliss of a soul which has once been lifted up to such a height. While it already tastes in advance this condition with a sweet hope, it can set its mouth to work on those hymns of praise with which in future all eternity will resound.

> When Nature fails, and day and night

Divide thy works no more,
My ever grateful heart, O Lord,
Thy mercy shall adore.
Through all Eternity to Thee
A joyful song I'll raise;
For, oh! Eternity's too short
To utter all Thy praise.

(Addison)[1]

Part Two
Supplement to Section Seven

Universal Theory and History of the Sun in General

There is still a major question the answer to which is essential in the natural theory of the heavens and in a complete cosmogony, namely, why will the middle point of every system consist of a burning body? Our planetary system has the sun as the central body, and the fixed stars visible to us are, all things considered, mid-points of similar systems.

In order to grasp why in the development of a planetary structure the body serving as the mid-point of the power of attraction must have a fiery body, while the other circular structures in the sphere of its power of attraction remain dark and cold world bodies, we need only remember the way in which a planetary system is produced, something we have outlined in detail in the previous parts. In the greatly expanded space in which the spread out elementary basic material prepares developments and systematic movements, the planets and comets are built up only out of those parts of the elementary basic matter moving downward towards the central point of the force of attraction which, through their fall and the reciprocal interaction of the particles

[1] [*Translator's note*: Joseph Addison (1672-1719) in *Spectator* 453. Kant quotes the German and notes in the bracket that the translation is by Gottsched]

collectively, were precisely adjusted for the velocity and direction required for orbital motion. This portion is, as has been established above, the smallest part of the total amount of matter moving downward and, in fact, is only what is left over of the denser varieties, which have been able to attain the degree of precision from the resistance of the other parts. In this mixture there are particularly light types of matter floating around, which, hindered by the resistance of space, do not in their descent push on through to the velocity appropriate to periodic orbits and which therefore, given the weakness of their orbital impetus, will all collectively fall down to the central body. Now, because these lighter and volatile parts are also the most effective at maintaining a fire, we see that, with their addition the body at the central point of the system has the distinction of becoming a flaming sphere, in a word, a sun. By contrast, the heavier and inert materials and those particles which are poor fuel for a fire will make planets which are robbed of these properties merely cold and dead clusters.

This addition of such light materials is also the reason why the sun ends up with a smaller specific density, so that it is even four times less dense than our Earth, the third planet away from the sun, although it is natural to think that in this central point of the planetary structure, as its lowest point, the heaviest and densest sorts of material are to be found and that without the addition of such a large amount of the lightest matter its density would exceed that of all planets.

The intermixing of the denser and heavier types of elements with these lightest and most volatile ones serves also to make the central body suitable for the most intense blaze which is to burn and maintain itself on its outer surface. For we know that the fire in whose nourishing fuel dense materials are found mixed in with volatile matter has the advantage of a greater intensity than those flames which are sustained only by the light varieties of matter. However, this mixture of some heavier sorts among the lighter types is a necessary consequence of our theory about the development of world bodies. It even benefits from the fact that the force of the heat does not immediately scatter the burning

material on the outer surface and that the fire will be gradually and constantly fed by the fuel supply within the planet.

Now that we have resolved the question why the central body of a large system of stars is a flaming sphere, that is, a sun, it appears not irrelevant to concern ourselves with this subject some more and to investigate the state of such a celestial body in a careful examination, especially since the assumptions can here be derived from more effective reasons than are commonly used where investigations into the composition of distant celestial bodies are concerned.

To begin with, I firmly maintain that we can have no doubt that the sun is truly a flaming body and not a mass of smouldering and glowing material heated to the highest degree, as a few people have wished to infer from certain difficulties they claim to find regarding the former view. For when we consider that a flaming fire has this fundamental distinction over and above every other form of heat, that it, so to speak, works on its own, instead of being diminished or exhausting itself by sharing its heat, that through this it rather acquires even more strength and intensity and thus requires only material and fuel to maintain itself so as to keep going continuously, whereas, by contrast, the glow of a mass heated to the highest degree is in a merely passive condition, which by the common interaction with the material in contact with it constantly diminishes and has no forces of its own to expand from a small beginning or to revive itself again should it diminish: when we consider this, I say (and I am not mentioning the other reasons), then we will already be sufficiently capable of seeing that that property must, in all probability, be attributed to the sun, the fountain of light and heat in every planetary system.

Now, if the sun, or rather suns in general, are flaming spheres, then the first requirement of their outer surfaces, which we can deduce from this point, is that air must be found on them, because without air no fire burns. This condition gives rise to remarkable consequences. For, first of all, if we first establish the atmosphere of the sun and its weight in relationship to the sun's cluster, how compressed will this air be and

how capable will it become on account of this very compression to maintain the intensest level of fire through its elasticity *[Federkraft]*? According to all assumptions, in this atmosphere, the clouds of smoke from the materials broken up by the flames (which, we cannot doubt, have a mixture of coarse and lighter particles in them), once they have risen up to an altitude which keeps the air cooler for them, fall down with heavy rains of pitch and sulphur and provide new fuel for the flames. This very atmosphere is also, for the same reasons as on our Earth, not free from the motions of the winds, which, however, according to this view, must far exceed in intensity everything that the power of the imagination can merely picture. When some region or other on the surface of the sun, either through the suffocating force of the vapours pouring out or because of the limited supply of combustible material, sees the eruption of flames diminish, then the air above cools to some extent, and since it is contracting, makes room for the air in the immediate vicinity to rush into its space with a force proportional to its expansion and to re-ignite the extinguished flames.

However, all flames always consume a great deal of air, and there is no doubt that the elasticity of the volatile elements of the air which encircle the sun must, in this way, over time suffer not insignificant damage. If we apply here on a large scale what Mr. Hales has, through careful research, proven in this matter with respect to the effect of flames in our atmosphere, then we can see the ceaseless striving of the particles of smoke coming out of the flames to destroy the elasticity *[Elasticität]* of the sun's atmosphere as a serious problem, the solution to which is associated with difficulties.[1] Because the flames which burn over the entire surface of the sun themselves consume the air essential for their combustion, the sun is in danger of going out entirely when the largest portion of its atmosphere has been consumed. True, from the dissolution of certain materials fire also produces air. But the experiments demonstrate that more is always consumed than produced.

[1] [*Translator's Note*: Stephen Hales (1677-1761), an English natural scientist who in 1727 published an analysis of the air.]

In fact, when a part of the sun's fire under the suffocating vapours is deprived of the air which serves to maintain it, then, as we have already noted, violent storms destroy the vapours and work to carry them away. But on a large scale we will be able to make the replacement of this necessary element understandable in the following manner, if we bear in mind that in the case of a flaming fire the heat acts almost exclusively above it and only a little underneath it. When it has suffocated for reasons we have cited, its intensity turns to the inside of the sun's body and forces the deep hollow places to let the air enclosed in their depths break out and renew the fire once more. If, using that freedom permitted in dealing with such unknown circumstances, we assume there are in these depths special materials which, like saltpetre, are inexhaustibly rich with elastic air, then the sun's fire will not be able to suffer easily from a deficiency for an extremely long period, because the supply of air is constantly renewed.

However, we do see the clear marks of mortality also in this inestimably valuable fire which nature sets up as the world's torch. There comes a time when it will be extinguished. The dispersal of the most volatile and finest materials, which, scattered by the intensity of the heat, never turn back again and add to the stuff of the zodiacal light, the accumulation of incombustible and burned out materials, for example, the ashes on the surface, and finally the lack of air will establish an end point when the sun's flames at some point in the future go out and eternal darkness will take over in its place, now the central point of light and life of the whole planetary structure. The alternating impulse of its fires by which it opens new caverns to become vital again and through which it renews itself perhaps several times before being overcome could provide an explanation for the disappearance and renewed illumination of a few fixed stars. There would be suns which are close to being extinguished and which still strive a number of times to live on from their debris. This explanation may win approval or not, but we will certainly let this thought serve for us to recognize that since, in one way or another, an unavoidable decay threatens the perfection of all planetary systems, we will find no difficulty with the

laws mentioned previously concerning their collapse through the tendency of the mechanical arrangement, which will, nonetheless, be particularly worthy of acceptance, since it brings with it the seeds of a renewal in the interaction with chaos.

Finally, let us use the power of our imaginations to picture such an amazingly strange object as a burning sun, as it were, at close hand. We see at a glance wide seas of fire, raising their flames towards the heavens, frantic storms, whose fury doubles the intensity of the burning seas, while they themselves make the fiery seas overflow their banks, sometimes covering the higher regions of this world body, sometimes allowing them to sink back down within their borders. Burned out rocks extend their frightening peaks up above the flaming chasms, whose inundation or exposure by the seething fiery element causes the alternating appearance and disappearance of the sun spots. Thick vapours which suffocate the fire, lifted up by the power of the winds, make dark clouds, which in fiery downpours crash back down again and as burning streams flow from the heights of firm land of the sun into the flaming valleys, the cracking of the elements, the debris of burned up material and nature wrestling with destruction—these bring about, along with the most awful condition of their disorder, the beauty of the world and the benefits for its creatures.[1]

If, then, the mid-points of all large planetary systems are burning

[1]I ascribe to the sun, not without reason, all the inequalities of the firm lands, the mountains and valleys, which we come across on our Earth and on other world bodies. The development of a planetary sphere which changes from a volatile condition into a firm one necessarily brings about such inequalities on the outer surface. When the outer surface solidifies while in the volatile interior parts of such masses the materials are still sinking down to the mid-point in accordance with their gravitational pull, then the particles of the elements of elastic air or fire, intermingled with these materials, are forced out and accumulate under the outer layer which has meanwhile solidified. Under this, they produce large and, in proportion to the sun's cluster, gigantic cavities. The outermost layer just mentioned finally falls into these cavities with various folding patterns and in this way creates, not only elevated regions and mountains, but also valleys and flood beds for more seas of fire.

bodies, then we can assume that this is most particularly the case with the central body of that immeasurable system which comprises the fixed stars. Now, if this body, whose mass must be proportional to the magnitude of its system, were a self-illuminating body or a sun, will it not be visible with a exceptional illumination and size? However, we do not see anything like such a predominantly different fixed star shining out among the host in the heavens. In fact, we must not think it strange if such a thing does not occur. If the mass of such a sun was equivalent to a mass 10000 times greater than our sun, nevertheless, if we assume its distance away was 100 times greater than the distance of Sirius, it could appear no larger or brighter than Sirius.

However, perhaps it is reserved for future ages to discover at some later date at least the region where the central point of the system of fixed stars to which our sun belongs is located or perhaps really to determine where we must place the central body of the universe towards which all its parts aim with a common downward motion.[1] As for what the

[1]I have a conjecture according to which it strikes me as very probable that Sirius or the Dog Star is the central body in that system of stars making up the Milky Way and occupies the central point towards which all of them are related. If we consider this system according to the design in the first part of this treatise, as a teeming mass of suns which have accumulated on a common plane and which are scattered on all sides of its middle point and yet make a certain, so to speak, circular space, which because of the slight deviations of it from the interrelated plane extends out somewhat in width on both sides, then the sun which is similarly located near this plane will view the appearance of this circularly shaped zone with a shimmering white light as widest on that side where the sun is located nearest to the outermost edge of the system. For it is easy to assume that it is not positioned exactly at the central point. Now, the band of the Milky Way is widest in the part between the sign of the Swan and the sign of the Archer. Thus, this will be the side where the location of our sun is closest to the outermost periphery of the circular system. And in this section we will consider the place where the constellations of the Eagle and the Fox stand with that of the Goose, to be the particular location closest to them all, because there in the intervening space, where the Milky Way divides, the greatest visible scattering of stars shines out. If we then draw a line approximately from the place near the tail of the Eagle through the middle of the plane of the Milky Way right to the spot on the opposite side, this line must meet the mid-point of the system. And in fact it does meet Sirius with great precision. Sirius is the brightest star in the entire heavens. Because of the happy and harmonious combination of this and

composition of this fundamental part of the entire creation may be and what may be found on it, we wish to leave it to Mr. Wright from Durham to determine. With a fantastic enthusiasm, in this happy place he elevates, so to speak, on a throne of collective nature a powerful being of the divine variety, with spiritual forces of attraction and repulsion, which, effective in an infinite sphere around it, draws all virtue to it but pushes back all vice. We do not wish to allow the daring of our conjectures, which we have permitted perhaps too much, to slip the reins into arbitrary poetical fictions. The Godhead is equally present in the infinity of the entire cosmic space everywhere. Wherever there are natures capable of rising above creature dependency into the company of the Highest Essence, that Essence will be immediately close at hand. The entire creation is permeated by His forces, but only that person who knows how to liberate himself from the living creature, the person who is noble enough to appreciate that only in the enjoyment of this original fountain of perfection is the highest level of blessedness to be sought alone and by himself, only that person is capable of finding himself closer to this true point interconnecting all excellence than to any other place in all nature. Meanwhile, if I, without sharing the Englishman's enthusiastic picture, am to offer my conjectures about the different levels of the spiritual world from the physical relationship of their dwelling places in relation to the mid-point of creation, then I would seek with more probability the most perfect classes of reasoning beings further from this mid-point rather than close to it. The perfection of creatures endowed with reason, insofar as they are dependent on material composition, in connection with which they are limited, depends a very great deal on the fineness of the material stuff whose influence determines these creatures in their perception of the world and in their response to it. The inertia

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its preponderant shape, Sirius appears to merit being considered that central body itself. According to this idea, Sirius would appear directly in the band of the Milky Way, if the location of our sun, which, with respect to the tail of the Eagle, deviates somewhat from its plane, did not cause the visual displacement of the mid-point toward the other side of such a zone.

and resistance in matter excessively restrict the freedom of the spiritual beings in their work and in the clarity of their sensations of external things. It dulls the edge of their capabilities, since they cannot obey their movements with appropriate facility. For when we assume, as is likely, that the densest and heaviest sorts of materials are close to the mid-point of nature and, by contrast, that the increasing degrees of fineness and lightness are at the greater distances in the same proportion as in the analogy which governs our planetary structure, then the result is understandable. The reasoning beings whose place for development and habitation is located closer to the mid-point of creation are sunk in a stiff and immobile matter, which keeps their powers enclosed in an invincible inertia and is equally incapable of transmitting and reporting on the impressions of the universe with the necessary clarity and ease. Thus, we will have to count these thinking beings in the low group. By contrast, with the distances away from the common centre, this perfection in the spiritual world, which rests on the reciprocal dependency of it on matter, will grow as if on a constant scale. At the lowest depths toward the sinking point, therefore, we have to place the poorest and least perfect groups of thinking creatures and below this is the place where in all shades of diminution the excellence of beings finally loses itself in the utter lack of thought and reflection. In fact, if we consider that the central point of nature marks simultaneously the start of its development out of raw matter and its frontier with chaos, if we establish in addition that the perfection of spiritual beings, which really have an outermost border marking their beginning, where their capabilities jostle back and forth with unreason, but which have no limit to going forward over which they cannot be raised and instead discover in that direction a complete infinity in front of them, then, if indeed there is to be a law according to which dwelling places are distributed for reasoning creatures in accordance with the order of their relationship to the common mid-point, we will have to put the lowest and least perfect types, which, as it were, make up the beginning of the family of the spiritual world, in that place designated the start of the entire universe, in order at the same time as this to fill in

the same forward movement all infinity of time and space with endlessly growing levels of perfection of the thinking capacity and, as it were, gradually to come closer to the goal of the highest excellence, namely, to the Godhead, but without ever being able to attain that.

Part Two
Section Eight

General Proof of the Correctness of a Mechanical Theory of the General Arrangement of the Planetary Structure, in particular of the Correctness of the Present Theory

We cannot look at the planetary structure without recognizing the supremely excellent order in its arrangement and the sure marks of God's hand in the perfection of its interrelationships. After reason has considered and wondered at so much beauty and excellence, it rightly grows indignant at the daring foolishness which permits itself to ascribe all this to chance and a happy contingency. There must have been a Highest Wisdom to make the design, and an Infinite Power must have produced it. Otherwise it would be impossible to encounter in the planetary structure so many purposes cooperating in a single intention. It comes down only to deciding whether the plan for the structure of the universe is already set in the fundamental composition of eternal natures by the Highest Understanding and implanted in the eternal laws of motion, so that they develop themselves freely from them in a manner appropriate to the most perfect order or whether the general characteristics of the component parts of the world are completely incapable of harmony and have not the slightest united relationship and it must have absolutely required an alien hand to produce that restriction and coordination which permit us to see the perfection and beauty in it. An almost universal judgment has made most philosophers oppose the capability of nature to produce something ordered through its universal laws, just as if it meant that we were challenging God's rule over the world, when we seek the primordial developments in the forces of nature, as if these forces were a principle independent of the Godhead and were an eternally blind fate.

However, if we consider that nature and the eternal laws prescribed for substances in their reciprocal relationships are not a self-sufficient, necessary principle with no connection to God, and, for that very

reason, we see that, because nature demonstrates so much harmony and order in what it produces by universal laws, the essential natures of all things must have their common origin in one particular Original Essence, and that for this reason nature must reveal nothing but mutual interrelationships and harmony, because its properties originate in one single Highest Intelligence, whose wise idea has planned it with universal interconnections and has implanted in it that capability, whereby, left alone in its own state to do its work, it brings forth nothing but beauty, nothing but order, when we, I say, consider this, then nature will seem more worthy to us than it commonly appears, and we will expect nothing from natural developments but harmony, nothing but order. If we, by contrast, permit an ungrounded judgment that the universal natural laws in and of themselves produce nothing but disorder and that all the coordination for useful purposes shining forth in relation to natural arrangements reveals the immediate hand of God, then we will be forced to transform all nature into miracles. We will have to account for the beautifully coloured bow appearing amid the rain drops, when it separates the colours of the sun's light, on the basis of its beauty, the rain on the basis of its benefits, the winds on the basis of the indispensable advantages which they bring in countless ways in answer to human needs; in short, we must not explain all the changes of the world which bring delight and order with them on the basis of implanted natural forces of matter. The natural scientist who begins by surrendering to such a philosophy will have to make a solemn apology before the judgment seat of religion. In fact, there will then be no more nature. There will be only a God in the machine who produces the world's changes. But what then will this curious method of demonstrating the certain existence of a Highest Being out of the fundamental incapacity of nature prove, by way of an effective counter to Epicurus? If the natures of things bring forth by the eternal laws of their being nothing but disorder and absurdity, then they will show in that very manner the nature of their independence from God. What sort of an idea will we be able to create for ourselves of a divinity whom the universal natural laws obey only through some sort of

compulsion and which in and of themselves act against the wisest designs of the Divinity? Will the enemy of providence not win just as many victories from these false basic principles, when he can point to harmonies which the universally effective natural laws produce without any special limitations? And is it possible that he would really lack examples of such things? By contrast, let us with greater propriety and correctness conclude the following: nature left to its general properties is fertile in nothing but beautiful and perfect fruits, which not only display in themselves harmony and excellence, but also are in harmony to the total extent of their being with benefits for humanity and with the glorification of the properties of God. From this it follows that their fundamental characteristics can have no independent necessity but that they must have their origin in a Single Intelligence, the basis and the fountain of all being, in which they are designed according to common interrelationships. All things connected together in a reciprocal harmony must be united among themselves in a single being on which they collectively depend. Thus, there is present a Being of all beings, an Infinite Intelligence and Self-sufficient Wisdom, from which nature, even in its potentiality, draws its origin according to the whole embodiment of its purposes. From now on we must not deny the capacity of nature, claiming it is disadvantageous to the existence of a Highest Being. The more perfect nature is in its developments, the better its universal laws lead to order and harmony, then the more certain the proof of the Godhead from which nature derives these relationships. Its productions are no longer effects of contingency and results of accidents. Everything flows from it according to unchanging laws which thus must display nothing other than nature's skill, because they are exclusively features of the wisest of all designs from which disorder is prohibited. The chance collisions of the atoms of Lucretius did not develop the world. Implanted forces and laws which have their source in the Wisest Intelligence were an unchanging origin of that order inevitably flowing out from nature, not by chance, but by necessity.

If we can thus dispense with an old and ungrounded judgment and the

shoddy philosophy which seeks to hide under a pious appearance an indolent lack of wisdom, then I hope to base a sure conviction on incontrovertible reasons *that the world gives evidence of a mechanical development from the general natural laws as the origin of its arrangement and, secondly, that the manner of the mechanical development which we have presented is the true one*. If we wish to render judgment whether nature is sufficiently capable of bringing into existence the ordering of the planetary structure through a mechanical sequence of its laws of motion, then we must first consider how simple the movements are which the celestial bodies observe: they have nothing inherently in them which requires a more precise determination than what the universal rules of natural forces bring with them. The orbital movements arise from the combination of the force moving downward, which is a certain consequence of the properties of matter, and the projectile movement, which can be seen as the effect of the first, as a velocity attained through the fall downward in which only a certain cause was necessary to deflect the vertical fall sideways. After once reaching the necessary determination of these movements, nothing else is required to maintain the orbital motions permanently. They arise in empty space through the combination of the projectile force, once impressed, with the power of attraction flowing from fundamental natural forces, and from that point on they suffer no change. The analogies in the harmony of this movement themselves demonstrate the reality of a mechanical origin so clearly that we can entertain no doubts about it, for the following reasons:

1. These movements have a continuous shared direction: of the six main planets and the ten satellites, not a single one moves, either in its forward motion or in its axial rotation, in any other direction than from west to east. Moreover, these directions are so precisely coordinated that they deviate only a little from a common plane, and this plane, to which everything is related, is the equatorial plane of the body which rotates on its axis at the central point of the entire system in exactly the same direction and which has become, through its predominant power of attraction, the reference point for all motions and thus necessarily

participates in them as precisely as possible. This is proof that the collective movements arose and were determined in a mechanical way in accordance with general natural laws, that the cause which either impressed or guided the sideways movements governed all the space of the planetary structure and there obeyed the laws which materials located and moving in a common space observe, and that all the different movements finally assume a single direction to align themselves as precisely as possible with a single plane.

2. The velocities are constituted as they must be in a space where the force of movement is at the central point, namely, they decrease in steady degrees with the distances from this point and are lost in the remotest distances with a total exhaustion of movement, which displaces the vertical fall to the side only very slightly. Beyond Mercury, which has the greatest orbital force, we see these velocities diminish in stages and in the outermost comets they are as insignificant as they can be without falling straight down toward the sun. We cannot object that the rules of the central movements in circular orbits require that the closer to the mid-point of the general downward motion, the faster the orbital velocity must be. For why must the particular celestial bodies near to this centre have circular orbits? Why are the closest ones not very eccentric and the ones further away not orbiting in circles? Or rather, since they all deviate from this measured geometric precision, why does this deviation increase with the distances? Do these relationships not indicate a point to which all movement originally was directed and, according to the measure of its proximity to this point, attained a greater level of precision, before other determining factors changed its directions into what they are now?

If, however, we now wish to exclude the planetary structure and the origin of movements from the general natural laws in order to ascribe them to the immediate hand of God, then we immediately realize that the analogies referred to openly contradict such an idea. For, firstly, with reference to the general harmony in direction, it is clear that here there is no reason why the celestial bodies must organize their orbits

precisely in one single direction, unless the mechanics of their development had determined the matter. For the space in which they move provides an infinitely small resistance and limits their movements as little in one direction as in another. Thus, God's choice would not have the slightest motive for tying them to one single arrangement, but would reveal itself with a greater freedom in all sorts of deviations and difference. There is still more. Why are the planetary orbits so exactly related to a common plane, namely, to the equatorial plane of that large body which rules their orbits in the mid-point of all motion? This analogy of the immediate hand of God, instead of showing a reason for its inherent propriety, is rather the cause of a certain confusion, which would be removed through a free deviation in the planetary orbits. For the forces of attraction of the planets now disturb to a certain extent the similarity in the form of their movements, and they would not obstruct one another at all, if they were not so precisely moved to a common plane.

Even more than all these analogies, the clearest mark of the hand of nature is revealed in the lack of the most precise determination in those relationships which it has striven to attain. If it were for the best that the planetary orbits were oriented almost on a common plane, why are they not oriented with extreme precision? And why has a portion of that deviation remained in place, when it should be avoided? If, therefore, the orbits of planets near the sun have received a large enough orbital impulse to maintain an equilibrium with the force of attraction, why is there still something lacking for a complete equilibrium? And why are their orbits not perfectly circular, if only the Wisest Intention, reinforced with the greatest capability, worked to produce this arrangement? Is it not clear to see that the cause which set up the orbital paths of the celestial bodies, while striving on its own to bring them to a common plane, could not achieve that completely and that, in the same way, the force which governed celestial space when all matter, now developed into spheres, received its orbital velocities really worked to bring the spheres near the mid-point into an equilibrium with the force pulling downward, but was unable to achieve

complete precision. Can we not here recognize the general method of nature, which, because of the interference of the different interactions, is always made to deviate from exactly determined measurements? And will we really find the reasons for this way of constructing things only in the end purposes of such an immediately commanding Highest Will? We cannot, without demonstrating stubbornness, deny that the estimable way of explaining the characteristics of nature through a recitation of their benefits does not in this instance contain the hoped for proof to demonstrate a basis for it. Certainly, with respect to benefits for the world, it was entirely irrelevant whether the planetary orbits were fully circular or a little eccentric, or whether they fully coincided with the common interrelating plane or should still deviate somewhat from it. Rather, if it was indeed necessary to be restricted with this sort of harmony, then it would be best for them to have it completely in themselves. If what the philosopher said is true, that God constantly practices geometry, and if this is reflected in the methods of the general natural laws, then certainly this principle of the immediate work of the Omnipotent Will would be perfectly traceable and the latter would reveal in itself all the perfection of geometrical precision. The comets belong among these natural deficiencies. We cannot deny, that with respect to their paths and the changes they thereby undergo, we should see them as imperfect links in creation, which can neither serve to provide comfortable dwelling places for reasoning beings nor to become useful for the greatest good of the entire system, in that they, as has been conjectured, could at some point have served the sun as nourishment. For it is certain that most comets would not achieve this purpose before the collapse of the entire planetary system had been reached. In the theory of the immediate highest organizing of the world without a natural development from universal natural laws such an observation would be objectionable, although at the same time it is certain. But in a mechanical form of explanation, the beauty of the world and the revelation of that omnipotence of the Almighty are glorified by this in no small way. Since nature contains in itself all possible stages of heterogeneous variety, it extends its circumference

over all types from perfection to nothingness, and even the deficiencies are a sign of the excess for which its essence is inexhaustible.

We can believe that the analogies cited could well prevail over prejudice to make the mechanical origin of the planetary system worthy of adopting, if certain reasons derived from the very nature of the subject did not still seem to contradict this theory completely. Celestial space, as has already been mentioned several times, is empty, or at least filled with infinitely sparse material, which, as a result, can provide no means of impressing the common motions on celestial bodies. This difficulty is so significant and valid that Newton, who had reason to trust the insights of his philosophy as much as any other mortal, saw himself compelled here to abandon the hope of resolving through natural law and material forces the transmission of the orbital forces present in the planets, in spite of all the harmony which pointed to a mechanical origin. It is a troubling decision for a philosopher to give up the effort of an investigation in the case of a compound phenomenon which is still remote from the simple basic laws and to be satisfied with the reference to the immediate hand of God. Nevertheless, Newton acknowledged here the dividing line separating nature and the finger of God from each other, the pattern of set laws of the former and the nod of the latter. After the doubt of such a great philosopher, it may appear presumptuous still to hope for some fortunate progress in a matter of such difficulty.

But this very difficulty, which deprived Newton of the hope of understanding on the basis of natural forces the orbital forces allotted to the heavenly bodies, whose direction and arrangements make up the system of the planetary structure, was the origin of the theory which we have presented in the previous sections. It sets up a mechanical theory, but one which is far from the theory which Newton found unsatisfactory and on account of which he rejected all basic causes, because, if I may be so bold as to say it, he made a mistake in maintaining that his doctrine was the only possible one of its kind. It is quite easy and natural, with the help of Newton's difficulty, from a short and basic

conclusion to reach certainty about the mechanical style of explanation which we have set down in this treatise. If we presuppose (and we cannot do otherwise than acknowledge the fact) that the previous analogies establish with the greatest certainty that the harmonious and well- ordered interrelated movements and orbits of the celestial bodies point to a natural cause as their origin, then this cause cannot be the same material which now fills celestial space. Thus, the material which earlier filled these expanses and whose movement was the reason for the present orbiting of the heavenly bodies, after it had collected on these spheres and thus cleaned out the spaces which we now see as empty, or, what flows directly from this, the materials themselves out of which the planets, the comets, even the sun are made up, must at the start have been spread out in the space of the planetary system and, in this condition, have set themselves in the motions which they maintained when they united in particular clusters and developed the celestial bodies, which contain in themselves all the previously scattered matter making up the worlds. We have little difficulty seeing in this idea the mechanical impulse which might have set in motion this material of self-developing nature. The very impulse which brought about the union of the masses, the force of attraction, which is inherently present in matter and which, thus, with the first stirring of nature, is really suitable to consider the first cause of motion, was the source of that mechanical impulse. The direction which, through the effects of this force, always aims right at the mid-point, here creates no problems. For it is certain that the fine material of the scattered elements in its vertical motion downward would have had to develop motion in different directions both through the heterogeneity of the points of attraction and through the obstacles which their vectors create by intersecting with each other. Among these motions the certain natural law which causes all materials restricting each other through reciprocal interaction finally to be brought to a condition where they induce change in each other as little as possible produces both the uniformity in the direction and the appropriate levels of velocity, which are carefully balanced at each distance according to the

centripetal force. Through the combination of these, the elements do not strive to deviate either above or below, for all the elements thus have been made to run, not just in one direction, but also in almost parallel free circles around the common point of downward motion in the sparse celestial space. These movements of the particles must have kept going from this time on, once the planetary spheres had developed out of them, and remain in place now, through the combination of the sideways momentum implanted once and the centripetal force, for an unrestricted future period. On this basic principle, so easy to grasp, rest the uniformity in the directions of the planetary orbits, the precise relationship to a common plane, the amount of the projectile impetus appropriate to the power of attraction at a location, the decreasing accuracy of these analogies over distance, and the free deviation of the outermost celestial bodies on both sides as well as in the opposite direction. If these indications of the reciprocal dependency in the requirements for development point with more obvious certainty to a material in motion originally distributed through all space, then the total lack of all materials in this now empty celestial space, except for what the bodies of the planets, the sun, and the comets are composed of, proves that this very material would have had to have been at the start in a condition of being spread out. The ease and correctness with which all the phenomena of the planetary structure have been derived from the assumption of this basic principle in the previous sections is the completion of such a conjecture and gives it a value which is no longer arbitrary.

The certainty of a mechanical theory for the origin of the planetary structure, particularly of ours, will be elevated to the highest peak of conviction, if we consider the development of the celestial bodies themselves, the importance and size of their masses, according to the relationship which they have with respect to their distance from the central point of gravitation. For in the first place, the density of their material, when we consider them as a total cluster, decreases in constant stages with distances from the sun, a fixed condition which points so clearly to the mechanical arrangements of the initial development

that we can demand no more. They are put together out of materials in such a way that those of the heavier sort have reached a deeper position in relation to the common point of downward motion and, by contrast, the lighter sort a distance further away. This condition is necessary in all sorts of natural development. But with an arrangement issuing from the immediate Divine Will, there is not the slightest reason to encounter the relationships mentioned above. For although it might immediately seem that spheres further away must consist of lighter materials so that they could not notice the necessary effect of the diminished force of the sun's rays, this purpose pertains only to the composition of the material located on the outer surface and not to the deeper varieties on the inside of its cluster. The heat of the sun never has any effect on these inner materials, which serve only to make effective the planet's power of attraction, which is to make the bodies moving around it sink down towards it. Therefore, they cannot have the slightest relationship to the strength or weakness of the sun's rays. If we then ask why the densities of the Earth, Jupiter, and Saturn, as determined by the correct calculations of Newton, stand in relation to each other as 400 to 94.5 to 64, then it would be absurd to attribute the cause to God's intention, which adjusted the densities according to the degrees of solar heat, for then our Earth can serve as a counterexample. In the case of the Earth, the sun only affects such a small part under the outer layer with its rays, that the part of the Earth's cluster which must have some relationship with these rays does not by a long way make up the millionth part of the total planet. And the remaining part is entirely indifferent in this matter. Thus, if the material of which the celestial bodies consist has a well-ordered relationship in mutual harmony with the distances and if the planets cannot now restrict each other, separated as they are from one another in empty space, then their matter must have previously been in a condition where they were able to bring about a common effect on one another in order to limit them to locations proportional to their specific gravity. This could have happened only if their parts before development had been spread out in the entire space of the system and if they took up locations appropriate to their

densities, in accordance with the general laws of motion.

The relationship among the sizes of the planetary masses, which increases with distances, is the second reason by which the mechanical development of the celestial bodies, and especially our theory of that, is clearly demonstrated. Why do the masses of the celestial bodies approximately increase with the distances? If we subscribe to a theory which assigns everything to God's choice, then no purpose can be imagined why the further planets have to have larger masses other than the fact that because of the preponderant strength within their sphere of attraction they would be able to hold onto one or several moons, which are to serve the inhabitants destined for the planets by making their stay comfortable. But this purpose could have been achieved just as well by a preponderant density in the interior of their clusters. And why then would the lightness in the material flowing from special grounds, something which goes against this relationship, have had to remain and be so overwhelmed by the preponderance of the volume that the mass of the higher planets became more significant than the mass of the lower ones? When we do not take into account the manner of the natural development of these bodies, then we have difficulty being able to provide a reason for this relationship. But in the light of mechanical theory nothing is easier to grasp than this arrangement. When the material of all planetary bodies was still spread out in the space of the planetary system, the power of attraction developed spheres out of these particles. Undoubtedly the spheres must have been bigger the further the location of their developing globe was away from that common central body, which from the mid-point of the entire space limited and hindered this combining as much as it could by means of its powerful force of attraction.

We will notice with satisfaction the features of this development of the celestial bodies from basic material spread out at the start in the width of the intervening spaces separating their orbits from each other. These, according to this concept, must be deemed empty compartments from which the planets have appropriated the materials for their develop-

ment. We perceive how these intervening spaces between the orbits have a relationship to the size of the masses which developed out of them. The width between the orbits of Jupiter and Mars is so large that the space enclosed in it exceeds the area of all the lower planetary orbits taken together. But it is worthy of the largest of all the planets, the one which has more mass than all the others collectively. We cannot attribute this distance of Jupiter from Mars to the intention that their powers of attraction were to interfere with each other as little as possible. For according to such a reason, the planet between two orbits would always find itself closest to the planet whose power of attraction combined with its own could disturb their dual orbits around the sun as little as possible; as a result, the planet would be closer to the one with the smallest mass. Now, according to the correct calculations of Newton, the force with which Jupiter can affect the orbit of Mars is related to the force which it exercises on Saturn through their combined forces of attraction is as 1/12512 to 1/200. So we can easily calculate by how much Jupiter would have had to be closer to the orbit of Mars than to that of Saturn, if their distance away had been determined with their external relationship in mind and not through the mechanism of their development. However, this phenomenon is quite different. For in relation to the two orbits above and below it, a planetary orbit often stands further away from the one in which a smaller planet runs than from the path of the larger mass of the two. However, the extent of the space around the orbit of each planet always has a correct relationship to its mass. Thus, it is clear that the manner of their development must have established these relationships and that, because these arrangements seem to be bound up with this development, as their causes and effects, we will in reality estimate it most correctly if we consider the space included between the orbits as the container of that material out of which the planets were built. From this it immediately follows that the size of these spaces must be proportional to masses of the planets. However, this relationship will be augmented with the further planets because of the greater scattering of the basic material in their first state in these regions. Therefore,

of two planets which are almost equal to each other in mass, the one further away must have a larger space in which to develop, that is, a greater distance to the two nearest orbits, both because the material there was inherently of a specifically lighter variety and because it was more widely scattered than in the case of the planet which developed closer to the sun. Thus, although the Earth together with the moon still does not appear to be equal to Venus in its physical contents, nevertheless, it required for itself a greater room for development, because it had to be built out of a more scattered material than this lower planet. For these reasons, we can assume, so far as Saturn is concerned, that its sphere of development stretched much further on the distant side than on the side of the central point (as this holds true for almost all planets). Consequently, the intervening space between Saturn's orbit and the path of the higher celestial body next to Saturn, which we can assume is above it, will be much wider than the space between Saturn and Jupiter.

Thus, everything in the planetary structure proceeds in stages out into all limitless distances with accurate relationships to the first force of development, which was more effective near the central point than far away. The diminution of the impressed projectile motion, the deviation from the most precise agreement in the direction and the orientation of the orbits, the densities of the celestial bodies, the scarcity of nature in relation to the space where they developed, everything diminishes stage by stage from the centre into the far distances. Everything shows that the first cause was bound up with the mechanical rules of movement and did not take place through a free choice.

But what illustrates as clearly as anything else the natural development of the celestial bodies out of the basic material originally spread out in the now empty celestial space is the agreement, which I take from M. de Buffon (which, however, in his theory does not by a long way have the benefit it does in ours). For, according to his observation, if we add up together the planets whose masses we can determine by calculation, namely, Saturn, Jupiter, Earth, and the Moon, they give

a cluster whose density stands in relation to the density of the body of the sun as 640 to 650. In this comparison, since these are the major parts of the planetary system, the remaining planets (Mars, Venus, and Mercury) hardly merit counting. Thus, we will with good reason be astonished at the remarkable equality which governs between the materials of the planetary structure collectively, if we consider it as a single united cluster, and the mass of the sun. It would be an irresponsible foolishness to ascribe this analogy to chance, that materials, among a variety so infinitely different that there are a few encountered even on our Earth which are fifteen thousand times more dense than others, nevertheless comes so near a ratio of 1 to 1 in the total. And we must concede that, if we consider the sun as a mixture of all types of matter, which in the structure of the planets are separated from each other, all of them together seem to have developed in one space, originally full of material uniformly spread out. These materials were collected on the central body without distinction. For the development of the planets, however, they were divided up in proportion to the altitudes. I leave it to those who cannot subscribe to the mechanical development of the celestial bodies to explain from the motives of God's choice such a remarkable arrangement as this, if they can. I will finally stop establishing more proofs for a matter of such convincing clarity as the development of the planetary structure out of the forces of nature. If people are in a position to remain unmoved in the midst of so many convincing details, then they must either lie far too deep in the bonds of prejudice or be entirely incapable of rising above the jumble of received opinions to the observation of the purest truth of all. Meanwhile, we can believe that nobody except the very foolish, on whose approval we may not count, can deny the correctness of this theory, if the harmonies which the planetary structure has with all its links to the benefits of reasoning creatures did not appear to have something more than general natural laws as its basis. We believe correctly that skilful arrangements which point to a worthy purpose must have as their originator a Wise Intelligence, and we will become completely satisfied when we consider that, since the natures of things

acknowledge no other original source than just this, their fundamental and universal arrangements must have a natural inclination to proper and really mutual harmonious consequences. We will thus not allow ourselves to feel strange if we become aware of the arrangements of the planetary structure rich in mutual advantages for creatures and attribute these to a natural consequence arising out of the general laws of nature. For what issues from these is not the effect of blind accident or of unreasoning necessity. It is, in the last analysis, based upon the Highest Wisdom from which the universal arrangements derive their harmony. One conclusion is entirely correct: If, in the arrangement of the world, order and beauty shine forth, then a God exists. But another is no less well established: If this order could have emerged from the general natural laws, then all of nature is necessarily the effect of the Highest Wisdom.

If people nevertheless let themselves at their own discretion acknowledge the immediate application of the Divine Wisdom in all the ordering of nature, which includes in itself harmony and beneficial purposes, while they do not credit the development out of general laws of motion with any harmonious consequences, then I would like to advise them in their contemplation of the planetary structure to direct their eyes not to a single celestial body but to the totality, in order to tear themselves for once away from this delusion. If the steep inclination of the Earth's axis in relation to the plane of its annual orbit is to be a proof of the immediate hand of God because of the well-loved changes in the seasons, then people should insist on this relationship in connection with the other celestial bodies. Then they will become aware that it is different in each one and that in this difference there are even some planets that do not have this feature at all, as, for example, Jupiter, whose axis is perpendicular to the plane of its orbit, and Mars, whose axis is almost perpendicular. Both of these enjoy no difference in the seasons and are, nonetheless, as much works of the Highest Wisdom as the others are. The moon satellites of Saturn, Jupiter, and the Earth would seem to be special configurations of the Highest Being, if the free departure from this purpose throughout the

entire planetary system did not illustrate that nature produced these arrangements without being disturbed by an extraordinary constraint in its free actions. Jupiter has four moons, Saturn five, the Earth one, and the other planets none at all, although it immediately seems that the other planets were in greater need of moons than the former group because of their longer nights. If we admire the proportional equilibrium of the projectile force impressed on the planets with the centripetal force at their distance as the reason why they run almost in circles around the sun and are adapted to be residences for sensible creatures because of the uniformity in the heat distributed in this way and look upon that as the immediate finger of the Almighty, then we will be led back at once to the general laws of nature, when we consider that this planetary arrangement loses itself gradually with all grades of diminution in the depths of the heavens and that even the Highest Wisdom, which derived satisfaction from the regularity of planetary motion, did not exclude the deficiency with which the system ends, since it runs out in complete irregularity and disorder. Regardless of the fact that it is essentially established for perfection and order, nature includes in itself in the range of its multiplicity all possible changes, even deficiency and deviation. Just this unlimited fecundity of nature has produced the inhabited celestial globes, as well as the comets, the useful mountains and the harmful cliffs, the habitable landscapes and barren deserts, the virtues and vices.

PART THREE

which contains in it an attempt, based on natural analogies, to establish a comparison between the inhabitants of different planets.

> He, who through vast immensity can pierce,
> See worlds on worlds compose one universe,
> Observe how system into system runs,
> What other planets circle other suns,
> What varied Being peoples every star,
> May tell why Heaven has made us as we are.
>
> (Pope)[1]

Appendix

In my view it is a disgrace to the nature of philosophy when we use it to maintain with a kind of flippancy free-wheeling witty displays having some apparent truth, unless we are immediately willing to explain that we are doing this only as an amusement.[2] Thus, in the present essay I will not introduce any propositions except those which can really expand our understanding and which are at the same time so plausibly established that we can scarcely deny their validity.

It may appear that in this sort of project the freedom to be poetical has no real limits, that in judging the make-up of those who live in distant worlds we could allow unbridled fantasy much more free rein than a painter in an illustration of the flora and fauna of undiscovered lands, and that these very ideas could not be proved right or wrong. Nevertheless, we must admit that the distances of the celestial bodies from the sun involve certain relationships which bring with them a vital influence on the different characteristics of the thinking natures found on these very bodies. Their way of working and suffering is associated

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[1] [*Translator's Note*: The quotation, which Kant gives in German, comes from Alexander Pope's *Essay on Man*, Epistle I.]

[2] [*Translator's footnote*: Kant's text has "if" rather than "unless," which seems clearly wrong in the context of the entire sentence.]

with the composition of the material to which they are bound and depends upon the quantity of impressions which the world arouses in them, according to the relationship of their living environment with the centre of the power of attraction and heat.

I am of the opinion that it is not particularly necessary to assert that all planets must be inhabited. However, at the same time it would be absurd to deny this claim with respect to all or even to most of them. Given the richness of nature, where worlds and systems are only sunny dust specks compared to the totality of creation, there could, in fact, also be deserted and uninhabited regions without the slightest function in nature's purpose, namely, the contemplation by sensible beings. It would be conceded, even if one wished to consider things on the basis of God's wisdom, that sandy and uninhabited deserts make up large stretches of the earth's surface and that there are in the earth's oceans abandoned islands where no human being is found. Meanwhile, a planet is far less in relation to the totality of creation than is a desert or an island in relation to the earth's surface.

Perhaps all the celestial bodies have not yet completely developed. Hundreds and maybe thousands of years are necessary for a large celestial body to reach a stable material condition. Jupiter still appears to be in this state of disharmony. The remarkable changes in its form at different times have already led astronomers for a long time to assume that the planet must be experiencing large upheavals and is a long way from having a calm outer surface, a condition which must pertain for a planet to be inhabited. If Jupiter is uninhabited and even if it is never to have any inhabitants, would that not be an infinitely small natural expenditure compared to the immeasurable size of the total creation? And if nature were carefully to display all her richness in every point of space, would that not be much more a sign of nature's poverty than of her abundance?

But it is more satisfying for us still to assume that if Jupiter is uninhabited right now, nonetheless the planet will be inhabited in the future, when it has had time to develop completely. Our Earth perhaps

existed for a thousand years or more before it was in a condition to be able to support human beings, animals, and plants. The fact that a planet reaches this complete state only after a few thousand years does nothing to detract from the reason for its existence. For this very reason the planet will be around for a longer time in the future in its state of complete development, once it has attained it. For there is a certain natural principle that everything which has a beginning gets steadily closer to its dissolution and that much closer to destruction the further it is from its origin.

One can only approve of the satirical portrayal by that witty person from the Hague who, after quoting the general news from the scientific world, could humorously present the imaginary picture of the necessary habitation of all planets. "Those creatures who live in the forests of a beggar's head," he says, "had for a long time thought of their dwelling place as an immeasurably large ball and themselves as the masterworks of creation. Then one of them, whom Heaven had endowed with a more refined soul, a small Fontenelle of his species, unexpectedly learned about a noble man's head. Immediately he called all the witty creatures of his district together and told them with delight: We are not the only living beings in all nature. Look here at this new land. More lice live here."[1] If the final part of this conclusion provokes laughter, that happens not because it is far removed from the way human beings judge things, but because that very same mistake, which among human beings has basically a similar cause, seems more excusable in our case.

Let us judge in an unprejudiced manner. This insect, which in its way of living as well as in its lack of worth expresses very well the condition of most human beings, can be used for such a comparison with good results. Since, according to the louse's imagination, nature is endlessly well suited to its existence, it considers irrelevant all the rest of creation which does not have a precise goal related to its species as

[1] [*Translator's Note*: Bernard le Bovier de Fontenelle (1657-1757), French writer].

the central point of nature's purposes. The human being, who similarly stands infinitely far from the highest stages of being, is sufficiently bold to flatter himself with the same imaginative picture of his existence as essential. The limitlessness of creation contains within itself, with equal necessity, all natures which its superbly fecund richness produces. From the most refined classes of thinking beings right down to the most despicable insect, no link is irrelevant to nature. And not a single one can fail to appear without in the process fracturing the beauty of the whole, which consists in the interrelatedness. Meanwhile, everything is determined by universal laws which nature effects through the combination of forces originally planted in it. Because nature's process produces only what is appropriate and ordered, no particular purpose is permitted to disturb and break her results. In its initial development a planet's creation was only an infinitely small consequence of nature's fertility, and it would now be somewhat absurd that nature's well- grounded laws should defer to the specific purposes of this atom. If the composition of a celestial body establishes natural barriers against its becoming inhabited, then it will not have inhabitants, even though in and of itself the planet would be more beautiful if it had its own population. The excellence of creation loses nothing in such a case, for among all large quantities the infinite is the one which is not diminished by the subtraction of a finite part. It would be as if one wished to complain that the space between Jupiter and Mars is unnecessarily empty and that there are comets which are not populated. In fact, however, that insect may appear as unworthy to us as we wish, but to nature it is certainly more appropriate to maintaining its entire class than a small number of more excellent creatures, of which there would nevertheless be infinitely many, even if one region or locale should lack them. Because nature is endlessly fertile in producing both species, in their preservation and their destruction we really see both equally abandoned disinterestedly to the universal laws. Indeed, has the possessor of those inhabited forests on the beggar's head ever created greater disasters among the races of this colony than the son of Philip brought about among the race of his fellow citizens, when

his wicked genius gave him the idea that the world was created only for his sake?[1]

However, most of the planets are certainly inhabited, and those that are not will be in the future. Now, what sort of interconnections will be brought about among the different types of these inhabitants through the relationship between their place in the cosmic structure and the central point from which the warmth which gives life to everything extends outwards? For it is certain that, with the materials of these celestial bodies this heat will bring with it certain relationships in their compositions proportional to the distance from the centre. In this comparison, the human being, who is, among all sensible beings, the one we know most clearly, although at the same time his inner composition is still an unexplored problem, must serve as the foundation and common reference point. We do not wish here to comment on his moral characteristics or even on the physical arrangement of his structure. We want only to explore how the capacity to think sensibly and the movement of his body, which obeys that, suffer restrictions because of the material composition to which he is linked, proportional to the distance from the sun. Regardless of the infinite distance encountered between the power of thought and the movement of matter, between the reasoning spirit and the body, it is nevertheless certain that a human being, who receives all his ideas and conceptions from impressions which the universe awakens in his soul by means of the body, both with respect to their clarity and to the skill of combining and comparing them, which we call the capacity for thought, is totally dependent on the composition of this material stuff to which the Creator has bound him.

The human being is created to take in the impressions and emotions which the world is to arouse in him through that very body, which is the perceptible part of his being. The body's material serves not only to impress on the imperceptible spirit which lives inside him the first

[1] [*Translator's note*: The "son of Philip" referred to is Alexander the Great].

ideas of the external world but also is indispensable in its inner working for repeating these impressions and linking them together, in short, for thinking.[1] As a person's body grows, his intellectual capabilities also proportionally attain the appropriate stage of full development and first acquire a staid and soberly mature capacity when the fibres of his corporeal machine have gained the strength and endurance which mark the completion of their development. Those capabilities develop early enough within him, thanks to which he can cope sufficiently with the necessities of life to which he is bound by dependence on external things. Some people's development remains at this level. The ability to combine abstract ideas and, through a free use of one's understanding, to gain control over passionate tendencies comes late. Some never reach this state during their entire lives. However, in all people this ability is weak; it serves the more primitive forces which it should nonetheless govern. In the control of these lower forces consists the good quality of a person's nature. When we consider the life of most people, it seems that this creature has been created to absorb liquids, like a plant, to grow, to propagate the species, and finally to grow old and die. Among all living things, human beings are the poorest at realizing the purpose of their existence, because they exhaust their excellent capabilities in those pursuits which other creatures, with far less capability, nonetheless attain more confidently and conveniently. The human being would even be the creature most worthy of contempt among all of them, at least from the point of view of true wisdom, if the hope for the future did not elevate him and if the time for a full development of the powers closed up inside him did not lie in store.

When we look for the cause of the obstacles which keep human nature so debased, we find it in the coarseness of the material stuff in which

[1]Psychological principles have established that, thanks to the present arrangement by which creation has made soul and body mutually interdependent, not only does the soul have to arrive at all ideas of the universe through the association with and the influence of the body but the practice of its power of thinking also depends upon the body's condition, and it borrows the essential capability for thought with the body's help.

his spiritual component is buried, in the stiffness of the fibres and the sluggishness and immobility of the fluids which should obey the movements of his spirit. The cerebral nerves and fluids provide him only crude and unclear ideas, and because he cannot offset the provocation of sensory stimulations in the inner workings of his thought process by means of sufficiently powerful ideas, he is taken over by his passions and dulled and disturbed by the turmoil of elements which maintain his machine. The attempts of reason to stand up against this and to drive away the confusion with light from the power of judgment are like moments of sunshine when thick clouds constantly interrupt and darken their serenity.

This coarseness in the stuff and fabric of the constitution of human nature is the cause of that lethargy which keeps the soul's capabilities continually weak and powerless. Coping with reflections and ideas clarified by reason is an exhausting condition. The soul cannot be placed in it without resistance. And because of a natural tendency the physical machine soon falls out of that state back into a condition of suffering, since sensory stimulations have a determining influence on and govern all its behaviour.

This lethargy in his power to think, a consequence of the dependence on a crude and awkward material, is the source not only of vice but also of error. The soul is held back because of the difficulty involved in the effort to scatter the clouds of confused notions and to distinguish universal knowledge, which arises from comparing ideas, from sense impressions, and prefers to bestow a quick approval on and is content with the possession of an opinion which the sluggishness of its nature and the resistance of the material scarcely allow it to see in perspective.

In this dependency, the spiritual capabilities disappear at the same time as the vitality of the body. When, on account of the weakened circulation of the fluids, extreme old age keeps warm in the body only thick juices, when the flexibility of the fibres and the agility in all movements decrease, then the powers of the spirit congeal in a similar fatigue. Rapidity of thought, clarity of ideas, liveliness of wit, and the

capacity of memory grow feeble and cold. The ideas which, through long experience, have become ingrained still compensate to some extent for the departure of these powers, and the understanding would betray its incapacity even more clearly, if the intensity of passions, which require its rein, did not decline at the same time and even earlier.

From all this it is clear that the powers of the human soul are limited and hemmed in by the obstacles of a coarse material stuff to which they are most intimately tied. But there is still something all the more worth remarking: the fact that this specific composition of the stuff has an essential relationship to the degree of influence with which the sun enlivens it and makes carrying out the animal functions efficient, an influence proportional to its distance away. This necessary connection with the fire which spreads out from the mid-point of the planetary system so as to maintain the required motion in the material stuff is the basis for an analogy which will be firmly established here between the different inhabitants of the planets. Thanks to this relationship, every single class of these inhabitants is bound by the necessity of its nature to the place which has been allocated to it in the universe.

The inhabitants of Earth and Venus would not be able to exchange their living environments without the mutual destruction of both. The material out of which the inhabitants of Earth are made is proportional to the degree of heat for their distance from the sun. Thus, it is too light and volatile for an even greater heat, and in a hotter sphere it would suffer from violent movements and a breakdown of its nature, arising from the scattering and drying up of the fluids and a violent tension in its elastic fibres. The inhabitants of Venus, whose cruder structure and sluggishness in the elements of their formation require a stronger solar influence, would in a cooler celestial region freeze and die from a lack of vitality. In the same way, the body of an inhabitant of Jupiter would have to consist of far lighter and more volatile material, so that the very small motion which the sun can induce at this distance away could move these machines just as powerfully as it does in the lower regions.

I summarize all this in one general idea: *the material stuff out of which the inhabitants of different planets, including even the animals and plants, are made must, in general, be of a lighter and finer type, and the elasticity of the fibres as well as the advantageous construction of their design must be more perfect in proportion to their distance away from the sun.*

This relationship is so natural and well grounded that not only do the fundamental motives of higher purpose, which in the study of nature are normally considered merely weak reasons, lead to it, but also at the same time the proportions of the specific composition of the materials making up the planets confirm it. These are derived from Newton's calculations as well as from the basic principles of cosmogony, which endorse the same concept according to which the material stuff out of which the celestial bodies are built is always of a lighter type in the more distant ones than in those closer to the sun. This point must necessarily bring with it a similar relationship for the creatures which develop and maintain themselves on them.

We have established a comparison between the material composition which sensible creatures on the planets essentially have in common. Thus, following the introduction of this idea, it is easy to consider that these relationships will also lead to a result which, so far as their spiritual capacities are concerned, has a necessary dependence on the material of the machine which they inhabit. Thus, we can conclude with more than probable assurance *that the excellence of thinking natures, the speed of their imaginations, the clarity and vivacity of their ideas, which come to them from external stimuli, together with the ability to combine ideas, and finally, too, the rapidity in actual performance, in short, the entire extent of their perfection, is governed by a particular rule according to which these characteristics will always be more excellent and more complete in proportion to the distance of their dwelling places from the sun.*

Since this relationship is so plausible that it is almost a demonstrated certainty, we have an open field for pleasant speculations arising from

the comparison of the characteristics of these different inhabitants. Human nature, which in the scale of being holds, as it were, the middle rung, is located between the two absolute outer limits of perfection, equidistant from both. If the idea of the most sublime classes of sensible creatures living on Jupiter or Saturn provokes the jealousy of human beings and discourages them with the knowledge of their own humble position, a glance at the lower stages brings content and calms them again. The beings on the planets Venus and Mercury are reduced far below the perfection of human nature. What a view worthy of our astonishment! On one side we saw thinking creatures among whom a Greenlander or a Hottentot would be a Newton; on the other side we saw people who would admire Newton as if he were an ape.

> Superior beings, when of late they saw
> A moral Man unfold all Nature's law,
> Admir'd such wisdom in an earthly shape,
> *And shew'd a NEWTON as we shew an Ape*. (Pope)[1]

What an advance in knowledge will the insight of those blissful beings of the highest celestial spheres not attain! What beautiful results will this illumination of knowledge not have for their moral constitution! When intellectual insights have the appropriate level of perfection and clarity, they have in themselves far more vital charms than the attractions of sense and are able to govern these successfully and tread them underfoot. How beautifully will the very Godhead, who pictures Himself in all creatures, present His own portrait in these thinking beings; like a sea unmoved by storms of passion, they will calmly receive and shine back His image! We will not extrapolate these assumptions beyond the limits prescribed for a physical treatise; only we do once again take note of the above mentioned analogy *that the perfection of the spiritual as well as the material worlds in the planets from Mercury right up to Saturn, or perhaps beyond Saturn (insofar as there are still other planets), grows and advances in an appropriate*

[1] [*Translator's Note*: The quotation comes from Alexander Pope, *Essay on Man*, Epistle II. Kant quotes the German version and adds italics to the last line].

sequence of stages proportional to their distance from the sun.

Since this principle flows, in part, naturally from the consequences of the physical interrelationship between the dwelling places and the centre of the system, it is, to that extent, appropriately acceptable. On the other hand, a real look at the most excellent habitations prepared for the superb perfection of these natures in the higher regions confirms this rule so clearly that it should almost demand complete assent. The active speed associated with the merits of a lofty nature is better fitted to the rapidly changing time periods of the higher spheres than the slowness of lethargic and more imperfect creatures.

Telescopes teach us that the changes in day and night on Jupiter occur in ten hours. What would an inhabitant of Earth really do with this division of time, if he were placed on this planet? The ten hours would scarcely be sufficient for the rest this crude machine requires to recuperate in sleep. What would the preparation for going through waking up, getting dressed, and the time taken up with eating demand as a share of the available time? And how would a creature whose activities occur so slowly not be rendered confused and incapable of anything effective when his five hours of business would be suddenly interrupted by an intervening period of darkness of exactly the same duration? However, if Jupiter is inhabited by more perfect beings who combine more elastic forces and a greater agility in practice with a more refined development, then we can believe that these five hours are for them exactly equivalent to and more than the twelve hours of the day for the humble class of human beings. We know temporal demands are somewhat relative. This cannot be known and understood except from a comparison of the size of the task which is to be performed and the quickness with which it is carried out. Thus, the very same time which for one type of creature is, as it were, merely an instant can for another creature be a long period in which a large sequence of changes develops because of its speed and efficiency. According to plausible calculation of the axial rotation of Saturn, which we have dealt with above, the planet has a very much shorter division

of day and night. It therefore allows us to assume even more advantageous capabilities in the nature of its inhabitants.

Finally, everything comes together to confirm the proposed principle. Nature has visibly distributed her goods as richly as possible to the far regions of the world. The moons, which compensate the active beings of these blissful regions for the loss of daylight with a sufficient substitute, are placed in that area in the greatest number, and nature appears to have taken care to make them effective with its full assistance, so that there is be scarcely any time when the moons are prevented from using it. So far as moons are concerned, Jupiter has an obvious advantage over all the lower planets, and Saturn once again has the advantage over Jupiter. The arrangement whereby Saturn has the beautiful and useful ring going around it probably creates even greater advantages for its composition. By contrast, the lower planets, for whom this advantageous feature would be a useless waste and whose class approaches much more closely the borders of irrationality, either do not share such an advantage at all or only very little.

However (and here I anticipate an objection which could destroy all the harmony I have mentioned) we cannot consider the greater distance from the sun, this source of light and life, as nothing but a drawback for which the spaciousness of the dwelling places in the further planets would serve as only a partially useful remedy, making the objection that in fact the higher planets have a less advantageous situation in the cosmic structure, a position which would be injurious to the perfection of those abodes, because they receive a weaker influence from the sun. For we know that the effects of light and heat are determined, not by their absolute intensity, but by the capacity of the material stuff which absorbs them and, to a greater or lesser extent, resists their impetus and that, therefore, the very same distance at which we could designate a moderate climate for a coarser type of material would destroy more subtle liquids and would be a damaging intensity for them. Thus, only a more refined material stuff composed of more mobile elements is appropriate to make the distances of Jupiter

or Saturn from the sun a fortunate location.

Finally, because of a physical connection, the excellence of the natures in these higher regions of the heavens seems to be connected with an ability to last which is appropriate to it. Decay and death can afflict these excellent beings less than they do our low natures. Exactly the same torpor in the material and coarseness in the stuff, the specific principle in the degradation in the lower echelons, are the cause of the tendency which they have to decay. When the juices which nourish the animal or human being and make it grow, as they are assimilated among the small fibres and increase its bulk, can no longer expand the spatial dimensions of their vessels and canals, when growth is already complete, then these nourishing liquids which add to the body's mass must, through the mechanical impulse which is used to feed the animal, constrict and block up the hollow sections of their vessels and destroy the structure of the entire machine with a gradually increasing paralysis. We can believe that, although mortality also eats away at the most perfect beings, nevertheless there is an advantage in the refined quality of the material stuff, in the elasticity of the vessels, and in the lightness and efficacy of the fluids which make up those more perfect entities living in the distant planets. This benefit checks for a much longer time the frailty which results from the inertia of a coarse material and gives these creatures a durability whose length is proportional to their perfection. Thus, the fragility of human life is appropriately linked to human baseness.

I cannot leave these observations without anticipating a doubt about it, which could naturally arise from a comparison of these opinions with our previous principles. In dealing with the dwelling places in the planetary structure, we have acknowledged the wisdom of God in the number of satellites which illuminate the planets with the most distant orbits, in the velocity of their axial rotation, and in the composition of their material stuff, which is proportional to the effects of the sun. This Divine Wisdom has organized everything so beneficially for the advantage of sensible beings who inhabit the planets. But how would we now

reconcile the concept of intentionality with a mechanical theory, so that what the Highest Wisdom itself devised is assigned to raw material stuff and the rule of providence is turned over to nature left to act on its own? Is the first not rather a confession that the organizing of the cosmic structure is not developed through the general laws of the latter?

We will soon dispose of this doubt if we only think back to what was cited previously in a similar case. Must not the mechanism of all natural movements have an essential tendency towards only such consequences as those which really coincide with the project of the Highest Reason in the full context of interrelationships? How can they have erratic inclinations and an independent scattering originally, when all their characteristics, from which these consequences develop, are themselves regulated by the eternal idea of the Divine Understanding, in which all things must necessarily interconnect with each other and fit together? When we think correctly, how can we justify the kind of judgment where we see nature as a rebellious subject, which can be kept on a regular track and in communal harmony only through some kind of compulsion which sets limits to her free conduct, unless we maintain something to the effect that nature is a self-sufficient principle, whose characteristics acknowledge no cause and which God seeks to force according to His purposeful plan, to the extent that this is possible? The closer we come to getting to know nature, the more we will realize that the universal ways in which things are made are not strange and separate from each other. We will be sufficiently convinced that they have essential connections, through which they are coordinated, to support each other in providing a more perfect state, in the reciprocal effects of the elements on the beauty of material things and at the same time for the benefit of the spiritual realm and that, in general, the single natures of things in the field of universal truths already make up amongst themselves, so to speak, a system, in which one is related to another. We will also immediately realize that the connection between them in their common origin is unique to them and that from this they, as a totality, have created their

fundamental properties.

And now to apply this repeated observation to the proposed goal: the very same universal laws of motion which have allocated to the highest planets a location far from the mid-point of the power of attraction and inertia in the planetary system, have at the same time in this way set them in the most advantageous condition to develop themselves as far as possible from the point where they are connected to the coarse material and, indeed, with greater freedom. However, these laws have also simultaneously set the distant planets in a rule-bound relationship to the influence of the heat which, in accordance with the same law, extends out from this mid-point. Now, it is these very requirements which have removed obstructions from the development of the cosmic bodies in these distant regions and made the production of movements, which is dependent upon this development, faster and, in brief, created a more properly established system. Since, finally, the spiritual beings necessarily depend upon the material stuff to which they are personally bound, it is no wonder that the perfection of nature is shaped by both points into a single coordinated system of causes and on the same foundations. In a more precise view, this harmony is also not something sudden or unanticipated. Because through a similar principle the latter beings have been infused into the universal constitution of matter, the spiritual world is more perfect in the distant spheres for exactly the same reasons that the physical world is.

Thus, everything in the total extent of nature holds together in an uninterrupted series of stages through the eternal harmony which makes all the steps related to each other. The perfections of God have clearly revealed themselves at our levels and are no less beautiful in the lowest classes than in the more lofty ones.

> Vast Chain of Being! Which from God began,
> Natures ethereal, human, angel, man,
> Beast, bird, fish, insect, what no eye can see,
> No glass can reach! From Infinite to thee,
> From thee to nothing.

(Pope)[1]

We have continued the earlier conjectures, being faithful to the main idea of physical relationships. This has kept them on the path of a reasonable credibility. Should we permit ourselves one more digression from this track into the field of fantasy? Who indicates to us the border where grounded probability stops and arbitrary fictions begin? Who is so bold as to dare an answer to the question whether sin exercises its sway also in the other spheres of the cosmic structure or whether virtue alone has established her control there?

> The stars perhaps enthrone the exalted soul
> As here vice rules, there virtue has control. (von Haller)

Does not a certain middle position between wisdom and irrationality belong to the unfortunate capacity to sin? Who knows whether the inhabitants of those distant celestial bodies are not too refined and too wise to allow themselves to fall into the foolishness inherent in sin; whereas, the others who live in the lower planets adhere too firmly to material stuff and are provided with far too little spiritual capacity to have to drag the responsibility for their actions before the judgment seat of justice? With this in mind, would the Earth and perhaps even Mars (so that the painful consolation of having fellow sufferers in misfortune would not be taken from us) be alone in the dangerous middle path, where the experience of sensual charms has a powerful ability to divert from the ruling mastery of the spirit? The spirit, however, cannot deny its ability to resist, unless its inertia prefers instead to allow itself to be carried away by these charms. Thus, here is the dangerous transition point between weakness and the capacity to resist, for the very same advantages which raise the spirit above the lower classes, set it up at a height from which it can again sink down infinitely deeper under them. In fact, both planets, Earth and Mars, are the most central rungs of the planetary system, and for their inhabitants we can

[1][*Translator's Note*: The quotation comes from Alexander Pope, *Essay on Man*, Epistle I. Kant quotes the German version].

assume perhaps with some probability a physical condition as well as a moral constitution half way between the two end points. But I prefer to leave this thought to those who find in themselves more reassurance in dealing with unprovable knowledge and more motivation to set down an answer.

Conclusion

We do not really know what the human being truly is today, although our awareness and understanding should instruct us in this matter. How much less would we be able to guess what a human being is to become in future. However, the curiosity of the human soul grasps with great eagerness for this far distant subject and strives to put some light on such unilluminated knowledge.

Is the everlasting soul for the full eternity of its future existence, which the grave itself does not destroy but only changes, always to remain fixed at this point of the cosmos, on our Earth? Is it never to share a closer look at the rest of creation's miracles? Who knows whether it is not determined that in future the soul will get to know at close quarters those distant spheres of the cosmic structure and the excellence of their dwelling places, which already attract its curiosity from far away? Perhaps that is why some spheres of the planetary system are already developing, in order to prepare for us in other heavens new places to live after the completion of the time prescribed for our stay here on Earth. Who knows whether those satellites do not circle around Jupiter so as to provide light for us in the future?

It is permissible and appropriate to entertain ourselves with ideas of this kind. But no one will ground future hope on such uncertain imaginary pictures. When vanity has demanded its share of human nature, then the immortal spirit will, with a swift leap, raise itself up above everything finite and further develop its existence in a new relationship with the totality of nature, which arises out of closer ties with the Highest Being. From then on, this lofty nature, which in itself contains the source of blissful happiness, will no longer be scattered

among external objects in order to seek out a calming effect among them. The collective essence of creatures, which has a necessary harmony with the pleasure of the Highest Original Being, must also have this harmony for its own pleasure and will light upon it only in perpetual contentment.

In fact, when we have completely filled our dispositions with such observations and with what has been brought out previously, then the sight of a starry heaven on a clear night gives a kind of pleasure which only noble souls experience. In the universal stillness of nature and the tranquillity of the mind, the immortal soul's hidden capacity to know speaks an unnamable language and provides inchoate ideas which are certainly felt but are incapable of being described. If among thinking creatures of this planet there are malicious beings who, regardless of all incitements which such a great subject can offer, are nevertheless in the condition of being stuck firmly in the service of vanity, how unfortunate this sphere is that it could produce such miserable creatures! But, on the other hand, how lucky this sphere is that a way lies open, under conditions which are the worthiest of all to accept, to reach a blissful happiness and nobility, something infinitely far above the advantages which the most beneficial of all nature's arrangements in all planetary bodies can attain!

The End

Immanuel Kant

Universal Natural History and Theory of the Heavens

Translated by Ian Johnston

Using Isaac Newton's mathematical principles and laws of motion and taking up an idea first suggested by Emanuel Swedenborg, Immanual Kant, the greatest philosopher of the eighteenth century, in 1755 produced a detailed account of what has come to be known as the Nebular hypothesis, still considered the most plausible explanation for the formation of the solar system: the structure of the universe develops from widely dispersed materials scattered throughout space which, under the influence of the forces of attraction and repulsion, rotate, flatten, and over time produce stars and planets. In his account, Kant also considers the ring of Saturn, the formation of moons, and other celestial phenomena (like the axial rotation of the planets and the development of comets). He also lets his imagination run rampant in a fascinating exploration of what living creatures must be like on other planets.

The extent to which Kant fully understood the mathematical complexities involved in his explanation has been strongly challenged, but, for all that, his account is an important document in the most important trend of natural science in the eighteenth century, that is, placing scientific accounts of natural phenomena on a historical basis and seeing them as the result of a process of development maintained by mechanical forces (a revolutionary trend which culminates a century later in the work of Charles Darwin). In this way, while honoring Newton's achievement, Kant is also issuing a direct challenge to it.

Kant's work also offers an enthusiastic defense of the design argument (that the harmonies in the design of the solar system are the best physical evidence we have for the existence of God), a claim which, ironically enough, his later philosophy would do so much to undermine.

About the Translator

Ian Johnston was born in Valaparaiso, Chile, and educated in Canada and England. He has a BSc from McGill in Geology and Chemistry, a BA from Bristol in English and Greek, and an MA from Toronto in English. For many years he taught as a college and university-college instructor in British Columbia teaching English, Classics and Liberal Studies. He is the author of *The Ironies of War: An Introduction to Homer's Iliad*. Since 2006, he has had 18 titles published, including his translation of Homer's *Iliad* and *Odyssey*, which were issued in both book and audio form. He is now retired and living in Nanaimo, British Columbia.

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