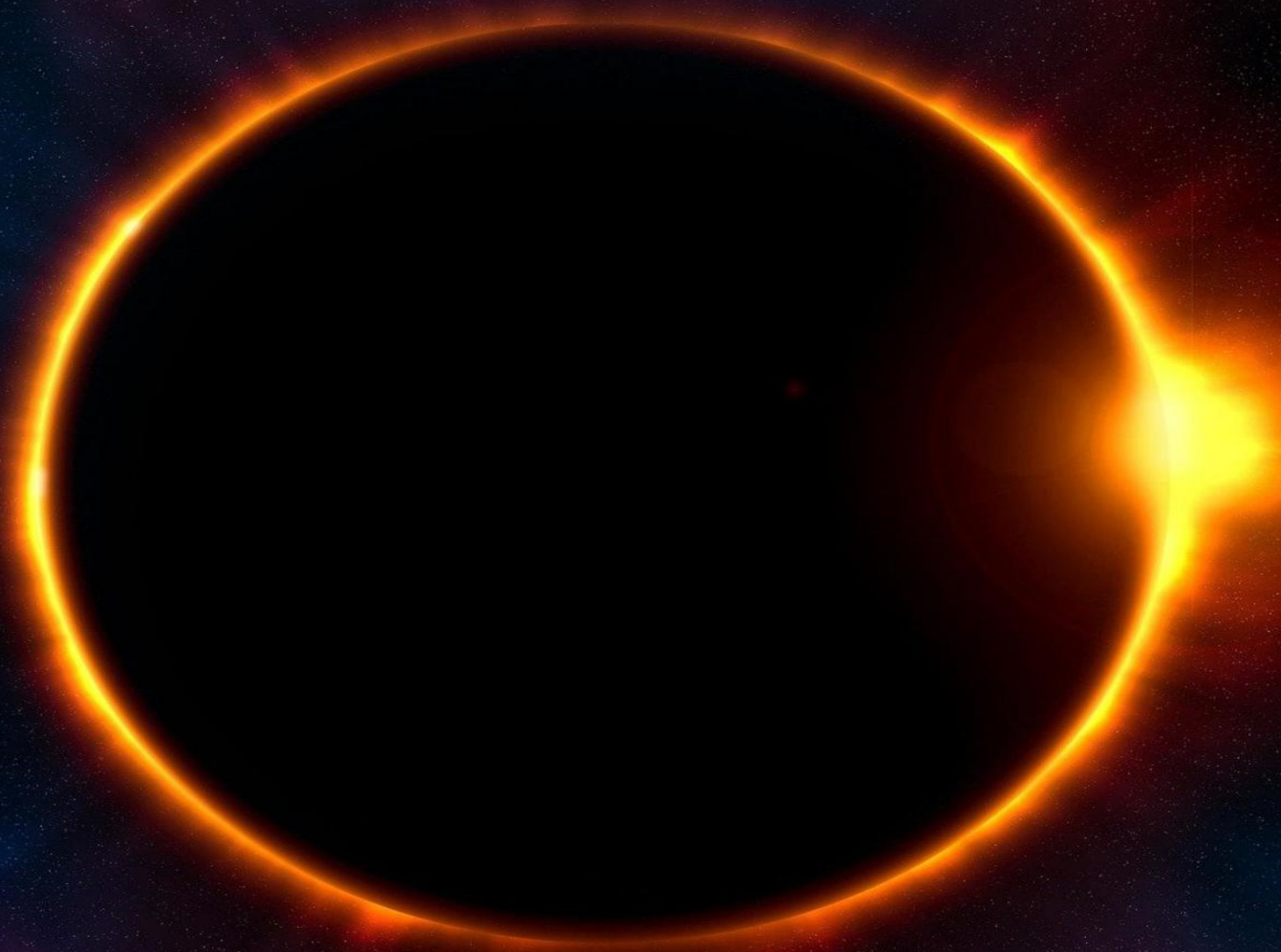


Modern cosmogonies

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CHAPTER I

FROM THALES TO KANT

Very few even of the most savage tribes are content to take the world just as it is without speculating as to how it came to be. For time has three dimensions—past, present, and future—and we can no more restrict our thoughts within one of them than we can exist corporeally in Flatland. We are, indeed, told that the Abipones and Esquimaux refuse to trouble themselves with questions of origin, on the ground that the hard facts of life leave no room for otiose discussions; but even they feel obliged to justify their incuriosity. In easier circumstances they, too, would claim the entirely human privilege of 'looking before and after,' as their forgotten progenitors may have done. It is, indeed, difficult to think at

all about the framework of nature without attempting to divine, were it only by a crude surmise, the process of its construction. We are instinctively convinced that there is no such thing as fixity of condition. So far, Heracleitus was in the right.

Experience tells us of continual change in ourselves and whatever surrounds us. Reason teaches us that its minute momentary effects, if pursued backward for an indefinite time, must sum up to a prodigious total. No limit, that is to say, can be put to the difference between what is and what was. Yet the machinery of modification must somehow have been set going. An initial state is prescribed by logical necessity. And the start was made on certain terms—it was 'conditioned.' But the conditioned implies the absolute; ordinances, an enactive power. The inevitableness of the connection has been more or less obscurely perceived wherever men have tried to establish some kind of accord between phenomena and intuition, with results legible in

the wavering outlines of many primitive cosmogonies. Only, however, in the Hebrew Scriptures has the idea of Creation been realized

in all its fulness and freedom; elsewhere the gods invoked to bring the world into existence themselves demanded a birth-history, a theogony being the usual and necessary prelude to a cosmogony.

Nevertheless 'picture-thoughts' (it has been well said),
[1]

and nothing more, were represented by these prefatory genealogies. Night and darkness loomed into personal shape, and from the obscurity of their union the creatures of light radiantly sprang, and proceeded, according to a predetermined law of order, to sort out the elements of chaos and dispose them into cosmical harmony.

This mythical phase of thought terminated in Greece with the rise of the Ionian School of Philosophy. Immemorial legends, discredited by the advent of a new wisdom, took out a fresh lease of life under the guise of folk-lore; Orphic fables were left to the poets and the people; and the sage of Miletus set on foot a speculative tradition, maintained by a long succession of metaphysicians down to the very threshold of the recent scientific epoch. All

were what we should call evolutionists—Thales of Miletus no less than Descartes and Swedenborg; their main object, in other words, was to find a practicable mode of evoking a systematic arrangement of related parts from the monotony of undifferentiated confusion. Now, in essaying this enterprise they encountered two distinct problems. One was concerned with the nature of the primeval world-stuff; the other with the operations to which it had been submitted. Modern theorists have made it their primary object to expound the mechanism of cosmic growth—the play of forces involved in it, the transformations and progressive redistribution of energy attending it. But

questions of this kind could only in the scantiest measure be formulated by early thinkers, who accordingly devoted their chief attention to selecting an appropriate material for the exercise of their constructive ingenuity.

Thales asserted all things to have been derived from water, and water is still among unsophisticated tribes the favourite 'Urstoff.' Anaximenes substituted air. Heracleitus gave the preference to the mobile and vital element (as he thought it) of fire. Anaximander, on the other hand, might put forward a colourable claim to priority over Sir William Crookes in the invention of 'protyle.' He imagined as the matrix of the world a boundless expanse of generalized matter, containing potentially all the chemical species, which, separating out by degrees through the affinity of like for like, formed, by their contrasts and conjunctions, the infinitely varied sum of things. The successors of Anaximander had recourse to spontaneously arising condensations and rarefactions as the mainspring of development; but all these vague principles were quickly crowded into oblivion by the definite and intelligible doctrine of the 'four elements' enunciated by Empedocles, which, guaranteed by the imprimatur of Plato, took a place unchallenged for nearly two millenniums among the fundamentals of science. Erroneous and misleading though it was, it yet served as a means of regulating appearances and guiding vagrant ideas—it was a track to follow in the absence of any better method of orientation.

Leucippus and his more famous disciples, Democritus and Epicurus, were the first who ventured to trace the mechanical history of the cosmos. Their primordial atoms were endowed with weight, and it was weight or gravity which ultimately determined their spacial arrangement and mutual relations. Rectilinear in the first draft of the scheme, their movements were somewhat arbitrarily deflected by

Epicurus; and the gyrations thence ensuing eventually became, so to speak, authentic and precise in the Cartesian vortices and in Swedenborg's solar maelstrom. Kant's *Natural History* of the universe was another, though an entirely separate branch of the atomistic stock. The Democritean atoms, however, and in a lesser degree the Kantian atoms, differed essentially from the ultimates of chemical analysis postulated by Dalton. They were a scratch lot—an incongruous assortment of fragments, rather than of elementary portions of matter, indefinitely various in size, shape, and mass.

Nor was this diversity created as a mere play of fancy. It was strictly necessary to the plan of action adopted. For, apart from heterogeneity, there could obviously be no development. Absolute uniformity involves absolute permanence. Change can originate only through inequality. There must be a tilt of level before the current will begin to flow; some cause of predominance is needed to set it going in a given direction. Here, of a surety, is the initial crux of all cosmogonists. They usually surmount it by assuming the occurrence of casual condensations, secure against disproof, while incapable of verification. The expedient thus begs the question.

Theories of world-history made an integral part of antique philosophy. Each founder of a school aimed at establishing a complete system of knowledge, co-extensive with phenomena, embracing all things, from the *primum mobile* overhead to the blade of grass underfoot, and rationalizing the past, present, and future of the comprehensive whole. Modern science is less ambitious. Aspiring to no such vast synthesis, it is content to make laborious acquaintance with the facts of nature, to ponder their implications, and, if possible, to reconstruct on the basis supplied by them the condition of things in the 'dim backward' of unmeasured time. By no such means, it is true, can their beginning in any real sense be arrived at; the weapons of induction

become

blunted long before they strike home to the heart of that mystery; yet the recognition of their inadequacy brings compensation in a fuller mastery over their properly adapted use. Science, so called, was, indeed, down to the Baconian era, a turbid mixture of physics with metaphysics. The solution, it might be said, was attempted of an insoluble material which refused to dissolve and was hindered from precipitating.

The Greek view of nature was essentially pantheistic. The Ionian speculators appear to have presumed without expressly insisting upon its self-regulating power. Aristotle alone emphatically rejected the doctrine of cosmic vitality or sub-conscious tendencies. But Plato accepted and magnified the Oriental tradition; the conception of a 'World-Soul' owed to him its vague splendour and perennial fascination. The function of the Platonic vice-creator (for such the World-Soul must be accounted) was that of moulding brute matter into conformity with the archetypal ideas of the Divine mind; this was not, however, accomplished once for all, but by a progressive spiritualizing of what in its nature was dead and inanimate. The spiritual agent, becoming incorporated with the universal frame, lent to it a semblance of life, an obscure sensitiveness, and even some kind of latent intelligence; and so the *anima mundi* was shaped into existence, and continued century by century to be the subject and source of imaginings beyond measure wild and fantastic.

One great thought—that of the unity of nature—lay behind them, but its significance was lost amid the phantasmagoria of Neo-Platonist exaltations. Hence the Bacchic fervours of Giordano Bruno took their inspiration; here was the groundwork of Spinoza's pantheism. Shelley's Demiorgon, felt as 'a living spirit,' seen as 'a mighty darkness,' descended lineally from that strange essence—

formless, inarticulate, devoid of individual self-consciousness—which animated the submerged philosophy of Neo-Pagan times with the barren ardours of mysticism. The doctrine, in its original and more sober version, obtained memorable expression in Virgil's melodious hexameters:

'Principio cœlum, ac terras, camposque liquentes,
Lucentemque globum lunæ, Titaniaque astra,
Spiritus intus alit, totamque infusa per artus
Mens agitat molem, et magno se corpore miscet.'

In Conington's rhymed version they run as follows:

'Know first, the heaven, the earth, the main,
The moon's pale orb, the starry train,
Are nourished by a soul,
A bright intelligence, whose flame
Glows in each member of the frame,
And stirs the mighty whole.'

Kepler was no cosmogonist, but he aspired to found a 'physical astronomy,' and in his gropings for a mechanical power that might suffice to regulate the movements of the heavenly bodies, he stumbled upon a mode of action highly appropriate for the explanation of their growth. His ignorance of the laws of motion precluded him from the conception of velocities persistent in themselves, and merely deflected from straight into curved paths by a constant central pull. Hence he was driven to the twofold expedient of creating a whirling medium for maintaining the revolutions of the planets, and of supposing the sun to exercise a 'magnetic influence,' by which they were drawn into closed orbits. Here, then, central forces made a definitive entry on the astronomical stage, although with scarcely a discernible promise

of their brilliant future. But it was otherwise with the clumsy machinery they helped to animate. Kepler's simple *modus operandi* , adopted, or more probably re-invented by Descartes, was published as an epoch-making discovery in his *Principia Philosophica* (1644), and sprang under its new aspect into swift notoriety. The wide acceptance of the theory of vortices was at least in part due to the impressive largeness of its framework. Descartes left nothing out. The spacious scope of his speculations embraced all that was knowable—nature, animate and inanimate, life and time: 'Planets and the pale populace of heaven,
The mind of man, and all that's made to soar.'

A philosophy, a metaphysic, and a cosmogony were linked together in a single plan. Its author distinguished in matter three gradations of fineness. The coarsest kind was that composing the earth and other opaque bodies; the more sublimated materials of the sun and stars came next; finally, there was the ethereal substance of the skies, so delicately constituted as to be luminous or luminiferous. This last variety was regarded as of subordinate origin. It represented, in fact, a kind of celestial detritus. Interstellar space had gradually become filled with intangible dust, the product of molecular attrition among originally angular solar and stellar particles. Ether was thus supposed to bear to the subtlest description of ordinary matter very much the same sort of relationship that ions presumably do to atoms.

Enough has been said to show that the Cartesian universe was based on crude atomism. Its mode of construction, moreover, evinced a total disregard of mechanical principles. Yet some acquaintance with the laws of motion was by that time easily within reach. The first of the three, at any rate, had been unmistakably enounced by Galileo in 1632, and Descartes himself strongly championed its

validity. Yet he thought it necessary, in order to keep the planets moving, to immerse them in one great self-gyrating vortex centred on the sun, each being further provided with a similar subordinate whirlpool for the maintenance of its domestic system. Comets were left in a singularly anomalous position. They circulated freely on the whole, their exemption from planetary restrictions being tacitly recognized; nevertheless, they took advantage of every encountered swirl to help themselves on towards their destination. Among the fables of pseudo-science Delambre declared that, had the choice been offered to him, he would have preferred the solid spheres of Aristotle to the *tourbillons* of Descartes. 'The spheres,' he added,
[2]

'have proved helpful both for the construction of planetariums representing in a general way the celestial movements, and for their calculation by approximate rules deduced from them; but the system of vortices has never served any purpose whatsoever, whether mechanical or computative.'

Its vogue had, nevertheless, been brilliant and sustained. Advanced thinkers in the time of Louis Quatorze piqued themselves upon being Cartesians. The vortical hypothesis was novel—it seemed daring; and though it might not be true, it had plausibility enough for fashionable currency. Nor did it deserve the unmitigated contempt with which it was

treated by Delambre. A glance at the skies makes us pause before condemning it to scornful oblivion. Just two centuries after its promulgation the first spiral nebula was identified in Canes Venatici. That the heavens swarm with analogous objects is certain, and their status as partially developed systems is visible in every line of their conformation. Our own planetary world may, or may not,

have traversed the stage they so copiously illustrate; but in any case they prove beyond question that vortices variously conditioned are prevalent among the forms assumed by cosmic masses advancing towards an orderly arrangement. Mystical cosmogonies belong to the period of ethnic infancy. They have not ceased to be current. World-fables must be invented wherever the obscure wonder of savage communities is excited by the mysterious spectacle of Nature's apparently designed operations and irresistible power. But they were superseded among peoples in the van of progress by philosophic cosmogonies at the epoch when Thales began to diffuse throughout Ionia the wisdom of the Egyptians and Chaldeans.

Schemes, however, such as he and his successors elaborated result from the discourse of reason unfettered by any close attention to facts. They have been mostly wrought out by men who, in Delambre's words, 'Dissertaient à perte de vue, sans jamais rien observer, et sans jamais rien calculer.'

The insubstantial fabrics reared by them were then fatally discredited by Baconian methods and the Newtonian reign of law; they survived—forms of thought die slowly—but insecurely, with noticeably undermined foundations.

Swedenborg was the last eminent reactionary, and his restoration in 1734 of the Cartesian gyrating medium as the motive power of the solar machine was a palpable failure. It could not be otherwise, since its inceptive idea had grown superannuated. The modern era of scientific cosmogony was at hand.

It was preceded by some remarkable attempts at sidereal generalization. Cosmology is the elder sister of cosmogony. What *is* must be studied before what *was* can be inferred. Precedent states remain visionary unless they can be closely linked to actual and observable conditions. Now about the middle of the eighteenth century an intelligible plan of the stellar

universe, so far as the telescope had then disclosed it, began to be a desideratum. And the enterprise of supplying the need was undertaken independently by two men of obscure origin and imperfect education—one English, the other German.

Thomas Wright, of Durham, was the son of a carpenter at Byer's Green, where he was born September 22, 1711. His life was one of many vicissitudes, but ended happily.

Having struggled hard for a livelihood—now at sea, then again on shore as a clock and almanac maker, a teacher and lecturer—he finally attained, somewhat unaccountably, to distinction and affluence, built himself a handsome house hard by his native shanty, and prosperously and reputably inhabited it during a quarter of a century. He died February 25, 1786, just one year after Herschel had described to the Royal Society the outcome of his first experiments in 'star gauging.' As the originator of the 'cloven disc' theory of the Milky Way, Wright is still deservedly remembered, for although that majestic structure is assuredly

otherwise designed, it was no mean achievement to have initiated the science of its architecture.

Heinrich Lambert was a still more adventurous speculator than his unknown English rival. His father was a poor tailor at Mühlhausen, then in Swiss territory, and he worked as his apprentice. But his irrepressible talents brought him into notice, and he died, in 1777, through the favour of the second Frederick, a Berlin Academician. His *Cosmological Letters*, published in 1761, were entirely original; they were composed in ignorance of what Wright and Kant had already written. In some respects he overtopped them both. He had splendid intuitions, and just touched the confines of greatness. And if his performances fell short of the very highest, it may have been rather through abridgment of opportunity than through lack of capacity. The Milky Way marked, to his apprehension, a sidereal ecliptic, and he

coincided with Wright in regarding it as a disc of aggregated stars, but with breaches and gaps indicating a multiplicity of systems circulating, he thought, round a common centre. Nor did he doubt the existence of other Milky Ways—numberless, remote, unseen—grouped into a combination of a higher order; while beyond, and still beyond, stretched further hierarchies of systems on an ascending scale of magnitude and grandeur.

Our knowledge of the structural facts of the universe can never be made exhaustive; in the middle of the eighteenth century, before Herschel had opened his sidereal campaign, it was barely elementary. Wright and Lambert were accordingly on a stint of material—they had to make bricks with very little straw. Yet they did their best with what was at hand. Both paid profound attention to the stellar heavens; they earnestly sought the true interpretation of the appearances presented by them, holding it possible, as we, despite accumulating difficulties, still do, to harmonize countless detached phenomena in one vast synthetic plan. It was this purpose of fidelity to Nature which gave value to their work, and made it a new thing in cosmological history. This alone lent it impulsive force, and caused the meditations of two lonely thinkers to become effective in stimulating fresh attempts, favoured by improved conditions, to comprehend what actually exists, and to infer thence, with rational confidence, its sources in the vague but undeniable past.

FOOTNOTES:

[1]

Zeller, *History of Greek Philosophy*, translated by S.F. Alleyne, vol. i., p. 86.

[2]

Quoted by R. Wolf, *Handbuch der Astronomie*, Bd. II., p. 593.

CHAPTER II

THE NEBULAR HYPOTHESIS

Immanuel Kant was, in 1751, still in the plastic stage. His period of 'pure reason' was remote, and might have appeared improbable. Such as they were, his distinctions had been won in the field of concrete science, and the world of phenomena invited his speculations more seductively than the subtleties of logic. A seed was accordingly thrown into fertile soil by his reading of Thomas Wright's *New Theory of the Universe*, as summarized in a Hamburg journal. It set him thinking, and his thoughts proved to be of the dynamic order. Wright regarded the heavens under a merely statical aspect. He laid down the first definite plan of their construction, showing that the stars were not scattered at random, but aggregated by method; and this was much for one necessitous human being to have accomplished unaided.

But the young professor of Königsberg could not rest satisfied with the idle contemplation of any subsisting arrangement. His mind was incapable of acquiescing in things simply as they presented themselves; it craved to know further how they came to stand to each other in just such mutual relations. He was, moreover, permeated with Epicurean doctrines. Not in any reprehensible sense. He could not be reproached either as a hedonist or as an atheist. His pleasures were intellectual, his morals austere, his convictions orthodox. Behind the veil of material existence he divined its supreme immaterial Originator, and his perception of the activity in Nature of an ordering First Cause remained equally vivid, whether its disclosures were taken to be by immediate creation or through tedious processes of modification and growth. His large and

luminous view embraced besides the ethical significance which such processes adumbrate. The following sentence shows an appreciation of the place of man in Nature truer and more profound than was attained perhaps by any other of his philosophical contemporaries: 'The cosmic evolution of Nature,' he wrote in memorable words, 'is continued in the historic development of humanity, and completed in the moral perfection of the individual.'

[\[3\]](#)

Nevertheless, he owed to a community of ideas with Democritus as to the origin of the universe. Lucretius had cast over him the spell of his lofty diction, and captured his scientific adhesion by the stately imagery of his verse. With reservations, however. Docile discipleship was not in his line. He availed, then, of the Democritean atoms, but by no means admitted their concourse to be fortuitous. Chaos itself, as he conceived it, half concealed, half revealed the rough draft of a 'perfect plan.' His postulates were few. He demanded only a limitless waste of primordial matter, animated by no forces save those of gravitation and molecular repulsion, and undertook to produce from it a workable solar system. The attempt was no more than partially successful. Retrogressive investigations lead at the best to precarious results, and this one, in particular, was vitiated by a fundamental error of principle. Its author clearly perceived that planetary circulation must be the outcome of a vortical swirl in the nebulous matrix; but he failed to see that no interaction of its constituent particles could have set this swirl going.

Systems cannot of themselves add to their 'moment of momentum.' No changes of internal configuration avail to increase or diminish the sum of the products obtained by multiplying the mass of each of the connected bodies into its areal velocity projected on a common plane. The sum is

of the algebraic kind. Equal and opposite motions cancel each other, the total representing only the aggregate excess of speed in either direction. A system with all its parts in rapid motion might then conceivably be devoid of moment of momentum. And if this were its state to begin with, it should be its state to the end of time, unless external force were applied to alter it. But the possibility may be dismissed as ideal. The establishment of so nice a balance as it would require is not practically feasible. In the actual world one side of the velocity account would be sure to exceed the other, albeit very slightly, and the smallest predominance would suffice to set on foot an eventual rotation of the system.

Had Kant been better acquainted with mechanical principles, he might then have safely trusted to the minute beginnings supplied by aboriginal inequalities of movement and dissymmetry of arrangement for the development in his colossal dust-cloud of the wheeling movement necessary for his purpose; and he would thus have escaped stumbling at the threshold of his daring inquiry. Rightly averse to employing arbitrary expedients, he piqued himself on the simplicity of his postulates, and was thus misled into substituting an imaginary for a real cause. The hypothesis adopted by him was that the particles forming the initial inchoate mass fell together by gravity, but were deviated from rectilinear courses through the effects of unequal resistance. And he derived from the combination of these multitudinous encounters a common axial rotation for the entire agglomeration. The futility of this mode of procedure was adverted to by M. Faye in 1885.

[\[4\]](#)

The deviations in question would, in fact, exactly balance one another, there being no reason why movement in one sense should prevail over movement in the opposite;