FROM NEBULA TO NEBULA

GEORGE HENRY LEPPER

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NEBULA TO NEBULA

BEING AN EXPANSION OF THE PRINCIPLE OF
UNIVERSAL GRAVITATION TO THE
SOLUTION OF COSMIC PROB-
LEMS IN GENERAL

BY

GEORGE HENRY LEPPER

"Our globe seen by God is a transparent law, not a mass of facts."—EMERSON.

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INTRODUCTORY

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INTRODUCTORY

The object of this book is twofold: first, to present a revaluation of certain time-honored cosmological theories in the light of present-day knowledge; and, second, to mold and apply this knowledge in a way to raise astronomy as nearly as may be to the rank of an exact science. Among the chief things I expect to prove are: That the theory of inertial motions, far from being an aid, is a positive hindrance to the scientific development of the principle of universal gravitation. That all the activities of the universe, including planetary motions both of revolution and rotation, and planetary, solar, and stellar heat, are born of the moment, and are not the inheritance from a dead and mythical past. That were the earth conceived to be gently brought for a moment to complete rest, on being released it would not drop to the sun, but would gradually recover its interrupted movements. That were the sun this instant by fiat chilled to zero, he would in the next, the fiat being lifted, immediately begin the generation of heat within himself until in a calculable period he would be radiating with the same intensity as now. That, in short, were the whole universe to doze off for a time into a state of cold and comatose inaction, it would, on waking, by virtue of its inherent vitality, resume its suspended operations with only slight dislocation of its parts, and with a rapid return to its present swing and vigor. In other words, the universe is a perpetual automaton.

In order to give the reader, in the outset, a general survey of the field to be covered in the chapters follow-

ing, I invite his attention to the subjoined syllabus of contrasts between the teachings of current science on the one hand, in roman, and my own views, in italic, on the other.

Current and Proposed Theory Contrasted

The original supply of energy in the universe can neither be increased nor diminished. It is rapidly being converted from available into useless energy by the wasting of heat into space, and by the gradual agglomeration of matter into fewer and fewer bodies of larger and larger mass.

> *On the contrary, this energy is on the increase, for* GRAVITATION IS FRESHLY EVOLVED EVERY INSTANT, *and is consequently continually adding new increments to the aggregate of force. Besides, the plain law of gravitation is that the nearer particles of matter approach each other the stronger their mutual attraction becomes, hence agglomeration means increase of energy.*

Planetary motions of revolution and rotation are the reactions of unknown and unguessed causes that existed tens of millions of years ago, and which then ceased to act.

> *On the contrary, all these motions are the effects* OF CURRENT, PRESENT-DAY CAUSES IN CONTINUOUS OPERATION.

The sun is shooting through space, but the fact has no further significance.

> *The sun is* FALLING *through space, and it is the impetus of this fall, which is gravitational, combined with the centripetal attraction of the sun, that produces the gyratory motion of the planets.*

The planets travel in ellipses.

On the contrary, they travel in descending spirals. The distinction is important and not captious.

Space is filled with matter that is imponderable.

This fanciful quality need not be predicated of the ether, since motions are shown to be produced by SUBSTANTIAL *causes capable of overcoming great resistance.*

The earth's continents are huddled around the north pole by chance.

They are there because the earth is a "falling body," falling with the sun, and its heavier parts settle naturally to the bottom.

Heavenly bodies attract each other as though their masses were concentrated at their CENTERS OF FIGURE. Hence the various theories of "disrupting tides."

Celestial, like terrestrial, bodies attract each other by their CENTERS OF GRAVITY. *Hence there can be no such thing as disrupting tides.*

Earth-tides are caused by the application of only the second half of the law of gravitation, namely, that bodies attract each other inversely as the square of the distance.

On the contrary, they are amenable also to the first half of the law, that bodies attract each other directly as their masses.

Notwithstanding that the evidence shows that the earth's day is as short as ever it was in historic times, yet it is gradually lengthening by reason of retardation by the tides.

The tides, on the contrary, are the motive force that turn the earth.

The prominences on the sun's rim show that he is in a constant state of ebullition. This condition is brought about by his contraction.

How can a body contract and boil at one and the same time?

The major planets are melting hot because they have had only 100,000,000 of years or so in which to cool.

They are hot because they are GENERATING *heat.*

Gravitation stops producing heat the instant it brings the molecular engines together.

It is just then that gravitation, which is a constant force, is ideally situated to transmute itself into heat by pressure. PRESSURE BEING NOTHING LESS THAN THE CONTINUOUS IMPACT OF MATTER UPON MATTER.

Kepler's third law is empirical.

On the contrary, it is the profoundly simple LAW OF THE LEVER *carried clear around the circumference. The solar system and its component systems are self-balancing units, in consequence of which property all the singular uniformities of planetary motions follow as matters of course. The mysterious "conservation of moment of momentum" is only Kepler's law, or the principle of the lever, disguised.*

The sun rotates on its axis, the equator rotating faster than the middle latitudes.

On the contrary, the sun REVOLVES *and its equatorial acceleration is due to the regular operation of Kepler's third law.*

The surface of Mars is a universal desert, else the surface could not show the markings of the "canals" all over it.

> *On the contrary, his surface is mainly ocean, else the snow-caps, which are very extensive and disappear every season, could not possibly so form and disappear. The surface marks can readily be accounted for by supposing the oceans to be extensively frozen over and seasonal changes to occur on the crust. Tidal waves of thaw-water sweeping over this smooth crust and washing up the icy detritus can explain the regularity of these marks; and alternating snowfalls and thaws the color transformations.*

The moon's surface is exceedingly rough because volcanic. Its oceans have evaporated into space. Its atmosphere has been absorbed by volcanic rock.

> *The moon's oceans have been completely transformed into* SNOW. *Snow covers every inch of land, building upon it plateaus, mountains, craters, etc., according to whether the natural surface is plain, island, pond, or lake. The carerys are the water-basins, whose original contents have flown to the land on snow wings. The low-relief formations are also of snow, on the sea bottoms last uncovered.* THE ABSENCE OF VAPOR IN THE ATMOSPHERE IS EXPLAINED BY THE WELL-KNOWN LAW OF PHYSICS, WHICH SAYS, NO VAPOR CAN ARISE FROM A CRYSTALLINE ICE OR SNOW SURFACE. *Assuming that the lunar night recurrently glaciates the surface* COMPLETELY, *and that the sun by day fails to penetrate down to*

the soil, general evaporation is out of the question. As an absorbent of air (to explain the latter's disappearance) oceans transformed into snowflakes are certainly not a deficient substitute for rock howsoever volcanic and porous. The "smoke" in the hollows, supposed to be volcanic fumes, is snow-storms produced from the thaw-water that periodically wins its way against all odds into the ancient pools. But snow is not vapor, and even vapor might exist in considerable quantity before becoming detectable from this distance.

Nature's processes are all cyclical—except in the case most important of all, world-building. Nebulae change into stars, and stars into dark, dead cinders that encumber space.

Stars are the dynamos whereby gravity, one sort of energy, is, under the established physical law of convertibility, continuously transmuted into heat. Whenever the star becomes so large that the heat generated by it exceeds the radiating power, the body explodes, and passes back again into nebula. Scientists call such a catastrophe a new star, instead of the new nebula that it really is. Hence the title I have chosen: FROM NEBULA TO NEBULA. The *life span of a planetary system! The ultimate physical cycle within the comprehension of finite man! The last round short of Infinity itself!*

II

GRAVITATION VERSUS INERTIA AS THE MOTIVE POWER OF PLANETS

II

GRAVITATION VERSUS INERTIA AS THE MOTIVE POWER OF PLANETS

Probably the first system of celestial motions meriting the epithet "scientific" was that devised by Claudius Ptolemy about the middle of the second century of our era. According to him, the earth was a fixed point and the absolute center of the universe around which the sun, moon, planets, and stars, all revolved, at various distances, every twenty-four hours. So far the theory may be called the *Impressionistic*, inasmuch as it relied wholly upon the concerted evidence of the three senses—sight, hearing, and feeling—which of themselves lead to no other conclusion.

Having once assumed that the heavenly bodies revolve daily around the earth, it was only natural to infer that they do so in circles. But the ancients went further, and gave what seemed to them an unanswerable ground for this inference, namely, that it is metaphysically abhorrent to suppose that the Creator would choose any but the perfect curve (every point of the circumference of a circle being equi-distant from the center) for the heavenly bodies to pursue.

However, systematic observation showed vagaries of movement on the part of the planets that appeared

to contradict this view. Had the question remained simply that of explaining the phenomena, the discovery of the ellipticity of the paths of planets might have been made then and there, and both Copernicus and Kepler been anticipated by many centuries. Unfortunately, the metaphysical deduction as to the perfection of the circle, and the anthropocentric and geocentric ideas of that age, were too deeply rooted in the minds of the ancient philosophers to allow conflicting thoughts to enter. Ptolemy sought to harmonize fact with fancy by the device of imagining the planet to be traveling around in a small circle while the center of that circle was simultaneously describing the main circle or orbit—forming to it a sort of scalloped border, as it were. But he soon found that one such imaginary superimposed cycle did not suffice, so he added another supplementing the first, then still another supplementing the second, and so on, until the final design, when sketched, became absolutely meaningless. These superadded circles bear the general name of *epicycles*.

Such was the state of the science of astronomy during the fourteen centuries immediately preceding the advent of Nicholaus Copernicus (1473-1543). To this man it seemed preposterous that the whole universe, whose immensity was then beginning to be comprehended, should be assumed, quite as a matter of course, to be doing homage to such a grain of sand as our earth. Accordingly, he brought out his celebrated work, *De Orbium Coelestium Revolutionibus*, which is founded upon the principle (note its simplicity) that the universe only *appears* to be circulating around us, because our little earth is turning on its axis—that it is our train, and not the scenery without, that is really in motion. This bit of common sense nearly cost Coper-

nicus his life, and it was only by the display of equal discretion in retracting his utterances that he escaped the rough logic of the Inquisition. However, one error Copernicus voluntarily carried over from the older theory, namely, the circular form of planetary orbits and with it the tinkering device of epicycles.

About sixty-five years later (the telescope having in the interim been invented) John Kepler, as the result of years of arduous observation and mathematical toil, announced his three famous laws of planetary motion, which may be paraphrased as follows:

1. The planets do not revolve in circles at all, but in ellipses. This for all time dispenses with the need of epicycles. Moreover, the sun is not located in the center of the ellipse, but in one of the foci, the focus he occupies being conveniently called the lower to distinguish it from the other.

2. If we imagine the circulating planet to be joined to the central body by an imaginary straight line which keeps traveling continually around the orbit with it, that line (known as the *radius vector*) passes over equal areas in equal periods of time.

3. The cube of the mean distance of any given planet from the sun bears the same ratio to the cube of the mean distance of any other planet, as the square of the time of revolution of the first does to the square of the time of revolution of the second. Example: If a planet B be twice as far as A from the sun, and if B's period of revolution is known to be 24 days, then

$$2^3 : 1^3 :: 24^2 : X^2$$

whence X, A's period, is found to be the square root of 72 days.

Therefore, given the two elements of distance and period of one planet, and the distance or period of another, we can find the missing term.

These laws were to Kepler himself purely empirical; he knew their truth only from observation, BUT NOT THEIR REASON WHY.

In the latter part of the same century (seventeenth) Sir Isaac Newton published his celebrated work, *The Principia,* in which, by a series of exquisite theorems, he proved that Kepler's laws are precisely consistent with the supposition that the body occupying the focus attracts the circulating one "directly as the product of their masses and inversely as the square of the intervening distance." He went even farther, and showed that no otherwise conditioned force would answer. This law is known as the law of gravitation, and lies at the very foundation of astronomical science.

But why doesn't the planet fall into the sun, if it is so attracted? What is the counteracting or sustaining force? These questions presented themselves to Newton, and he made an effort to answer them, taking the specific case of the earth and moon as the most convenient for analysis and illustration.

First, he distinguished the two counteracting forces by name: that drawing the moon to the earth he called *centripetal,* and the other propelling the moon forward in its course he named *centrifugal.*

Now, in Newton's time belief in the literal day of the Mosaic cosmogony was all but universal. Hence (although he did not say so in precise words) he saw nothing unreasonable in assuming as a matter of course that the Creator set the planets in motion at the same time that he gave them their substance and form. Modern science is not satisfied with this naive supposition of Newton's, but having not even a guess to offer in its place as to how, when, or where the motion originated, it tacitly ignores altogether the question of origin, while yet implicitly believing in the reality and

projectile character of the motion itself. *The possibility that there never was such an original motion, but that the planets are being actuated by some presently acting force as powerful and invisible as the centripetal force itself, seems never to have been considered.*

Assuming this initial motion (which is indifferently called "momental," "projectile," or "inertial")—divinely imparted, according to Newton; spontaneous, according to science—the problem still remained how to skimp along with it forever; FOR, BY EXPRESS PROVISO, IT CAN NEVER RECEIVE AUGMENTATION, AND MUST THEREFORE BE THEORETICALLY HUSBANDED AGAINST ALL POSSIBILITY OF WASTING.

The first difficulty that had to be cogitated out of the way was that of a *resisting medium* (atmosphere) in space, for did such a medium exist its inevitable effect would be, or rather must already have been, to wear down the moon's alleged momentum and precipitate it upon the earth. It has been proved beyond dispute, from ancient records of eclipses, that the moon is not only not slowing up, but is actually traveling *faster and faster* as the centuries fly by (10″ of arc in a century), showing the *theoretical* necessity for either an *absolutely void* space, or an *absolutely imponderable* ether. Now, scientifically speaking, space dare not be predicated as void, because light travels through it, which it could not do without its stepping stones, atoms. Hence it is seen that the theory of inertial motions not only starts with their purely speculative origin and existence, but is driven precipitately to build on that aerial nothingness by affirming (no longer merely postulating) the *tertium quid* of a *matter without substance,* a something that is and at the same time is not—a threadbare sophistical device worthy only of the Middle Ages.

Having now by make-believe got our moon into motion, and having transported it into this region of Nothing-something, we are fairly in the midst of Alice's Wonderland with appetite sharpened for further marvels. The next thing we know is that our moon is suddenly switched out of its straight course into a curved one, *but without in the least slackening speed,* so that in a unit of time it covers precisely the same distance through space as it did before! It is plain, is it not, that on this supposition all its alleged momentum is used up in prosecuting this forward motion, and that no surplus energy is left to resist and counteract fresh external strain? But what have we done to cause the moon to turn? Why, we have suspended to it the earth as a pendant, and now require it to carry this load forever without complaining! I have already defined for the reader the term "radius vector." Suppose we represent the earth's attraction on the moon along this line by an elastic string. Whence, I ask, is derived the energy that keeps this string stretched taut? It cannot be filched from the momentum of the moon, for that must be religiously guarded against waste; and, besides, as we have already seen, *it is already wholly appropriated toward linear speed.*

Again, projectile motions are in their very nature fortuitous as to the three elements of location, velocity, and direction. The likelihood, therefore, of all these elements just happening to coincide so as to produce a practically circular orbit is almost inconceivably remote. Supposing this marvel should happen in the case of two planets, which, besides, should travel in almost the same plane, around the same central body, and with a definite relation to each other as to distance and velocity, then the supposition of mere fortuity must be discarded and either divine intervention be invoked or some great fun-

damental law be discovered. Yet not only is this miracle true of two cases in the solar system; it is true of the entire eight. All the primary planets revolve in approximately circular orbits, in nearly the same plane, in the same direction (from west to east) and at speeds bearing an exact relation to each other. Most remarkable still is it, that the satellites revolve around their respective primaries according to equally uniform laws, and the planets themselves "rotate" in the same direction as their orbital revolution! How can mere *chance* account for these marvels?

To sum up, the Projectile theory holds in effect: That the planets are revolving around the sun, and rotating on their axes, from the effects of a force or forces the origin and nature of which are not only unknown but unguessable, and which millions of years ago ceased to act; that they travel through a medium of ghost-matter invented for the purpose; that they can change their courses and bear loads without loss of momentum; that they have marvelously happened to ally themselves to the same sun, to have hit upon approximately the same plane, to be traveling in the same direction, to have velocities bearing a fixed ratio to each other; and, finally, that, after millions of years, no accidents have happened to any of them, by meteoric collisions or otherwise, to disturb this singular correspondence! *But the gravest objection of all to this theory is that it commits the philosophical folly of daring to marry, in undivorcible union, a visionary, fortuitous, finite, unaugmentable, and wasting force, to that of centripetal gravitation, which is in all things precisely what the other is not.*

But why has the theory been so long accepted and implicitly believed in? The answer is simple, and lies in the nature of man himself, who finds in faith of

some kind intellectual as well as religious repose. Just as many honest souls believe in this or that religious dogma under the mistaken conviction that denial thereof involves a denial of God, so do men believe in this inertial theory under the hallucination that to deny it is to sacrifice the doctrine and law of Gravitation itself. This sacrifice is needless—falsehood is never a safe anchor for Truth.

So much by way of destruction. What, now, by way of construction?

The Prime Resultant

What does the nicety of the equipoise between the centripetal and the centrifugal forces suggest to the intelligent reader's mind? Does it not indicate the existence of a second source of gravitation *extraneous* to our system, and simultaneously playing upon the planets from a distance? a gravitational force A pitted against a gravitational force B?—But where is there such a force?

Astronomers have proved, by the most elaborate and painstaking research, that our solar system is headed northwardly at a speed approximating eleven miles a second. Exactness in so delicate a matter, either as to velocity or apex (goal point), cannot reasonably be expected, nor perhaps is it even possible; but the fact of movement and of the general trend is sufficiently well settled. This knowledge is comparatively recent, although the elder Herschel suspected the fact a century or so ago. It was certainly unknown to Newton who, had he but known, might have seized upon it, as we are now doing, as the possible cause of centrifugal motion.

But how do we know that this movement is *gravitational?*[1]

Obviously the first answer to this is, that the burden is on the other side to prove that it is *not* of that character. Newton proved what gravitation can do—that it is a force, that it acts uniformly according to a settled law—and in the absence of proof of some other adequate agency we are bound to assume that which is already established. The second answer is, that falling bodies lower their center of gravity in the direction of fall. If it be true that the sun is falling by gravity, so must the earth be; and on turning to it, behold, its continents are preponderatingly settled toward the north and its waters relegated to the south, showing that the *earth has a bottom* and that that bottom hangs downward toward the north star. The only other planet that is enough like the earth to serve as a criterion of the same fact is Mars, and see, he too shows by his permanent northern snow-cap (the southern disappears every season) that his heavier or land end lies in that direction. Third. The axes of the earth and Mars lie almost if not quite parallel, indicating as by a compass the direction of the gravitational pull. Fourth. Perhaps, however, the most telling proof of all, since it is apparently so isolated, is that of the acceleration of the moon's mean motion, to which reference has already been made. Of this Dr. Young says:[2]

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1 Modern science assumes this motion, also, to be projectile. Is it not wonderfully illuminating to learn that although a bullet can be shot in only one direction at a time, a planet can be projected in at least two ways, and probably in as many more as the exigencies of science may require? Newton postulated that the moon was projected tangentially along the plane of her orbit, **which he assumed to be fixed in space;** but here we have another projection that he knew not of, **at nearly a right angle to the first!** It speaks marvels for the elasticity of his demonstration that he could omit a factor like this new motion, and yet come out right in his result! Or is it that the faith of modern science so far surpasses that of the prophets and martyrs of old? Or have planets perhaps astral bodies and bifurcated trajectories?

2 General Astronomy, Page 301.

> "There remains one lunar irregularity among the multitude of lesser ones, which is of great interest theoretically, and is still a bone of contention among mathematical astronomers, namely, the secular acceleration of the moon's mean motion. It was found by Halley, early in the last century, by a comparison of ancient with modern eclipses, that the month is certainly shorter than it was in the days of Ptolemy, and that the shortening has been progressive, apparently going on continuously * * *. In 100 years the moon, according to the results of Laplace, gets in advance of its mean place about 10″, *and the advance increases with the square of the time?*" (The italics are his.)

Now, the remarkable fact is that falling bodies do by rule increase their velocity precisely in this way, that is, with the square of the time!*

Indeed, what logic would there be in arbitrarily assuming that the universe, which we see filled with countless points of attraction, should *not* have its gravitational influence on our system? After all the various attractions are balanced up, there cannot fail to remain a residuum, an excess, a net resultant, in some one definite direction (not necessarily toward that quarter of the heavens most filled with stars, for proximity and counteraction are also to be considered), which residuum I shall call, for convenience, the PRIME RESULTANT. Defined, this term denotes *the net gravitational pull, both as to force and direction, of the whole universe upon the solar system considered as a* GRAVITATIONAL UNIT. And by the term GRAVITATIONAL UNIT I mean any body, simple, compound, or systemal, moving freely in space

*A resisting medium would of course follow a different law in its effect; that is, it would be practically uniform from year to year.

and flowingly adjusting and disposing itself and its multifarious parts, *as a whole,* into successive states of equilibrium with respect to the myriad gravitational influences acting upon it both from within and without,—in short, *it is any such body habitually engaged in accommodating itself to a common center of gravity.*

Now it is plain, that since the universe in its entirety is responsible for our system's flight, the apex of that flight is just as, or even more, likely to be a blank spot in the heavens as a particular star or group of stars. Moreover, as the sun's position changes, his direction may likewise suffer change; for he has no will of his own, but passively and automatically, by the shortest cut, keeps pursuing that elusive thing, his equilibrium, wherever it may lead him, down the bottomless well of space.

In this equilibristic performance the sun is not alone; he is only one, albeit by far the largest, body in *a great system, which is likewise behaving itself as a gravitational unit.* Each member too of the system down to the minutest asteroid, is doing its "level best," automatically, and by the directest route, to maintain a perfect balance, not only for itself but for the system, and aye, for the universe itself. Each subordinate system is in turn a gravitational unit, doing its duty as such to the same general purpose; each comet, we shall find, is such a systemal unit. Indeed, who can say how many such eddying whorls there may be in the vast spaces around us, or how minute may be the least of them? Contemplating upward, May not our vast solar system be but a member of a systemal unit still greater, and that again of one yet greater, and so on, until our concept of physical infinity begins to take on the definiteness of the finite, and to spell the one word—BALANCE?

In order now to gain a conception of relations and distances, let it be stated that the pole star, which is certainly not far from the *present* location of the apex of our drift, is, in round numbers, 100,000 times farther away than Neptune, our outermost planet, is from the sun, or 50,000 times the width of his orbit. Representing our whole system then as encompassed within a disc one foot in diameter, the star will be about ten miles distant! And if we accept eleven miles a second as the sun's real velocity, it will take a decade, on the scale we have chosen, to advance the system by so much as a single foot!

Returning again to the consideration of the actual system, imagine its members falling in space like the sparks from a burst rocket, and so being drawn downward into the gravitational vortex created by the Prime Resultant. Remember, also, that the planets are tethered to each other and to the sun by ties of gravity whose law is constant and not to be denied. What is more likely, then, than that they should seek to poise themselves on their common center of gravity as upon a fulcrum, and start to gyrate around this pivotal point in great descending spirals, whirled about by the impetus of their own fall? It is not only likely, but it can be mathematically demonstrated to be true.

Here we are forcibly reminded of the Cartesian doctrine of vortices. But Descartes died when Newton was but a child, and so knew naught of the great law of gravitation, nor yet of the sun's trend through space. All Descartes could do was to show mathematically that the planets revolve *as though they were caught in a whirlpool,* but in place of the subtle suction of gravitation he was driven to postulate impossible fluids to carry out his demonstration.

Now as this vast vortex dashes headlong downward, it would be strange indeed if it did not create a gravitational suction of its own, and draw in from the surrounding space bodies belonging in the outskirts of neighboring systems. Or, where its sphere of gravitational influence may happen to brush against other spheres still stronger, the result may be one of loss instead of gain. What is true of the major is no less true of the subordinate systems, and of such systems also as rise still higher in scale.

Granting these views to be true, it inevitably follows that the longer this act of falling continues the faster and faster must our planets revolve—that is, *with the square of the time.* We have seen how this has been proved in the moon's case; but astronomical data can carry us even further. The major axis of the earth's orbit has a forward revolution, and turns completely round in about 108,000 years, showing with each year a slight overshot or excess of speed. *Our sidereal year is therefore growing shorter, just as well as our month.* The same principle holds true as well in the case of the other planets.

The reader may here interject, "All this sounds plausible enough, but still somewhat speculative. You speak of whirling and balancing: How did the whirling begin? How came it to choose one way and not the other? What evidence have you as to the LAW of this balancing process?"

When a pole is delicately poised on a level base, we can with certainty predict that it will not remain upright long, but not the direction in which it will fall. Let it but once begin to topple, and we know it must continue the way it began until it comes to rest upon the ground. Even so massive a system as that of our sun is not superior to the same simple uniform law.

Finding itself originally out of balance with the universe at large, it first toppled and then tumbled, and it is still tumbling, with ever accelerating velocity, down the abyss of space, and will continue to do so until it shall find, or unless it shall find, a place to alight. Why the planets started to turn eastward instead of westward was as much a pure matter of chance as how our pole was to fall—the slightest cause might have sufficed. Once the die was cast, however, it was cast for every body in the system, and all had to follow their leader along the course marked out for them by the rival forces of the sun on the one hand and the Prime Resultant on the other. An endless diagonal line of force and movement resulted for each member of the system. Down spiral stairways they descend, attended by the sun and by each other, *mutually sustaining one another as they go, in perfect equipoise*, A SYMBOL OF ANYTHING BUT CHANCE AND GUESS.

We have already seen how Newton arrived at the law of gravitation by testing its virtue at the touchstone of Kepler's laws. But whereas he tested the truth of that principle from within, it is for us now to test the truth of it, BY THE SAME TOUCHSTONE, from without. He proved, once and for all, that the centripetal force that tethers the planets to their orbits is the same as that which causes the apple to fall. If it be equally true that the centrifugal motion is due to an *external* source of gravitational attraction, then we ought to be able to prove the fact by some means as simple and convincing as Newton proved his part.

Now, weight is our test of the force of gravity—the balance-scale is the instrument for testing weights—and THE LEVER is the mechanical principle governing the balance. If it be true then that the solar system

is really a gravitational unit, or balancing entity, under the control of a distant external attraction, then the velocities and distances of the planets should conform to the lever principle, should they not? And suppose I am able to show that THE LAWS OF KEPLER ARE MERELY THE EXPRESSION OF THOSE OF THE LEVER CARRIED THROUGH THE ENTIRE 360°, what more remains to be proved?

Let R be the longer arm of the lever and r the shorter. Then by rule,

$$R^2 : r^2 :: (2\overset{\frown}{\parallel}R)^2 : (2\overset{\frown}{\parallel}r)^2$$

But in the case of the lever, a weight r at the R end will counterbalance a weight R at the r end; or, expressed in terms of arc, any weight at R need travel only r degrees to counterbalance *an equal weight* through R degrees of the smaller circle; or, again, expressed in terms of units of time required to complete the full circuits, any weight at the R end can take R time units while the same weight at the shorter end must perform its journey in r units.

Taking now the last two terms of our proportion and correcting them so as to express the *time*, in place of the *linear*, length of the respective circumferences, and simultaneously multiplying the first two terms in the same order and manner, to preserve the proportion, we obtain the expression,

$$R^3 : r^3 :: (R \times 2\overset{\frown}{\parallel}R)^2 : (r \times 2\overset{\frown}{\parallel}r)^2$$

"The cubes of the distances are proportional to the squares of the periodic times," Q. E. D.

I therefore claim to have proved: That all the planetary revolutional (as distinguished from rotational) motions of our solar system, and presumably of all planetary systems, are not inertial in their nature

but are due to current, instantaneous causes. That the sun's journey through space is gravitational. That the solar system and each and every one of its component systems are "gravitational units" in the sense herein previously defined. That the sun and his systems are not isolated bodies, but integral parts of the great Whole. That the universe is not in the process of "running down," but is self-regulating (as to motion) and self-sustaining. That the so-called centrifugal motion is gravitational. That the empirical law of "conservation of moment of momentum" is a necessary incident of the law of balance as here enunciated. That the earth's continents are huddled about the north pole because of its falling in that direction. That its axis is fixed, compass-like, for the same reason.* That Kepler's law is that of the lever. That our month and year are really shortening. That the progressive movement of the perihelia of all the planets is due to gravitational acceleration. That the sun's apex is nearer the polar star than heretofore supposed. That the ether of space can now have some "body" to it without imperiling the safety of the universe. That the planets travel in the same direction, in nearly circular orbits, and in approximately the same plane because these are the shortest cuts to individual and general equipose. That, by necessary implication, comets are violent intruders from other systems and require to be assimilated.

Rotational Motions

If I have succeeded in convincing the attentive reader that current causes are responsible for the motions of revolution around a primary, he will be interested to know whether such causes may not also

*The author recognizes the importance of these facts to geology, but reserves their consideration for a future occasion.

be equally efficacious to explain the so-called *axial rotations*. They are.

Students of physics, but unfamiliar with the theory of astronomy, will think I am indulging in playful platitude when I soberly state that planets attract each other by their *centers of gravity*. On the contrary, I am giving utterance to rank astronomical heresy. More than two centuries ago Newton, who lived in the neolithic age of inductive science, and, for all his wonderful genius, was still human and liable to the errors of his day, expressed the opinion that planets behave as though their entire mass were concentrated at their centers of *figure*. This error has been blindly reiterated and adhered to for so long that it may be very difficult to eradicate it, notwithstanding its patent absurdity.

Suppose we were given, for purposes of experiment, a precise miniature of the moon, both as to form and structure, and that we wished first of all to ascertain the position of its center of gravity. Since that planet is considerably heavier than water, our moonlet will not float in that liquid, so let us immerse it in mercury instead. Suppose on doing this we should find that the bottom side of the moonlet, while freely floating in the mercury, exactly corresponded to the face of the real moon as turned toward us. We should then know that it is the bottom of the real moon that is turned our way, and that the gravitation of our earth must have some bearing on the fact. Now conceive this moonlet to be dropped from the top of the Washington Monument, and then successively from greater and greater heights, as far up as the moon itself, will it not in one case as in another, whether dropped from high or low, turn its weightier end toward the earth in falling? If the miniature will do so, why do scientists keep declaring that

the moon itself *does not obey* the same law? *Why* does it not? Is the test one of distance? or is it one of size? If it is either of one or of the other, where is the line of demarcation where body becomes planet or planet body?

Again, suppose instead of the moonlet we take a hollow glass globe filled with part sand and water, and conceive it to be first thoroughly shaken each time, and then successively *held* at the same heights previously mentioned. Will or will not the sand settle to the bottom of the vessel, that is, toward the earth? Of course it will so settle.

Now, science says that the moon, and in fact all the great heavenly bodies are, or were originally, in a molten condition. Granting the fact, the moon's substance was therefore once in a fit state to permit the precipitation of its heavier substances to the bottom, (that is to say, the under *half* of the planet, not the underneath surface) to wit, toward the earth-side, where of course they must have remained when the body cooled and hardened.

Here, then, is the governing principle of axial rotations: HEAVENLY BODIES ATTRACT EACH OTHER BY THEIR CENTERS OF GRAVITY, AND NOT BY THEIR CENTERS OF FORM.

Planetary rotations may be divided into three classes: (1) *True or Tidal*, (2) *Negative*, and (3) *Pseudo*.

The first class includes the earth, Mars, and probably Venus, of our system, and will be found explained in a later chapter.

The *Negatives* are Mercury, the moon, and all the satellites generally. Their peculiarity consists in always turning but one side toward their respective primaries,—for the matter of fact reason that they

are ballasted just that way. The longitudinal libration of the moon is a variation whose cause will be discussed in the special chapter on that body.

The third class, *Pseudo,* includes the sun, Jupiter, Saturn, Uranus, and Neptune. *These do not rotate on their axes at all,* but only seem to do so from the fact that they REVOLVE around the centers of their respective systems *in such restricted orbits* as to create the illusion of rotation. As previously explained, the sun is the center of a balancing system, and has his part to perform in this exercise as well as the planets circulating about him. Each instant some one point within him is the absolute pivot of the system, but this pivot is as elusive as a drop of quicksilver, and as fickle as the bubble of a spirit-level in a nervous hand. Nevertheless, the sun keeps circulating around it just as obediently as does his humblest asteroid.

Now the reason the sun does not seem to us to shift appreciably out of position on this account is that the planets largely counterbalance each other, so that the adjustments left to him are so minute as effectually to elude our detection.

At first glance, it may seem a small matter whether we say that the sun "rotates" or "revolves," but the distinction is not only important but fundamental. Thus:—

1. Were his movement really rotational, it would be arbitrary and *anti-gravitational* in character, and would demand the specification by science of a strange, remote, and long-spent cause.

2. The persistence of sun-spot cavities in a gaseous globe like the sun, not merely for days but for many months together, is incompatible with the rotational theory.

3. To attempt to explain the equatorial acceleration of sun-spots by axial rotation, requires the postulation of a compound rotation of the sun's outer layers that crucifies one's common sense.

4. The axial theory stands in the way of the explanation of Mercury's extraordinary perihelion movement, a phenomenon, indeed, which led even Simon Newcomb tentatively to question the accuracy of the law of gravitation.

One of the inexplicable inconsistencies of modern astronomy is to aver things in one connection, and then straightway to forget or misapply them in another. Thus, you will often see it stated that the sun revolves around the common center of gravity of the system, and yet the actual turning movement we see is invariably treated as though it could be nothing but one of *axial rotation.* Probably the reason for this is to be credited to the Laplacian theory; but whatever the reason, it is surely high time that this solar *revolution* be recognized as a real astronomical factor.

In the heart of the sun are a number of localities to be considered if we wish to get a clear understanding of his nature and behavior. These are: (1) His center of figure, (2) His center of gravity, (3) The systemal center or pivot, and (4) the medial line of the Prime Resultant, which passes through the pivot. Moreover, we must take into account the gravitational and eruptive influences at work within him; thus: (1) His heavier parts tend toward his own center of figure; and were he a body entirely isolated in space, this center and his center of gravity would eventually coincide. (2) The Prime Resultant seeks to cause him to precipitate his weightier substances to the side toward the pole star. (3) Each of his planets is following the example of the

Resultant (of course in proportionately less degree), but, unlike it, they are continually shifting their point of attack. The result is a tidal turmoil in the solar economy that, were there no better explanation forthcoming, might be magnified into a substantial cause of solar heat, and is the true cause of the sun's equatorial bulge.

Suppose, now, that the sun were suddenly converted, where he now stands, into a congeries of separate meteors equi-distant from each other, but retaining the general outline of a globe a dozen times his present diameter. In that case the particles ought severally to follow Kepler's third law, ought they not? If so, those particles *nearest the medial line* would revolve fastest, so that if we now fancy all the particles again coalescing in order, and resuming their former places, we shall be able, by looking sharp, to discover the phenomenon of *equatorial acceleration!*

But here I fancy the objection being raised that the sun's turning is only about one two-hundredths as fast as it ought to be, in order to harmonize with the velocities of the planets.

Under the inertial theory this objection was indeed insuperable, but in the present instance it is not well taken. It will be observed that all the planetary systems have a primary greatly exceeding the combined mass of all its satellites, which is just the condition we should expect of a gravitational vortex. In the case of the solar system it is the sun who stands astride this vortex. Now as the concern of the sun is to maintain an even keel for himself and his system in his giant trick of balancing, he will not wait for his rim to turn but will *lean,* now this way and now that, as a shorter cut to the same end, although he will nevertheless continue automatically to turn as well. The result of this maneuver will be that the sun's axis will describe a cone,

—his absolute south pole doing the turning, while the north pole remains fixed—so that *on the northern sky* his axis extended will describe an oval figure. For example: Take a pear and pass its stem vertically upward through a small aperture in glass, and so that you can grasp the tip of the stem. Now if with the other hand you twiddle the pear around you can get my idea exactly. The stem is the medial line of the Prime Resultant; where it joins the fruit, will be the point of the north pole; and the eye of the pear will be the true south pole. From this explanation it will be seen that the sun may greatly shift his mass without markedly changing his apparent position, and it is this nutation of his which seems to me to afford the key to Mercury's remarkable perihelion advance. If the existence of a small planet between the sun and Mercury could serve to explain the phenomenon, as the mathematicians declare, this oscillatory movement of the sun's center of weight ought equally to suffice, since any strategic advantage in the imaginary planet's position with reference to the pivot would be offset by the sun's excess mass.

Incidentally it may here be remarked, in order to be referred to later, that owing to the general gaseous condition of the sun, his center of weight would naturally be composed of his heavier substances, which, by the same token, are the most refractory, forming, as it were, a sort of knot in his otherwise comparatively homogeneous structure.

To the reader who has been vividly picturing to himself this stupendous whorl of countless orbs descending spirally through space, there must have occurred its likeness to a giant top. And just as the axis of a top, when going at low speed, possesses a gentle

swaying, or dipping motion whereby it points out an oval figure on the ceiling, so does the axis of our systemal top point out just such another figure on the sky. People generally are under the impression that the earth's axis points directly to the pole star, and that it always has done and will always continue to do so. This however is not the case. If you can imagine the axis of the earth to be a smoothly bored hole and your eye looking through it from the south end, the sky point you see will describe a circle of 23½ degrees around the ecliptic's north pole in approximately 25800 years, provided, of course, the movement continues uniform. The effect of this movement is to make our "tropical" (weather) year about twenty minutes shorter than the sidereal one. In technical language, this phenomenon is called the "precession of the equinoxes", because the instant in this year when night and day become of equal length precedes by 20 minutes the occurrence of the same event last year. Newton guessed that this phenomenon was caused by the sun's attraction on the equatorial bulge of the earth. If planets attract each other by their centers of figure and not by their centers of gravity, he was right. My own view is that it is the effect of this top-swaying motion of the solar system; and that the system, in addition to its falling movement, has a backward soaring, or wheeling motion in a large circle (being the result of reaction) requiring about 26,000 years to describe, and furnishing what I venture to suggest is the larger parallax for which astronomers have been long wishing. If this view is indeed correct, it would signify that the earth's extended axis is describing a *double* cone, whose common apex is a point in space perhaps a light year from us, the apparent celestial circle described being the outline of the base of the inverted cone.

Gravitation acts uniformly in all directions, hence we can picture our sun as surrounded by concentric isogravitational spherical shells marking gradations of his attractive power; and, going still farther, we can even liken these shells to waves. Such a sphere of influence in its course through space will necessarily impinge upon other similar spheres, and cannot help but cause "interference waves", answering to such as occur on water. This undulatory effect is manifested, I think, in the peculiar arrangement of the planets, both as to their size and separating distances, an arrangement that is moreover imitated with remarkable fidelity by the subordinate systems. In this scheme of gravitational harmonics wave crests are of course represented by the larger bodies.

It will naturally be very difficult to trace out any definite structure of the heavens along these lines, since we are not likely to be able to distinguish between the "conjunctional" and the "elongational" arrangement of stars and star-clusters. Nevertheless industry may yet avail to detect its evidences. Elsewhere I give two other keys to the probable structure of the sidereal system that seem to me to bear a more definite stamp.

Bodies which enter our system gently, as by "interference", will accommodate themselves to their new allegiance with a proper sense of duty. In other words, they will spontaneously adjust both their speed and the contour of their orbits so as to preserve, without shock, the harmonious balance of the whole. This they can do only by entering approximately circular orbits and observing Kepler's third law: witness Neptune's small eccentricity.

But not all of our immigrants enter thus. Many, like the comets, rush in violently as though seeking refuge after being forcibly expelled from other realms.

Such are restless spirits, and must be slowly assimilated by the solar body politic. Just as a pebble dropped into the sea may be said to affect the position of every particle in it, just so does a comet disturb the general equilibrium, until by many pulsings in and out across the gravitational field, it falls into the orderly circularity of path foreordained for it.

So much then in support of my proposition that the planetary motions, both of revolution and of rotation, are not inertial; but, on the contrary, are produced by substantial, consentaneous causes, the principal of these being the PRIME RESULTANT.

III

THE NEBULAR HYPOTHESIS

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Acceptance of the Copernican system brought with it the knowledge that the then known planets, Mercury, Venus, the Earth, Mars, Jupiter, and Saturn, all revolve around the sun in the same direction. This remarkable coincidence was rendered still more remarkable by the discovery by Sir William Herschel, in the year 1781, of the planet Uranus, which was shortly shown to be no exception to the general rule. About the same time Herschel also taught the world that the sky is dotted here and there with little clouds of luminous matter, which he called nebulae (the word nebula itself meaning "a little cloud"). At first he supposed these to be clouds of gas, but as he successively tried upon them telescopes of higher and higher power, he found he could resolve nearly all of them into clusters of stars. In the end it was only natural that he should conclude *all* nebulae to be so resolvable, given the requisite magnifying power; but in this it seems he was mistaken, inasmuch as the spectroscopic evidence shows some nebulae to be without visible nuclei of condensation.

Swedenborg, who died before the discovery of Uranus, and, following him, Kant, had sought to ex-

plain this uniformity of direction by imagining a common origin for the whole system. Their ideas, however, lacked plausibility because there was nothing in evidence, so far as then known, to image this unity to the minds of others. It was some years later that Herschel's discovery of nebulae occurred, and Pierre Simon de Laplace, a French mathematician second only to the great Newton himself, promptly conceived the idea that these might be the chrysalides of new systems—an idea surely lacking neither in romance nor attractiveness.

Accordingly, he evolved his celebrated "Nebular Hypothesis," which ever since has dominated astronomical theory, although now greatly modified in details. A generation or so ago, such was its vogue that the advanced clergy, taking a leaf out of past experience, went so far as to proclaim the Hypothesis a plagiarism of the Mosaic Cosmogony, and delivered multitudes of sermons in the effort to establish the parallelism!

Laplace postulated the parent nebula of our solar system to extend from the sun as a center to a point somewhat beyond the orbit of Uranus (Neptune was not discovered till long after Laplace's death), and assumed it to contain only what matter is embraced in the system of our own day. In imagination he endowed this nebula with the west-to-east motion of the planets, and, besides, assumed it to be in a complete state of incandescence. As the nebula condensed, a differentiation of speed developed between the core and the outer rim, he supposed, so that a ring was shed, which he imagined rolled up afterward to form the planet Uranus. The process of condensation of the core continuing, the incident of ring-shedding was repeated, and Saturn, the next planet, was this time the result. And so the process kept on, as he imagined, until all the planets and

their satellites were formed, and the sun himself was left as the indivisible residuum.

In round numbers Uranus is 1,800,000,000 miles distant from the sun. The sun is 866,400 miles in diameter. All the planets put together are only equal to 1/750 the mass of the sun.

As the calculation I am about to make does not require close accuracy, let us suppose that if all the planets were to be swallowed up by the sun, his diameter would be raised to an even 900,000 miles. Since, then, the volumes of spheres are to each other as the cubes of their diameters, on calculation it will be found that the volume of Uranus' orbital sphere is 64,000,000,000 times that of our augmented sun. If now we imagine the mass of this sun to be evenly distributed throughout the Uranian sphere, our figures mean that one cubic inch of the sun's matter would be diffused in an *otherwise absolutely vacuous* space as large as the Capitol building at Washington.

Extending the calculation to Neptune's orbit, which is 2,000,000,000 miles wider, we shall find that our cubic inch of solar substance would have to suffice for a space thrice the size of the Capitol!

Here it may be interjected that Laplace's nebula was supposed to be *lozenge* shaped and not spherical. What right he had to assume so unusual a shape for his cloud, in addition to its accommodating motion and its obliging incandescence, I shall not stop to inquire. Being in a generous mood let me concede at once that this was really the case, and that there was fully as much as a whole tablespoonful of matter for each space the size of the building mentioned.

Let us now inquire what is the extent of the sun's attraction at the distance of Neptune, in order to as-

certain the degree of tension brought to bear on the material of Neptune's alleged ring. Not to weary the reader with too much detail, let me give a few calculated results. The attraction of the sun on a given particle as distant from him as Neptune, is about one fourteen-hundred-thousandth as great as that of our earth on a like particle at her surface. It is only about one-fortieth as great as that of the moon upon the ring on your finger, and is proportionally about equivalent to that of the attraction of your own body upon the clock resting on the mantel a few feet from you.

Now, gravitational attraction is one thing, but frictional propulsion by it is altogether another. It is quite admissible to conceive of the particles of which we are speaking as being held back by their mutual gravitational attraction from escaping into outer space; but it demands the maximum of credulity, scientific or otherwise, to believe that the *friction* between particles so sparse and minute as here demonstrated, and bound to each other by a tie so slender, could ever, under any circumstances, sustain a general *rotational motion*. To refer again to our illustration, this friction is relatively the same as the act of turning around on your heels (while still preserving the intervening distance) would have on the clock, not to draw it toward you, remember, but to *rub* it to one side—no, even less, because the air intervening between the clock and you is ever so much denser than the postulated nebula, and consequently a stronger frictional medium.

But perhaps I shall be told that I have mistaken the principle governing this movement; that the principle involved is really that of viscosity, or, if not that, then the only other possible, namely, independent inertial movement on the part of each particle.

As to the question of viscosity I would fain doubt whether an ounce, even of our best make of mucilage, atomized into a cubical vacuum four hundred feet each way would supply the tenacity demanded for a spoke 3 billion miles in length! The last suggestion, namely, that of inertial movement being inherent in each separate particle, seems to me to multiply by duodecillions the original difficulty. It is surely easier to believe in the uncaused motion of a given planet *as a whole* than of its component particles dissociated!

But the tax on credulity was not even then reached. The planets not only revolve but *rotate,* and this motion must also be explained. Accordingly scientists again appealed to imagination rather than to common sense, and fancied the particles of matter composing the nebula to strike each other and the forming planets with such nicety of precision and angle as to cause them to turn on their axes! Once started, the law of inertia was depended upon to keep the motion going.

In short, the Nebular Hypothesis as proposed by Laplace removed no difficulties whatsoever, but only set up futile others. In its initial statement he frankly assumed, as much as did Newton himself, a physically uncaused motion for his matter. Second, he assumed its incandescence, despite its envelopment by the unspeakable cold of space, primarily, I believe, in order speciously to convey the suggestion of viscosity; third, he postulated an unnatural cloud-form; fourth, he made no attempt to explain how the nebula originated; fifth, he took no account whatever of the fatally disturbing factor of the sun's motion through space; and, sixth, granting him all his egregious postulates, the machine he invented was geared too high to keep going, even had it ever got started. To speak frankly, the Nebular Hypothesis, though so undeniably comprehensive and

attractive, bore upon its face such gross absurdities as should have condemned it on sight. Even had it provisionally solved all the details it was intended to do, its palpable and inherent defects should have discredited it nevertheless, and such apparent responsiveness been laid to the credit of mere coincidence. As it has turned out, science has frittered away a century in putting this fanciful wraith of a nebula through a series of imaginary gymnastics, only to have it perversely turn and twist the wrong way like a double-jointed harlequin. In its application to details the Hypothesis has been found consistently disappointing.

From Laplace down to Mayer and Joule, scientists peacefully believed in the possibility of this nebula being superheated, but no sooner did the Mechanical Theory of Heat appear than they confessed their previously concealed misgivings and welcomed the newcomer with open arms. With a great sigh of relief they improvidently cooled with its breeze the nebula's imaginary incandescence down to the zero of space, and began to build with the chilled embers the burning sun and molten worlds. New phrases, such as "kinetic energy," "energy of position," etc., sprang up, which, interpreted, mean that by the mere coming together of the particles of the nebula under the constraining influence of gravity, heat was produced by their mechanical impacts sufficient to melt the substance of the forming planets, and to endow the sun with a supply of caloric capable of lasting that prodigal ten thousand, thousand years. Thus science rested in smug content until Helmholtz, the great physicist, fortified the theory with his idea of a slowly contracting sun, so that certain sleepers who had given some signs of waking were lulled into still deeper slumber.

Of late, however, it has begun to dawn upon scientists that their theories involve the ultimate destruction of the universe by the dissipation of all heat, when the last impact shall have sounded and all the worlds shall finally have been gathered into a single inert mass. In this chapter I shall endeavor to disprove this dismal forecast.

In order to convey to the reader, in as concrete and graphic a form as possible, the current scientific notion of how the earth's internal heat came about, as well as the heat of the sun and the major planets, let us go back a bit, and instead of the spoonful of substance I spoke of let us fancy it transformed into, say, four hundred flakes. In newly apportioning these I suppose it will be about right if we allot ten such flakes to each imaginary *vacuous* space equivalent in cubical contents to an average Philadelphia dwelling-house.

It is a pet idea of modern science that the farther apart bodies are the greater their "energy of position", so let us meet her views, as nearly as we know how, by imagining the nebular field divided into cubical chambers thirty feet each way, and allot to each chamber ten such flakes, all we have in store. Now although Laplace assumed these flakes (of course he did not use this particular illustration) to be incandescent, modern science magnanimously admits they could not have been so, exposed as they were to the absolute zero of space. But, says science instead, these flakes immediately began to attract each other and to cause their mutual collision with such force as not only to keep themselves and their neighbors warm, but to store up so much excess heat that after a hundred millions of years or thereabout four major planets are still in a molten state, and the earth's interior is so hot as to melt granite and every instant to threaten its own cataclysmic disruption!

Assuming that the earth was actually formed in this manner, that the process took the moderate period of five million years (which is much less than scientists ordinarily allot) and that the accretions were gradual and uniform, the figures will show that the average daily sprinkle in the earth's case could not have exceeded one-fourth of an inch! When, in addition, we take into account that the flakes and the planet itself were continually exposed to a colder than arctic temperature, and that the sun had his own future to look after the while, one begins to feel, does he not, that the effects of this cosmic snow-storm have been somewhat Munchausenized?

But here I may be accused of unfairness in choosing the simile of a snow-storm, as no doubt the substance of the nebula was more compact than that, say in the form of meteors. To this I answer, first, that the larger the particles the fewer the impacts and the farther between, hence the theoretical aggregate would be just the same; but, fortunately, there is a second answer which may fairly be held to be *experimental in character;* and in weighing it let it be remembered that the earth is now *at its maximum of attractive power.* I quote verbatim from Prof. Percival Lowell's book, *The Evolution of Worlds,* page 41, who himself firmly believes in the theory. He says:

> "Most meteorites are stones, but one or two per cent are nearly pure iron mixed with nickel. When picked up they are usually covered with a glossy thin black crust. This overcoat they have put on in coming through our air. Air-begotten, too, are the holes with which many of them are pitted. For, entering our atmosphere with their speed in space is equivalent to immersing them suddenly in a blowpipe flame of

several thousand degrees Fahrenheit. Thus their surface is burnt and fused to a cinder. *Yet in spite of being warm to the touch their hearts are still cosmically cold. The Dhurmsala meteorite falling into moist earth was found an hour afterwards coated with frost. Agassiz likened it to the Chinese culinary chef d'oeuvre "fried ice." It is the cold of space* 200° *or more Centigrade below zero, that they bear within, proof of their cosmic habitat."* (The italics are mine.)

I ask, How many such meteroitic impacts as this of Dhurmsala *at 200° below zero* would be required to make up a sun as hot as ours? or how many million years would be required for them to cool *up* to the *molten* condition of the major planets?

This theory was held by discriminating science for some years, until Helmholtz, the great physicist, shrewdly suspecting a deficit, came to the front with the suggestion that the sun is falling together, and that the heat caused by its contraction is responsible for the daily output. According to his calculation, a sacrifice of 600 feet per annum in the sun's girth would be sufficient. Although this is now the orthodox view, I find myself opposed to it for a variety of reasons:

To begin with, Helmholtz's hypothesis has absolutely nothing to support it except pure supposition; there are no measurements, of course, possible.

Second. By spectroscopic and telescopic examination we can see enough of the sun's physical state to show that *he is in constant ebullition,* great jets of hydrogen and other gases spouting geyser-like to a height of many thousand miles, and this all over his surface. *Boiling and contracting cannot be concomitant states.*

Third. Let me ask, How long ago did this process of tumbling-in begin? Suppose we say, to be lenient, ten million years, when the sun's mass must have occupied, according to theory, a space equal to thrice his present diameter, or, what is the same thing, twenty-seven times his present volume. His heat at that time, then, must have been vastly more intense than at present, not only because Helmholtz says so, but also because, according to Boyle's law, pressure remaining the same, the temperature decreases directly as the volume. In other words, the farther back we go on this line the hotter and hotter our sun, *precisely contradicting the Kinetic theory,* which teaches increase of heat by condensation! Which of these theories is right?

According to Lane's theory, the more a gaseous body contracts under its own gravity as the result of cooling by radiation, the hotter it becomes! Of course he could not prove this experimentally, but only by theory. Let me answer it by a corollary *reductio ad absurdum*: To *cool* a gaseous body which is contracting under its own gravity, *heat* it, for the added heat will expand and thus cool it! Helmholtz's theory of a sun tumbling in upon itself because it is growing cold *presupposes a hotter ancient sun, Lane's a colder.* In either case the implied variation of the solar heat, primevally from now, is geologically and biologically abhorrent. *Regularity, at least approximate regularity, of the solar temperature is indispensable to the satisfactory explanation of the earth's geological records.*

I submit, therefore, that the Kinetic Theory of solar and planetary heat, as currently misunderstood and applied, is fatally defective in the following vital respects:

1. It is chimerical.

2. The supply of heat it provides is utterly inadequate to the requirements.

3. The sort of sun it accounts for is far too variable from eon to eon to satisfy the exacting specifications of the kindred sciences, geology, paleontology, etc.

4. It foredooms the universe to final destruction by agglomeration into a single mass void of heat.

5. Its acceptance is possible only by an exercise of faith, for it is lacking both in proof and in mental conviction.

6. *Worst of all, it is philosophically unsound inasmuch as it denies the potential integrity of the universe from instant to instant, and peccantly diverts the imaginary original capital of the universe to current needs.*

IV

GRAVISTATIC HEAT

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GRAVISTATIC HEAT

Were the fact not true, it would seem impossible for science to have missed asking itself the obvious question *whether celestial bodies may not be hot because they are large,* instead of stupidly contenting itself with the puerile inference that they are hot because "they have not had time to cool." Yet the reader may read astronomical treatises from A to Z without finding anywhere this important query either asked or answered; and it has been left for me both to ask and to answer it. I venture to reply in the affirmative.

Let us marshal plain facts and axiomatic principles and see to what conclusions they lead.

In the first place, since particles of matter *by the mere act of coming together can generate heat, would it not be passing strange if they should lose this power the instant they combined?* In union there is strength is a saying as true as it is common, yet for some inexplicable reason science has here chosen to deny it. Molecules of matter, as science well knows and is fond of reiterating, are minute and perpetual engines of energy. Hence, say I, the more of them that are clubbed together the bigger the results we have a right to expect.

Imagine that the entire universe consisted of but two bodies the size of our sun, precisely alike in all respects save that one possessed the property of gravitation, and the other did not. According to current belief, they would behave practically alike, at least below their respective surfaces, and the gravitational power of the first body would consequently be as though it did not exist. Surely this cannot be true! For if it be so, it means the overthrow of the doctrine of the conservation of energy. Were gravity an ordinary force it would act for a moment or a day and then cease. It is not such a force, but *one inherent in matter and perpetual, so that its continuous operation must be continuously manifested.* It so acts in the case of planetary motion, and it must so act in the internal economy of the individual planets.

The spectroscope tells us that some nebulae are self-luminous; they must therefore be hot. How came they to be so? Certainly not from impacts, as the Kinetic theory presumes, for even the strongest scientific imagination must recoil from the contemplation of two free clouds of frigid dust bumping together with a violence sufficient to raise them to incandescence! Nor is it possible for science to assume that in the Beginning the nebulae were incandescent, and have persisted so throughout the infinitude of ages. Where and what are the hidden celestial furnaces that fired them?

However long the period they consume, Nature's operations are always cyclical. Since all are agreed that nebulae are the raw material out of which worlds are formed, *they must also be the debris of worlds that have passed. The possibility that their heat was somehow generated while they were in the world state* is therefore surely as likely to be true as that they absorbed it out of the depths of frigid space, or were

originally endowed with it, and "have not yet had time to cool."

According to the theory of transmutation of energy, which has been abundantly demonstrated to be true, any kind of force may be converted into any other kind; thus light may be changed into heat, heat into motion, motion into electricity, electricity into light again, or any one of them directly into the other indiscriminately. *Hence gravity may be converted into heat, and heat into gravitational energy again,* or else the theory in question requires to be modified.

All substances possess the same qualities, and vary only as to their degree. Thus, all can be volatilized, or melted, or solidified, but at greatly diverse temperatures. They can also be *exploded by percussion, either by a blow or by mere pressure.* Hence, given sufficient *pressure,* no solid can continue in that state, but must pass into a gas. This is the corollary of what the physicists have termed the "critical point in gases," by which is meant that, *given a certain* TEMPERATURE, *no application of pressure however great can avail to reduce the gas to a liquid or solid.*

Now pressure is a force just as well as is a blow, for you can drive in a thumb-tack either by merely pressing upon it, or by hitting it with a hammer. Therefore *pressure also can be converted,* in accordance with the theory of transmutation of energy previously cited, *into heat, as well as into other forms of energy.*

Since pressure then may exist as such and also as heat, we have a combination of two kinds of energy growing out of one, quite sufficient in the sun's case to pulverize, or percuss, all substances into their chemical elements. The inevitable result must be an endless series of explosions whereby the dissociated gases con-

tinually force their way to the surface and to freedom (forming what astronomers technically call "convection currents") there to radiate away their cargoes of heat, to condense, and to resume their original place as part and parcel of the stupendous solar gravistatic press—prepared to go through the same cycle of performance again. And so on until the sun himself shall cease to be.

Hence it is true that the sun is continually "falling in upon himself," but not as Helmholtz conceived it to do. For Helmholtz failed to divine the real secret, namely, that the sun is at once pestle, mortar and grist, and that his central parts instead of packing tighter are retranslated into their elementary gases and so regain their own former "energy of position." But the sun is not contracting.

Briefly, then, the solar heat is due to the continuous conversion of the sun's substances into gases by virtue of the pressure of the superincumbent layers falling toward his center, the space allowing for such fall being vacated by the said gases, which rise to the surface upon the wings of their own explosive force, there render up their heat, condense, and regain their original energy of position as part of the great solar press.

Should I stop here I had told but half the truth, for *I maintain that even were the body composed only of solid refractory materials that had reached a condition of stable compactness, the production of heat would not be in the least curtailed. And this is really what I have primarily in mind when I use the expression* GRAVISTATIC HEAT. For pressure even without visible movement is yet generating heat, for the simple reason that *heat is a state of matter due to the activity of its*

molecules under strain. PRESSURE IS IMPACT RENDERED PERMANENT.

Thus, the force of a hammer-blow may be registered on a spring-scale and its equivalent in static weight determined. If now in place of showering blows upon a wedge, we place a weight upon it just equal to the blow's mark as registered on the scale, we shall have a permanent force, other things being equal, capable of delivering from instant to instant, throughout eternity, the same amount of work as would an infinite succession of the blows. But if instead of driving a wedge which moves, we beat an anvil which does not, we thereby create an equivalent of heat in lieu of motion; or by setting the weight on the anvil, we shall be able to obtain our meed in heat in the same proportion as we did before in wedge-motion. To show that this is not a biased conclusion I quote from Ganot's Physics, Art. 465 (repeated in new edition of 1910, Art. 453):

> "If a body be so compressed that its density is increased, its temperature rises according as the volume diminishes. Joule has verified this in the case of water and of oil which were exposed to pressures of 15 to 25 atmospheres. In the case of water at 1.2° C., increase of pressure caused lowering of temperature, a result which agrees with the fact that water contracts by heat at this temperature. *Similarly, when weights are laid on metallic pillars, heat is evolved, and absorbed when they are removed.*"

In fact, this knowledge is not new, for I have quoted from the edition of 1877; but it has never been taken practical advantage of, although it ought to be, for it is the germ of perpetual motion. That is, it indicates how the indisputably infinite force of gravity,

which I have shown both holds and propels the stars and planets in their courses, may be harnessed to do the petty chores of man. If gravitation is not itself an absurdity, it should not be, nor seem, more absurd that its power might in some way be rendered reversible (like any and every other form of energy may be) in order to perform useful work. *The way is pointed out by Nature herself: it is, by transmutation of the force into heat in the bowels of the globe.* It has often been proposed to sink a well miles deep to reach the internal fires. If we did so, we should tap sources of gravistatic heat as surely as there is such a thing as weight, or that molecules can store up and deliver energy. If gravitation perpetually acts it must be doing work of some sort continually. Then why not in heat? If not in heat, then in what? If in nothing, then is the doctrine of conservation of energy a nullity and gravitation a delusion. It is no answer to say of our postulated gravitational body that the force is required to keep the particles in their places, for they would stay there anyhow, under the law of inertia; as they would also, for the same reason, in the case of the non-gravitational body.

This cyclical process of converting gravity into heat and heat into gravity again finds a remarkable parallel in the terrestrial transformation of water into vapor, rain, stream and ocean, of which were one link unknown it would be infinitely more difficult to divine. In the solar heat- generating cycle, the descending jets, or geysers, answer to our rain, perpetually flooding the whole of the sun's surface, and falling, with the regular continuity of the Amazon, toward his center, there to suffer evaporation by his pressure instead of by his rays, and thence to rise again in fountains of life-giving warmth.

What is true of the sun is only in less degree true of the earth. As we descend we find the temperature uniformly increasing one degree for about every sixty feet of depth. Current theory lays this increase to conduction from the fires within, whereas I claim precisely the reverse, namely, that the fancied fires are due to gravistatic heat, that is, heat caused by gravitational pressure. That current theory is in this instance wrong is sufficiently demonstrated, I think, by the uniformity of the temperature gradations, the heat increasing REGULARLY. How comes it that science has ignored this conclusive objection to its accepted theory? Everyone knows that the conductivity of clay is very low, and that the thickness of a single foot of it around a blast furnace will protect the workmen from its intensity. The difference may be as much as two thousand degrees between the temperature inside of the furnace and that on the outer face of its wall. What words, then, can we have but of disdain for a theory which teaches that a temperature of seventy degrees will avail to penetrate a layer of earthy matter sixty feet in thickness at the cost of only one degree! Let those who still think otherwise give us some formula as the basis of their opinion.

In the last preceding chapter I intimated that I would recur to the consideration of the refractory agglomeration about the sun's center of gravity. It is evident that in the heat-generating process above described, the more refractory substances would resist volatilization longer than others, hence explosions arising from them would naturally be cataclysmic, and their recurrence tend to more or less regular periodicity. To this I attribute the sun-spot phenomena; and the tropical position of the maculæ I lay to the location of this "knot."

The connection of sun-spot periods with the remarkable terrestrial magnetic disturbances that accompany them is owing to the tremendous solar explosions at such times, which temporarily throw the sun off balance and so derange that of every body, earth included, of his entire family. Such a jolt would sensibly affect us by causing, as a secondary result, a dislocation of our planet's internal economy, and might even suffice to change the position of its center of mass. Were such a thing to happen, as perhaps it has happened in prehistoric ages when the globe was still soft, it could possibly cause a shift of the earth's axis, the fall of an Altantis, a glacial age, or a Noachian flood. That such solar cataclysms should in our day have the comparatively mild effects of magnetic pyrotechnics, earthquakes, and "tidal waves" is therefore not surprising.

The question may be asked, What becomes of the earth's excess heat? *Were it not for it the oceans would undoubtedly have frozen solid, for the solar heat does not penetrate the surface deeper than but a few feet,* and cannot possibly be responsible for the oceans remaining above freezing point. The waters of the ocean circulate, I opine, through a labyrinth of passages, kept open by explosions of its steam, perhaps clear to the earth's center, and thence convey the gravistatic heat to the surface and so on out into space. Only thus have the seas been maintained throughout the eons, and can they be, at *the uniformity of temperature essential to the very existence, not to mention the well-being, of marine life.*

That the ocean depths are very cold is no valid argument against this, but only goes to show the great need for a submarine source of heat. Besides, as all know, the warmed water flies to the surface, hence its

position is no criterion as to that of the source of its heat.

In boring tunnels through the Alps, several independent preliminary surveys are made with infinite care, so that the work may be prosecuted from both ends at once, with the certainty of accurately meeting in the middle. *What would the chances be of meeting thus fortuitously?* Now we have just such a parallel instance in the case of the earth's heat, for, just about five feet under the surface the temperature is uniform the year round, and exactly the mean of that of the atmosphere above. How comes it that scientists have never thought worth while to comment on this amazing coincidence, that the heat alleged by them to have been implanted in the earth tens of millions of years ago and ever since engaged in escaping, should, just in our day and hour, happen so precisely to match the mean surface temperature, which owes itself to a totally independent cause! What was the temperature a hundred feet below the surface a hundred, a thousand, a million years ago? and, since theoretically so much hotter than now, what must have been the effect upon animal and plant life?

If current theory were really correct, our planet would be a very unsafe one to dwell upon, for a central heat of 200,000° (as indicated by the temperature increase with depth) would speedily disrupt it, or, rather, there should now be no earth. According to my theory, the rate of such increase, being dependent on the strength of gravity, must diminish the farther down we get, so that the maximum calculated temperature would not be more than half the amount stated. As a matter of fact, it is far below this figure, because of the extensive internal water-circulation as above described.

Were the planet ever to increase to a great size, like that of Jupiter, for instance, the intense heat generated would quickly dissipate the present oceans, and in time cause the earth to acquire the same general characteristics as that giant orb.

We thus see that the earth's economy provides what it demands, a running supply of heat, and a uniform one. The extreme variation implied by the Kinetic theory, as currently understood, would have proved just as inevitably fatal to earth-life as a variation in the sun's temperature. *Nature does not dole out treasured heat, but evolves it as she goes along.*

In this process of gravistatic heat production we have the clue to why the universe did not long ago perish by agglomeration into one mass, and why it never can do so. Without some adequate dispersive force, constant mutual attraction must tell in the long run. No matter how long the climax might be deferred, the end would have to come some day, and, when it did, there would be nothing but a stupendous clinker to mark the tomb of Nature.

We have learned how our sun is a bubbling molten mass by reason of his own exertions; thus it is with the stars in general. At present he is able to get rid of his heat as fast as it is generated, and there is no doubt in my mind that he has still many million years of life. However, he is growing hotter and hotter by infinitesimal degrees, in precise ratio with his increase of mass due to bodies precipitating upon him. Since he cannot lose any part of what he thus gains, matter being assumed indestructible, the time must eventually come when his radiating surface, which relatively decreases with the volume, will no longer suffice to discharge the greater gravistatic heat of the bigger body,

and the result will be his dissolution by explosion back into a nebula. *This is the final fate of all stars, but it is the salvation of the universe.* As with human life, the old must die to make room for the young. Manifestly the destruction of a star terminates instantly its concentered attraction, and so relieves the congestion at that particular point; but as a *nebula* it still retains its intrinsic gravity, and so does not derange the universe as a whole. This, in my opinion, is the real explanation of new stars, like Nova Persei, that are once or twice in a century seen to explode and shower their substance out into space with a velocity even greater than that of light itself. Correspondingly, all nebulae are the ghosts of deceased stars, and help us by their multitudinosity to a comprehension of what eternity really means. Of course such explosions need not necessarily be total; many in fact are only slight.

There are, in my opinion, no nebulae, nor can there be any, which do not owe their origin to just such explosions, or to collisions. To me the universe is eternal, or at least so old that all the matter therein contained seems to have passed through the gamut of changes, *nebula, planet, star, nebula,* over and over again.

From Nebula to Nebula,—so runs the life history of a world and so does every particle of matter. As long as matter possesses the properties it does now, the cycle must go on eternally without change or hitch, save such as are normal and incidental to it.

When a star explodes, its fragments, some large, others minute, fly radially in all directions, and the former's power of recall (attraction) being incidentally dispelled, the fragments enter adjoining systems at high velocities and with projectile, as distinguished from

gravitational, motions. They are the unruly immigrants that I spoke of in the last chapter, and require to be assimilated and chastened into docile, orbit-abiding members. It is possible that the force behind a given fragment might serve to shoot it hyperbolically through one system into another beyond. However, this would likely be a rare occurrence. Here we see that *projectile motions are menaces* to a system's stability, that they require to be subdued and overcome, and how they are overcome. Surely Newton built his universe upon sand when he chose projectile motion for its corner stone!

As I suggested before, all matter has doubtless run the celestial cycle many times, so that the chances are a myriad to one that a given planet has not grown by simple accumulations of cosmic dust, but owes its nucleus to a fragment from a deceased star. Or rather, should I say, to fragments, for I am inclined to believe that stars are almost wholly gaseous, or at least molten, so that *the future planet gains separate existence in the form of a jet of coarse spray divided into many globules, which separately congeal and afterward cling together as a unit,* when their mutual attraction triumphs over the unequal dispersive effect of the explosion that begat them. That all planets are spherical follows from the law of gravitation, provided their parts are sufficiently small or mobile. Were the fragment but one irregular and very rigid block its future shape would depend upon its size alone; one very large would melt with the fervor of its self-generated heat, whereas a small one, such as an asteroid or a meteor, might be and stay any odd shape.

If the earth was formed out of star spray in the manner I have described, it must have been many eons ago, not because it is now superficially cold, but because of the circularity of its orbit, which is the evidence

of its ancient citizenship in the solar monarchy. If, on the other hand, it did not rush in rudely, but decorously detached itself from a former allegiance and gently joined itself to the sun's, it must be older still, since there have been many later comers than it. In either of these ways it may have immigrated, but if so it has been naturalized so long as altogether to have lost its foreign accent and behavior.

V

THE TIDES AND TIDAL ROTATION

V

THE TIDES AND TIDAL ROTATION

About a century and a half ago the celebrated philosopher, Immanuel Kant, wrote an essay that has since become classical in which he proved to his own satisfaction and to that of the scientific world generally that, owing to the retarding effect of the solar and lunar tides, the earth's day must be gradually growing longer. The arguments advanced by him were purely theoretical, so it was left to others to fortify his conclusions by marshalling physical facts to their support. Accordingly, extensive searches were made for records of ancient eclipses in order to furnish a basis for calculation, and two or three very ancient ones were discovered, which for less delicate work have been found to be invaluable. In this computation, however, accuracy as to the very days, or even the very hours, was not sufficient—minutes and even seconds assumed an importance. But these latter the records failed to furnish. When the reader then takes into account the further disadvantages that the ancients were dependent on the comparatively crude device of sun-dials for the measurement of time; that they had not yet learned how to predict solar eclipses and could therefore not have been on the *qui vive* to note the precise instant of beginning,

even had they thought such accuracy essential; and, lastly, when it is remembered that the investigators were expecting and wanting the fact to turn out a certain way, he will see how very little dependence is to be placed upon the result of the calculation. Yet even so, it was decisively ascertained that the earth's present day cannot be figured out as longer by so much as 1/100 of a second than the day Troy fell. Should we take this maximum possibility as established, it would mean that every succeeding 24 hours a given point on the earth's surface comes within exactly a half inch of reaching the mark of the day before. That is to say, the braking effect of both tides would bear a ratio to the earth's momentum of 1/2 inch to 25,000 miles, or of one to three billion. The result is still further discredited inasmuch as the computers left out of consideration certain side factors the nature of which can be stated but not defined, and probably still others of whose existence we do not even know, but which, were they known, might easily reverse so infinitesimal a finding.

Yet it is upon this frail point of fact, joined to the two theories of Newton and Kant, that George Howard Darwin has erected his now celebrated theory of Tidal Evolution, which, notwithstanding its very general acceptance, seems to me, for reasons presently to be given, a palpable error. Its conception is to be traced to the door of the Nebular Hypothesis, whose influence appears to permeate everything astronomical.

Mr. Darwin knew the dubious character of the finding reached by the computation just outlined, but he was so positive of the soundness of Kant's theoretical views that, throwing discretion to the winds, he decided that what Kant reasoned out should be true is true,

whether Nature agreed with him or not, and that the day has really lengthened.

Since, then, he reasoned, the day is longer (or ought to be longer) than it was yesterday, there must have been a time many millions of years ago when the day was (or ought to have been) so much shorter that the earth turned on its axis in a matter of three hours or so. But, he continued, if we go back so far as that we should also take into account the then theoretically high temperature of the earth, and consider the possibility of earth and moon having once formed a single body.

Now, since that greater earth, he went on, was (or might have been) both viscous, and rotating at a very high rate of speed, the solar tides raised upon it must, by theory, have been exceedingly powerful, so much so indeed as perhaps to be able to pluck away a rib from the earth's substance and thereby give birth to the moon as a separate planet. But this act of disruption would not, he argued, lessen the plasticity of the separate bodies, hence when they started to revolve around their common center of gravity at approximately the original rotational speed of the parent body, they must have proceeded to raise tides upon each other's surfaces. The resulting protuberances or ansae, by virtue of their gravitational attraction, then began, as he imagined, to exercise the double effect of retarding the rotation of their own respective bodies, and that of their respective opposites as well, with the result of little by little causing the moon to recede from the earth, and at the same time to slow up its rotation to its present speed.*

Now, any theory that breeds mysteries faster than it dispels them is *ipso facto* false. Having explained,

*Compare the later chapter on the Moon.

as he pretended, the moon's present motion by a series of assumptions upon assumptions, Mr. Darwin is now in duty bound to prove those assumptions, namely, the reason of the earth's original molten condition, how it came by its rotary motion in the first instance, why that motion was so much more violent than in the case of other planets presumably formed in the same way, and, indeed, how the moon managed to get a forward rotation when flung from the earth *instead of a backward one as his premises logically dictate.* In justice to Mr. Darwin I will quote his own words anent this theory, showing that he is not himself a dupe of his own imaginings:

> "There is nothing to tell us whether this theory affords the true explanation of the birth of the moon, and I say that it is only a wild speculation incapable of verification."*

Now, I do not object to speculations, even to wild ones, *per se*, for where all men are so densely in the dark, even a faint ray is better than nothing. What I do object to, however, is that this fanciful theory, for which the author himself refuses to stand sponsor, should have been so generally welcomed by scientists as to obtain an honored place in the astronomer's articles of faith. This case is a parallel to that of Laplace's, who in promulgating his Nebular Hypothesis distinctly warned the world that it was but tentative and did not express his final conclusions; yet astronomy for a century has persisted in believing it in spite of everything.

But all this merely by way of preliminary to the main point, which is, that the cause of the tides, according to my way of thinking, has always been misunderstood. I do not mean by this that the sun and moon

*The Tides, page 284.


Ice crust
Water
Kernel
E
Non-gravitational
M

Fig. I.

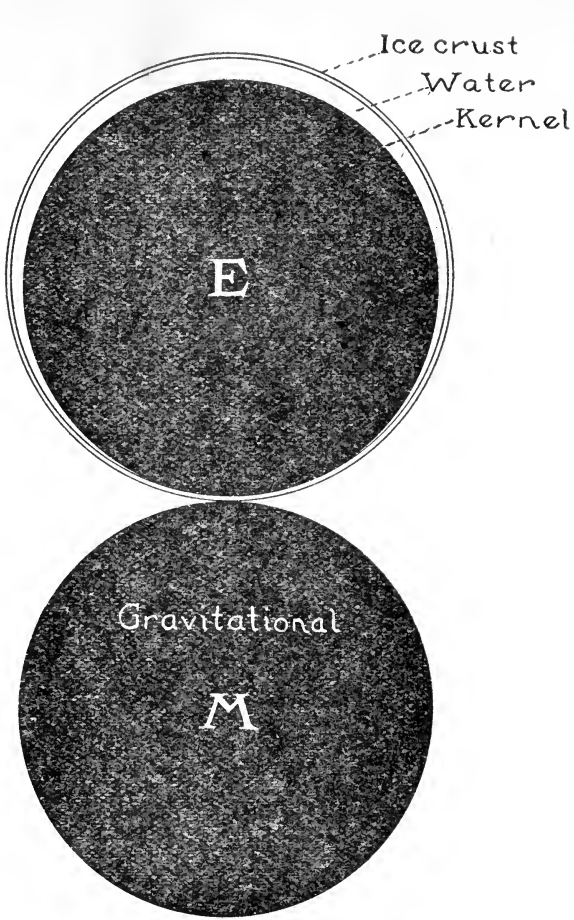
Ice crust
Water
Kernel
E
Gravitational
M

Fig. II.

do not cause the tides, but rather that they do not cause them in the manner generally supposed. The orthodox explanation is that the sun (or moon) attracts the water on the side of the earth nearest it more than it does the solid part or kernel, and the kernel in turn more than the water on the rearward side, thus heaping up her oceans fore and aft.

Now, the simple law of gravitation, formulated by Newton and known by heart to every freshman, reads as follows:

"All bodies attract each other *directly as their masses,* and inversely as the squares of their distances apart."

Through one of those fatal lapses to which astronomy of all the sciences has been most prone, she has applied to tides the second half only of this law, thereby giving rise to an error which has vitiated two centuries of thought and calculation on this and other cosmic problems. *When the full rule is given effect, it will be found that instead of the water being heaped up under the attracting body, it is depressed, and by a force indefinitely greater!*

In the diagram (Fig. 1) let E represent a planet in space, and endowed naturally with the property of gravitation. It consists, let us say, of a solid kernel 10,000 miles in diameter, entirely homogeneous throughout, and surrounded by an envelope of water five miles in depth. Let us suppose this water frozen to a depth of one mile (merely in order to aid the imagination). We now bring in touch with E a second body M, which, let us suppose, has no water envelope, and, for the moment, lacks altogether the gravitational power possessed by E. It is evident that under these conditions E will not be affected by this juxtaposition in the least.

We have, however, provided a means whereby, by the simple turning of a switch, we can turn into or out of M a current of gravity at will. We turn the current on, then, and watch E closely for results. Gradually, as M's gravity grows, we first detect a slight stir on the part of E's kernel, and then, behold, it begins to sink, and keeps on sinking through the water toward M till it rests on the inner surface of the ice crust. (Fig. II). In other words, the tide produced by M on E has resulted in *depressing, instead of lifting,* the intervening water. Again, let us turn on the discharging switch so that M will gradually lose its lately acquired power; there can then be no doubt that E will as gradually resume its original state. In this condition let us imagine E back again to its primitive isolation, and then conceive of the ball M, this time endowed normally with the power of gravitation, approaching E from a great distance. It is plain that since by supposition M now possesses gravitational power, the nearer it gets to E the more its effect on that body will become apparent, so that we shall witness a repetition of precisely the same chain of tidal phenomena as in the previous example; that is, the kernel of E will slowly push through its envelope of water in the direction of M, *thus producing a* LOW *tide on the side presented to M,* which is the very reverse of Newton's theory.

The conclusion is inevitable then that tides are caused by a depression and not by an elevation of the ocean under the tide-producing body.

This result certainly comports better with the observed facts, and when applied to the multifarious complexities of tidal phenomena will be found to work out vastly better. That the subject has heretofore, under the Newtonian theory, been one of science's *betes noires*

will appear from the following quotations from recognized authorities:

> "In fact the statical theory (of tides) becomes utterly unsatisfactory in regard to what actually takes place, and it is necessary to depend almost entirely on the results of observation, using the theory merely as a guide in the discussion of the observations."[1]

> "The establishment of a port is the mean interval between the time of high water at that port and the next preceding passage of the moon across that meridian. At New York, for instance, this establishment is 8 h. 13 m. although the actual interval varies about 22 minutes on each side of the mean at different times of the month."[2]

Interpreted, this means that according to current theory the moon's effect follows 8 hours in her wake; according to mine she "brings her knitting with her."

> "It is interesting to reflect that our tides today depend even more on what occurred yesterday or the day before in the Southern Pacific and Indian oceans than on the direct action of the moon today * * * the problem is one of insoluble mystery."[3]

> "The equilibrium theory is nearly as much wrong as possible in respect to the time of high water. In fact in many places it is nearly low water at the time the equilibrium theory predicts high water. It would seem then as if the tidal action of the moon was actually to repel

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1 Young's General Astronomy, page 307.

2 Ibid, page 403.

3 The Tides, page 188, Geo. H. Darwin.

> the water instead of attracting it, and we are driven to ask whether this result can possibly be consistent with the theory of universal gravitation."[1]
>
> "In fact, the evanescence of the diurnal inequality is not much closer to the truth than the large inequality predicted by the equilibrium theory; and both theories must be abandoned as satisfactory explanations of the true condition of affairs."[2]

It may seem strange that a force many times greater than another, and exactly reversed, should be seriously proposed as a substitute to explain, not only qualitatively but quantitatively, precisely the same phenomena. But the vagary is not mine. According to Dr. Young,[3] the moon's tidal action, as based on current theory, is only 1/8,640,000th of the earth's gravity and the sun's only 1/19,600,000th thereof,—preposterously inadequate to cause the actual phenomena, as may be convincingly shown. Thus, the mean depth of the ocean is said to be 13,000 feet, which, when reduced to inches and then divided respectively by the denominators above given, will yield approximately .02 and .009 inches respectively as the measure of the tide raising force of the moon and the sun as compared to the ocean depth! In other words, the sun's tidal power suffices to elevate the ocean level only by the thickness of a mere *film*, or of a leaf

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1 The Tides, page 161.

2 Ibid, page 180.

3 General Astronomy, Arts. 464 and 465.

of this book, a quantity *less than 1/10th of the sun's daily evaporating effect!**

Here I fancy the reader saying, "Your argument seems plausible, but its very simplicity condemns it. It is inconceivable that more than two centuries of brilliant scientists should have overlooked things so obvious. There must be a screw loose somewhere." This is always the hardest argument for the pioneer to answer. I daresay it was used to Copernicus when, after fourteen centuries of Ptolemaic tradition—seven times longer than that with which I have to contend—he dared to suggest that maybe after all it was only our earth and not the universe that was moving.

The first impulse of the general reader, had he originally analyzed all this is the class-room, would doubtless have been to scoff at the notion that the tidal action of this one-fiftieth of an inch as compared with the full ocean depth of 13,000 feet can by any possibility constitute the sufficient explanation of the enormous diurnal tides witnessed on our coasts, or that even the accession out of nothingness of a fresh sheet of water of that thickness could swell the ocean to the formidable tidal states we see. However, had the same reader been faced with the harsh alternative of either accepting this myth or repudiating the principle of universal gravitation altogether, he would probably have followed the example of the whole scientific world before him, and humbly submitted to the inevitable.

In a former chapter we saw how Newton in striving to prove his theory of centripetal gravitation, was con-

*I leave to others the calculation of what the tidal **depths** should be under my theory, partly because mathematical discussion is beyond the scope of the present book, and partly because the principle of **depression** of the water as opposed to that of **lifting**, raises a question of physical fact to which only careful experimenting can furnish conclusive answer. It may be said generally, however, that the effects of both sun and moon would be hundreds of times greater than under the present computations.

fronted with the necessity of providing a foil to it in the nature of a centrifugal force. We saw further how in order to achieve this he proceeded to make a series of violent assumptions, such as, uncaused motions, ghost-matter, curvature of motion without expenditure of energy, and the like, and how he spurned altogether his own third law of motion as to the necessity and equivalence of reaction to action. There too the issue lay between subscription to chimeras or denial of the principle of gravitation; and the choice that science made we know. Here in the case of tides and the earth's inertial rotational motion we are confronted with another similar alternative. Science having irrevocably committed herself to the doctrine of inertial motion because of the imaginary dependence of gravitation thereon, she is now obliged, for consistency's sake, to reconcile to it every adverse fact in the way. Drains upon this rotational inertia must be theoretically minimized even at the expense of common sense and self-delusion. Tidal *films* offer vastly less resistance than tidal *hills,* hence films it must be. Thus it is seen that out of a mistaken sense of devotion to the law of gravitation, science has committed herself, (1) to a denial of the reality of substantial tides, (2) to a theory of tides utterly contradictory of the observed phenomena (as the preceding quotations show), (3) to a repudiation of one half of the first law of gravitation, whose preservation is the very thing sought, (4) to virtual affirmation that the earth's rotation is not due to current causes, (5) that planets do not observe the law of physics as to the position of the center of gravity,—but why lengthen the painful chain of error, for it is endless.

But it is not true that tidal resistance tends to retard the earth's rotation.

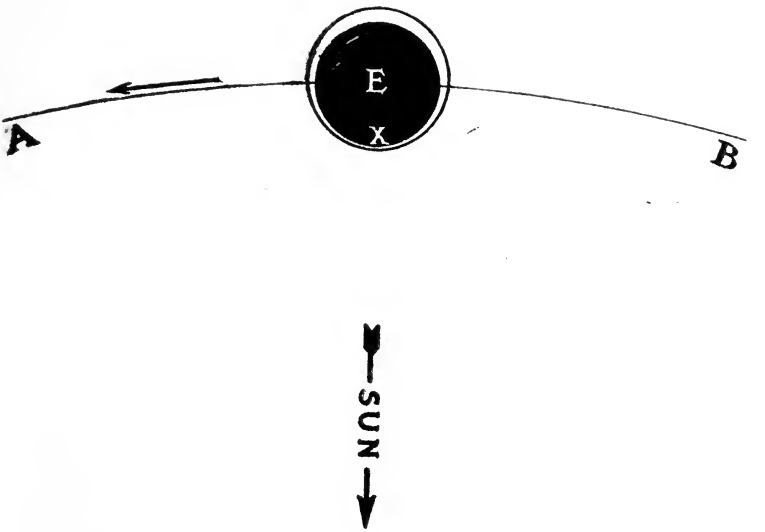

FIG. III.

Perhaps the reader will here ask, "Then what becomes of the friction?" One very obvious answer to this is that it *magnetizes the earth,* and so makes possible the mariner's compass. The second and more important reply is that *without this friction the earth would not rotate at all,* but, like the planet Mercury, would settle permanently with its center of gravity pointed toward the sun. Referring now to the diagram (Fig. III.): Let AB represent an arc of the earth's orbit, and E the earth. According to my previous explanation, the earth's kernel keeps continually sinking through and displacing the water that blocks its outlook to the sun, thereby causing closer contact, and of course stiffer friction, at the point X than elsewhere on its circumference, and so, as it were, continually *tripping* the kernel into rolling forward on its face. The planet is not, however, thereby retarded, whether rotationally or revolutionally, but is made to press onward, AT THE BEHEST OF THE PRIME RESULTANT, to sustain her share in the systemal balancing act, never alighting, and never by any chance rolling out of her encircling water-trough. A stately ship is our Earth, driven by wireless power from the stars; herself the compass; her oceans the trough; humanity her passengers; eternity her port.

The Prime Resultant has a still further bearing on this particular subject of the tides. As previously suggested, it creates a permanent low tide at the north pole and a correspondingly high one at the south pole; the result being, I think, that at some particular parallel of north latitude this permanent tide and the diurnal ones of the sun and moon clash and mutually cancel each other, thereby causing, on the one hand, a line of high water along the parallel and, on the other, comparatively smooth water farther north.

It is obvious that if this explanation of the earth's rotation be true, the earth's axis must wobble somewhat, and the periods and variations of the movement should be not only diurnal but monthly and annual as well, thus affording the probable explanation of the secular changes of latitude so laboriously investigated and mapped by Prof. Chandler.

It is no less obvious that the atmosphere ought to be affected, though perhaps less noticeably, similarly to the ocean. Accordingly, it is an observed fact that when the water-tide is low the barometer is always higher than normal. Heretofore this has been looked upon merely as a coincidence, when as a matter of fact both are due to the same law of tidal depression. Here, in my opinion, is the chief cause of trade winds.

It may be well to point out more clearly to those who have not already followed up the applications in their minds, just how a depression can cause high water, and how the coincidence of high tide with the moon's motion is explained. When the water is depressed in the middle of the Pacific, say, by the noonday sun, the water thus displaced must seek a passage round the globe in all directions until stopped by the land. Now, as the sun is always travelling westward it follows that the water in front of it is being continually pursued while the water behind it is being as gradually liberated; so that the tides on the eastern coasts should be both sharper and more severe. The moon's share in the operation is to send tide-waves backward and forward to those of the sun, and where they clash is the line of "high tide." By gently blowing down upon the surface of smooth water the reader can easily simulate the tidal effect; and if two persons join in the experiment, the action of both the sun and the moon can be fairly well illustrated. The higher tides of our winters are plainly

due to the fact that the farther south the sun, the greater the water expanse he has on which to operate, and the more telling his effect.

A spectacular object-lesson in atmospheric tides, which nevertheless has hitherto been lost upon science, is that of the comets, whose tails, when present, are invariably directed away from the sun. Current theory persists in regarding this behavior as an infraction of the law of gravitation, and seeks to explain it by a fantastic theory of light, or electrical, repulsion. The simple and natural explanation is, that when far remote from the sun, the comet, being for the time comparatively relieved from perturbing external strains, draws itself up into a ball and wraps its ethereal cloak evenly about itself. But later, as it nears the sun again, his increasing attraction compels it to keep lowering its center of gravity more and more (the better to preserve its balance in its mad rush through space) and, conversely, to relegate its tenuous gases in the diametrically opposite direction, which is to say, *away from the sun*. Whatever mystery the phenomenon possessed disappears instantly in the light of the rule that heavenly bodies attract each other by their centers of gravity and not of figure, and that the comet and the system to which it belongs are both *gravitational units*.

I must not close this chapter without correcting an error, as inexplicable as it is universal, in regard to the imaginary tidal action on molten bodies, an error too which lies at the very base of various modern theories of cosmogony which are even now aspiring to public favor. According to this notion, third bodies are formed by two sun's approaching each other sufficiently near to tear each other to pieces by tidal strain. This is sheer nonsense. A star's integral power is at its maxi-

mum where lies its center of gravity, *and as the latter is always in the forefront*, tidal disruption under any circumstances is out of the question. The theory must rely altogether on its other guess of stellar collisions; and these must be central, and not grazing as some imagine.

VI

MARS IN HIS ICY CUIRASS

VI

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Next to the earth itself, Mars is by far the most interesting of the primary planets, notwithstanding that it is the second smallest. The reason for this lies in the fact that, with the possible exception of Venus whose surface is hidden by a dense atmosphere, it is the only one thought to be capable of supporting forms of life similar to our own. When very closest to us, Mars is still over 35,000,000 miles distant, and this distance may vary all the way up to 235,000,000 miles. It will therefore not surprise the general reader to learn that very little is positively known regarding the details of its surface, and that even that little has been the subject of grave controversy between recognized authorities.

Prof. Percival Lowell, of the Flagstaff Observatory, whose facilities for observation are unexcelled, and who has devoted many years to the special study of this planet, has published the results of his investigations in a series of books, the last of which, *Mars as the Abode of Life,* appearing in 1908, contains a summary of practically all that is known about the planet, together with an expansion of his now celebrated theory of the existence of a race of intelligent beings upon it.

It is not my desire to single out any particular author for discussion, but Prof. Lowell has so closely identified his name with that of Mars as to render impossible the consideration of that planet without reckoning with him. We must either be for him, or against him. Either we must yield ourselves converts to his theory, or we must perforce explain away by natural causes the deep mystery underlying the so-called "canals" of Mars. This I shall here attempt to do, not by disputing the genuineness of his observations, but by interpreting them in a more natural way.

In order to prepare the reader to comprehend what follows, I shall attempt a brief summary of Prof. Lowell's facts and of his method of interpreting them, quoting in some cases his own language.

1. "Mars' surface is singularly devoid of irregularity. The more minutely it is viewed the more its levelness grows apparent. Calculation shows that heights even of very moderate elevation should be visible if such existed and none show."

2. Being approximately one and a half times farther from the sun than is the earth, Mars receives, area for area, four-ninths as much heat.

3. Mars' surface gravity is but thirty-eight per cent of the earth's. The atmospheric pressure too is much less.

4. "The northern snow cap diminishes from 78° to 6°, the southern dwindles from 96° to nothing."

5. "Excluding the polar caps the surface consists of large robin's-egg-blue patches indiscriminately placed upon a general background of rose ochre, the relative areas being 3/8ths to 5/8ths. The tints frequently vary in shade and grade off insensibly into each other thus making regions of intermediate color but the precise borders of which are not decipherable by the eye." The

ochre regions are construed to be deserts of sand and rock intrinsically of that color. "White dots too are scattered over the disk, dazzling diamond points that deck the planet's features to a richness beyond the power of pencil to portray, so minute are they that good seeing is necessary to disclose them."

6. The fact that certain permanent markings (to be described hereafter) appear on the dark blue regions as well as on the ochre, leads him to assume that both are land, the former, in his opinion, being probably the basins of evaporated oceans and now covered with vegetation.

7. But the distinctive feature which constitutes the corner-stone of Mr. Lowell's theory consists of certain curious markings crossing Mars' disk that by their regularity and other singular characteristics seem to proclaim methodical design. These markings Mr. Lowell, following Schiaparelli, not only likens to canals, but goes farther and declares them actually to be such. Until very recently the genuineness of these markings, on account of their exceeding faintness and the want of sufficient corroborative testimony, was questioned, but of late photographic reproductions have partially confirmed ocular report. When the reader considers that the disk presented by Mars is no greater than that offered by a silver dollar at the distance of about 300 yards, he will see that statements as to minutiæ should be received with extreme caution. Professor Lowell does not claim that the actual *channels* are wide enough to be descried from here, but that the supposed strips of cultivation paralleling them aid in delineating their courses against the prevailing ochre background.

These "canals," Mr. Lowell reports, follow the arcs of the planet's great circles, so that we who look centrally down upon them see apparently straight lines.

This studious regard for choosing the shortest distance, according to Mr. Lowell, implies not only provident economy in design but also a very high degree of technical knowledge and skill. Necessarily there are many points of intersection, and, strange to say, at the majority of these, he points out, there are circular dots about 75 miles in diameter, which in color correspond with the canals. These Mr. Lowell conceives to be oases, Martian cities, as it were, environed by irrigated farms. Not this alone, these canals connect with certain caret-shaped spots that appear to be the "salient points" of the blue-green patches; and from certain of the oases canals branch out numerously, always in straight lines, to other oases, forming a sort of open network. They always lead to definite destinations, never stop short as rivers might do, and, again unlike rivers, they preserve a surprising uniformity of line throughout.

In the first days of summer of each hemisphere, these canals, he states, begin to grow in distinctness, starting at the polar cap soon after it commences to thaw and thence gradually continuing down to the equator. At such times too certain of the canals have a trick of pairing or doubling, technically known as "gemination".

The aggregate length of the canals is stupendous, probably as much as 40,000 miles, or three times the circumference of the Martian globe. Five hundred and twenty-two of them have been mapped, the shortest being not less than 250 miles in length and the longest, the Eumenides-Orcus, stretching the enormous distance of 3450 miles. At least a dozen extend to points far within the polar circles, and would no doubt be found to reach even to the pole itself, were their ends not obscured by the sharp retreating figure of the globe in that high latitude.

Upon this foundation of observed phenomena, Prof. Lowell has built up his original and startling theory of life on Mars. And here is the gist of it:

1. The distance of Mars from the sun, its source of heat, is not so great, he argues, as absolutely to preclude the existence of animal life. Mars' summer is much longer than ours, and planetary life is determined rather by the mildness of summer than by the asperity of winter. Mars' mean temperature he estimates to be about 48° F.

2. Water is essential to life. There being no oceans, as he says, the streams too must be dried up. The alternative is presented of death from thirst, or of recourse to the only fresh water supply remaining, to wit, the polar snows.

3. Naturally this necessity, he contends, prompted to the Martians the canal idea. Of course the system now in evidence was not constructed in a day. It was the result rather of slow growth, developing painfully in inverse ratio to the failing sources of supply.

4. The undertaking, he suggests, was far less formidable than a similar one would be here. First of all, the flatness of the surface would render the mere digging easy. Then again, on account of the lesser surface gravity, the efficiency of the machinery would be perhaps quadrupled. If to these positive advantages be added the permissible suppositions that the Martians are gigantic, and also further advanced in the mechanical arts than ourselves, the objection on the score of mere physical difficulty is, he reasons, largely eliminated.

5. The surface being flat, every point within as well as beyond the polar circles would be in stable equilibrium. This means that the water would not descend through the canals at any useful speed without *artificial* propulsion. Observation proves to him that the canals

show activity of a certain kind immediately following the incipient thawing of the snow-cap, and that this active movement travels equatorward at the rate of 51 miles a day for a distance of 3300 miles. As to the nature of this change we can judge only from appearance, which, he avers, consists in a gradual darkening and broadening of the canal lines, and is construed by him to be due to stimulated vegetation.

6. The ancient "sea bottoms" Mr. Lowell infers to be regions of vegetation, on account of their color. Yet they too, he declares, exhibit "canals," not only entering from the nearest pole of supply, but rising again into the arid regions nearer the equator. This feat of canalizing the basin of an ocean and thence raising the water to the farther shore Mr. Lowell cites as an evidence of Martian engineering prowess.

7. Philosophically speaking, the evolution of life from matter is the order of nature. Mars, whether or not older than our planet, presumably cooled earlier, both because smaller in size and more remote from the sun. Hence, he argues, it has already run the gamut of evolution, and by the principle of survival of the fittest the present Martians must be the highest products of their race. Historically, they have witnessed the birth of a world, and seen it pass through its seven ages into that of the sere and yellow leaf. Even the seas have dried up, partly by absorption into the interior and partly by the escape of the molecules into the outer air. The race is at bay, being driven slowly, but none the less inevitably, to extermination by the road of thirst, for the snow caps must be thinning year by year, and eventually must altogether vanish.

Thus far Prof. Lowell's argument, which I have aimed to give as fairly and fully as the present circum-

stances allow. That it is fascinating in conception, elaborately argued, and exquisitely presented, no lover of truth or judge of literature will deny. Nevertheless it has failed of convincing the profession; and, what is more to the point, it is open to complete refutation.

Prof. Lowell has made the all too common error of twisting intractable facts to suit preconceived theory. Unconsciously he has reasoned, not to a conclusion, but to prove a conclusion previously formed. Let us see now whether the facts he himself adduces will yield a different and more credible interpretation.

1. The southern snow-cap at the full covers over a quarter of the planet's surface, and the northern cap considerably more than a fifth. The snow must come from evaporation, must it not? But Mr. Lowell denies the existence of any evaporating surface save that of his canals! Were the caps a *permanent* feature this point might be explained away; but the snow *disappears every summer,* and of course must be as often restored. It seems to me that if Mr. Lowell had not had his theory in mind, he would have reasoned that the caps could not come into existence from the evaporation of his canals alone. *The caps being so extensive and the solar heat so feeble, there must exist an exceptionally large evaporating surface.* He might have reasoned further that the vapors from the canals wouldn't extend his theory the courtesy of proceeding intact back to the poles, but would, after the manner of atmospheric humidity, spread in all directions, and come down in rain or snow, most probably the latter, indiscriminately over the whole surface. *His snow eggs are laid without the aid of the mothering ocean.*

2. What causes the caps *to disappear?* Surely not the solar heat! For consider. Prof. Lowell him-

self gives Mars a mean temperature of but 48° F., and that only by construing every doubtful factor in his favor. Other authorities who are not committed to his theory think the temperature cannot exceed 32° F., that is, our freezing point of water. The earth's mean temperature is 60° F., yet our arctic regions remain one perpetual snow. *Now if the sun does not and cannot do the work, what other effective agency remains but water?* And we can only explain how water does it by supposing the polar snows to find merely a temporary lodging place on the frozen surface of a sea, which surface, as the summer advances, becomes overflowed by warm tides from the tropics. A telling proof of this reasoning is the diminutive summer cap worn by the north pole; *it is permanent because it rests on land, the inevitable implication being that the rest is sea.*

3. On a planet where warmth is surely as much of a desideratum as water, *we should expect to find settlements only in the very warmest belts.* The hypersophisticated Martians, however, have nearly *as many canals and oases in the very heart of the arctics as in the best favored regions, and, marvel of marvels, underneath the very snow-caps themselves!* For proof, consult Mr. Lowell's published maps.

4. The canal mileage is about forty thousand. The oases are rarely if ever closer to each other than 250 miles. Why this prodigality in length of canal, when, as in another place Prof. Lowell points out, the Martian engineers are so alive to the economy vested in great arcs and straight lines? It is altogether likely that some, perhaps many, isolated outposts would be found necessary on Mars just the same as here, even under their dire need for huddling together; but it taxes sound reason to comprehend why there should be *nothing but outposts,* why there should not be evidence of

the existence of a great and extended community somewhere in the more favorable climatic sections.

5. I am tempted to ask, Is it a mark of capacity, or of stupidity, to conduct irrigating canals into the deeps of an ocean bed assumed to be fertile, and then, at the cost of tremendous labor and resource, to raise them to the heights of the further shore for the purpose of irrigating alleged deserts?

6. Since these canals appear to be feasible everywhere, why did it not occur to the Solons of the planet to surround the snow supply with a belt line, and thus save themselves the manifestly useless task of boring a multiplicity of canals through countless miles of what must be hard-frozen soil?

7. And has Prof. Lowell in his zeal really succeeded in misleading himself into the belief that, *given sufficient ice-water*, vegetation in the arctic zones would proceed as speedily as in the tropics? His own words leave no room for doubt that such is his meaning. For, obsessed by his theory, he proceeds, in close logical sequence, to describe how first the coming sun thaws the snow-cap, then how the water is made to descend by artificial aid toward the equator in the timed flow of 51 miles daily for the huge distance of 3300 miles, and how, *in precise step with this flow*, the canals, beginning with the uppermost in latitude, *successively* darken with the revived growth of vegetation. Dramatically he contrasts the regular poleward trend of our sprouting seasons with the reversed order on Mars, and seems to derive a discoverer's elation from the circumstance that one is as regular and sequential as the other! Now, there are three conclusive answers to this pretty demonstration, which Mr. Lowell, for the sake of his pet idea, studiously ignores. One is, that unless Mars is very much hotter than our earth, the frost in the latitude

where he assumes vegetation to get the earliest start must be perpetual, and vegetation altogether impossible, whether with or without water, be it warm or cold. The second reason is, that the water freshly melted from the snow-drifts would be veritable ice-water, and would be no stimulant to plant-life in a warm, let alone in so cold a climate; and, third, it is only by screwing up his estimate of Mars' temperature to the last notch that he can convince himself or others that life, *even on Mars' equator,* is possible, not to speak of canals and oases at its very poles! Then there is the sensible, economical reason, that the canny Martians of the tropics, did they actually exist, should long ago have learned to take thought for the future, and to provide in advance stores of water against the opening of the season; so as not to be dependent upon their esquimaux for their early spring vegetables.

A New Theory About Mars

1. Analogy would lead us to expect seas on Mars. And behold the shining proof of them in the polar caps and their seasonal coming and going.

2. Unlike our polar snows, which are perpetual, Mars' snow-caps totally disappear every season save for a small bonnet at the northern pole, which always stops short at the same minimum size. Two agencies capable of causing the mere thawing suggest themselves, namely, *heat* and *flowing water.* Internal heat is out of the question, since in that case the snow could never have lain in the first instance. Solar heat, *if* sufficiently ardent, might explain the disappearance of the snow, *but not the sparing of that pertinacious bonnet,* which defies any explanation save that it rests on land, and, conversely, that the remainder of the cap which seasonally disappears rests on an ice-crust.

3. Now Mars' polar caps are exceptionally extensive, and for their production demand the existence of a relatively large ocean surface. This requirement is rendered more imperative by the sun's remoteness, and is even further accentuated by the compulsory exclusion from the available evaporating surface of that part of it covered, for the time being, by the opposite cap.

4. If Mars' seas bear a similar ratio to its solid kernel as ours do to the earth's, the surface there must be pretty generally covered to the depth of a mile or more. This assumption, it may be said, is sustained by my theory that rotation is due to the sun's tidal action. Mars rotates on its axis in 24 hrs. 40 ms., a period reasonably consistent with the earth's case, when their respective masses and solar distances are taken into the reckoning.

5. The center of gravity of Mars (according to my argument regarding the earth) lies toward its north pole, and conformably we can see the land there revealed, while the southern pole is entirely covered with water.[1]

The conclusion is inevitable: *The hitherto supposed lands, with the possible exception of the blue-green patches, must, after all, be seas, and the riddle of the markings must be solved on that basis.*[2]

Now it goes without saying that water in its fluid state may exhibit great waves, but these quickly vanish and leave no permanent signs. The insistent reality about Mars, however, is *its frigidity,* and this fact ought long ago to have prompted the thought that the *oceans*

1 If it could be shown that Mars' form is somewhat more rotund about the region of its antarctic circle than at its arctic, the circumstance would tend to corroborate my views, but the disparity is probably too slight for detection.

2 Since the blue-green patches also exhibit similar, though much less distinct, marks around their margins, these latter may be regarded as mingled sea and land—something like the marshes near Atlantic City, or the Everglades of Florida.

may be frozen over, in which state they can as easily carry markings as the most rigid land, and more regular ones besides.

It would be an error to jump to the conclusion that Mars' oceans must be frozen *solid,* for decidedly they are not. For one thing, the planet could not rotate unless the water were fluid, as I have previously shown; and, for another, the gravistatic heat generated by the planet is sufficient to avert total congelation.

That Mars' gravistatic heat is by no means a negligible quantity may be proved by a simple calculation. Mars' superficial gravity being .38, one would have to descend toward its center about 150 feet for each degree of increase in temperature (this distance increasing with the diminishing gravity), which would give a maximum theoretical temperature at the center of about 40,000 degrees, or an average of 20,000 for the whole mass. This is a much lower temperature than our earth theoretically generates, and seems insufficient until we call to mind that Mars' rarer atmosphere and lesser gravity *both operate to greatly lower the freezing point of the water, and that ice is a bad conductor of heat.*

The excessive external cold must evince itself somehow, and this it does by freezing a thick crust over a major portion of the ocean surface. Nevertheless *even such a surface may experience seasonal changes,* and this is the real key to the whole mystery. It remains for us now only to reason by natural steps just what would take place under such conditions.

Going toward our own north pole we come eventually to a parallel of latitude of perpetual frost. In the case of Mars, this critical parallel is nearer the equator than it is with us. During the warm season the ice-crust thaws partly through, but not entirely so except very

late in the season, and then only at the equator where the crust is thinnest. So cold must be the planet that the sun would be powerless to cause evaporation were it not for the accidental circumstance that, on account of the diminished surface gravity and lower atmospheric pressure, the boiling point of water there is reduced from our 212° F. to about 111°, and the thawing point correspondingly.

The process of evaporation takes place from the surface of this glacial crust, or rather from the surface of the thaw-sheet submerging that crust,* during the daylight hours of Mars' protracted northern spring of 199 days and his scarcely shorter summer of 183 days. The nights are relatively cold, and during them much snow falls upon the thaw-softened surface, thus giving birth in the course of time to a vast litter of disintegrated ice, extending far into the high latitudes.

When this condition reaches a maximum, this superficial sheet of thaw-water is of itself sufficiently deep (or perhaps is reinforced by the subjacent waters breaking through the softened crust at or near the equator) to reflect in its movements the tidal effect of the sun. *Waves of wide scope are formed, which progress with a high degree of regularity over the smooth ice-crust-bottom sweeping the glacial detritus before them* until, having reached the limit of their range, they deposit their cargoes in long, regular, geometrical lines, which then form embryonic ridges, or dams, for future waves and new cargoes to respect and add to, until in the end the accumulations grow to a WIDTH capable of arresting our attention even over the abyss of space.

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*Of course no **evaporation** can take place from the **crystalline** surface of ice or snow; but when a pool is formed over a substratum of ice, there is no bar, other things being favorable, to evaporation taking place from the surface of the pool itself.

Veritable congealed tide-waves are they, following by the very law of their formation the great circles of the planet, and supported from beneath by the permanent ice-crust. As the sun moves northward or southward, the new waves that keep forming take slightly different courses, and give rise to new "canals."

Now, when waves touch or cross they "interfere," and create at the points of intersection hills of double height and width. This, I take it, is the origin of the "oases," and of the curious "carets." On this theory it ceases to be mysterious why both canals and oases are so segregated, why so many of them affect the polar regions, and why they connect the "salient points."

The dams, being composed of ice, would melt away were they not seasonally recruited. But they are, as the gemination process eloquently attests. The seasonal or capricious lightening and darkening of the canals may be aptly explained by fresh snowfalls, or the meltings of snow; which are doubtless as common and natural climatic phenomena there as here, and not especially significant.

The same explanation ought to suffice for similar general variations of color. The brilliant white diamond points which Mr. Lowell has described can assuredly be nothing else than islands capped with snow—his own theory of an exclusively land surface precluding him from advancing the same natural conclusion.

In one place in his book, Mr. Lowell graphically describes a great Martian storm, in which the cloud was estimated by him to be flying at a height of 14 miles above the planet's surface. He expresses the opinion that this cloud was composed of sand, "because its color was almost that of the planet's surface," which, as we already know, he assumes to be desert. Now if

correspondence of color between surface and cloud counts for anything, then the cloud, according to my theory of a frozen-over ocean, should have consisted of snow; and the issue narrows as to whether sand or snow is the likelier element to be found at an altitude of fourteen miles, in a case where the atmosphere is admittedly rare.

My conclusion, then, as to the character of Mars' surface is: That the planet is largely enveloped by its oceans, that these in turn are incrusted with ice; and that whatever markings and irregularities there may be thereon, whether comporting with Mr. Lowell's reported observations or not, are the natural result of seasonal change and tidal action. Under these conditions the planet is not habitable by any but the very lowest forms of life, and can never in the past have been any better fitted to support life than it is today.

VII

THE MOON IN MASQUERADE

VII

THE MOON IN MASQUERADE

The general reader would naturally suppose that since we are able to form an idea regarding the character of Mars' surface, which, at the best, is more than 140 times as far from us as is our satellite, it should be a comparatively simple matter to construe the lineaments of the moon. Such however is not the case. In round numbers the moon is only 240,000 miles from us, and has a diameter of 2163 miles, being a fraction over half that of Mars. When viewed through a telescope of about 400 diameters (which is found by experience to be the most satisfactory, everything considered), it is possible to perceive, *though as a mere point,* any feature upon its surface as large as an ordinary city block.

There are two peculiarities about the moon which have puzzled astronomers beyond measure, and until the present moment have escaped their true solution. One of these is that it presents only one side toward us, and the other, that its topography appears to be so abnormally volcanic in character.

Problem of the Moon's Motion

Is it not truly singular that axial rotation, the cause whereof science has never managed to guess, has been

assumed to be the *normal* thing, whereas a condition of passive equilibrium ought to seem so much more natural and likely? So far as we know, Mercury (the smallest of the planets) and the only satellites of other planets susceptible of sufficiently definite telescopic examination (namely, some of Jupiter's) exhibit the same idiosyncrasy of motion as does the moon. It is positively unthinkable that such a uniformity of motion can be the result of mere chance; but, on the contrary, it must be due, not only to a similarity of causes, but to such causes as inevitably lead to the one result.

As a matter of fact, the moon doesn't rotate on its axis in any true sense; that is to say, it hasn't an inherent motion of that character any more than a balloon could be said to have were it also to circumnavigate our globe. Not having any fluid oceans our satellite has simply settled into a position of stable equilibrium, ballast down.

In this attitude the moon makes a circuit about the earth every 27½ days, the plane of its orbit being approximately the same as that of the earth's around the sun, so that we have what are known as the lunar phases.

Now the moon has a peculiar trick, in rounding from full to last quarter, of seeming to turn gently to the east so as to hide a part of that edge, and simultaneously expose an equal segment or crescent around the westerly limb. After passing the quarter, the body swings just as gradually backward until at "new," were it then visible, we should see its face precisely as it is at full. In the last half of its circuit the same process is repeated, except that here we get to see an extra crescent around the other or easterly edge. This phenomenon is what is known as the "longitudinal libration."

In order to solve this peculiarity, it will be necessary to mention another fact or two by way of pre-

liminary. The gravitational effect of the sun on the moon, after all allowances as to distances are made, is a little more than twice that of the earth. Hence it may be asked why the moon does not settle with its center of gravity turned sunward instead of earthward; in which case it would show every side of itself to us, but keep one side only perpetually directed to the sun. The answer to this is not difficult. The test is not one of degree of power alone, but of differentiation of power. For the sun being some 400 times more distant than the earth, the angle formed by two lines drawn from its center to the two points marking respectively the center of figure and the center of gravity of the moon (for the two are by no means identical) will be only 1/400 as great as a similar angle formed from the earth's center to the same points. Hence the sun cannot bring its greater strength so well to bear. It is a question of purchase, or twist. Now, as the moon progresses in her orbit she keeps shifting her angular position relative to these rival attractions of sun and earth, and this it is that produces the libration in question. Thus when she is at new and full, the sun and earth act along the same straight line; but when she is at the quarters, their attractions conflict most, and the moon swings east or west accordingly.

In a former chapter I explained how the earth and moon together are kept revolving around the sun by the action of the Prime Resultant, so that, including it, we have three rival forces continually pulling at the moon, all together being capable of accounting from instant to instant for all its varying movements. If, now, to these were added an inherent, arbitrary rotation as predicated by current theory, it is plain that the moon's safety would be imperilled. Like a weather vane it has to be, and it is, free to respond automatically to the eddying currents continually playing upon it, only

in this case the "currents" are gravitational instead of atmospheric in their nature.

Problem of the Lunar Surface

Generally speaking, the moon has a mottled appearance, consisting of dark splotches on a silver shield. In the telescope the brighter part is seen to be exceedingly irregular and, as might be expected, contains the most interesting objects. The dark spots, before the day of the telescope, were called seas, and are still so named notwithstanding that they have ceased to be looked upon as such. These cover about two thirds of the entire disk, and present in a sort of bas-relief the same characteristic formations of the brighter surface. Were it not for this latter peculiarity, they would probably still be regarded as seas, in spite of other considerations to the contrary.

SPECIAL FEATURES

1. Craters. These are ordinarily likened to a saucer in shape, but misleadingly, doubtless from ignorance of the interpretative significance of the detail. They more nearly resemble a pie-tin, being practically flat on the bottom and having steep walls extending all around, in some cases, but usually exhibiting one or more gaps of greater or less extent. The resemblance is not complete, however, inasmuch as the walls are terraced. The outer slopes of the containing walls are not only much less steep, but invariably the vertical descent on the inner side of the wall is greater than that measured from the same summit to the average level of the plane without. This peculiarity is in some cases so accentuated as to inspire the conviction that the mouth of the crater does not stop at the surface but *extends deep down into it.*

On the other hand, many craters, while bearing the same general characteristics, are quite shallow, and between the two extremes exist many hundreds of all sorts and gradations. In horizontal diameter too they vary amazingly. The crater Shickard, for example, is 120 miles across, and a dozen or more others exceed 30 miles. From these dimensions there is a downward gradation to the limit of the telescopic power, and we know not how far beyond. Again, some craters are contiguous and overlap, as though one had formed later and disturbed the regularity of the outlines of the earlier one. And, finally, a large percentage of the more conspicuous craters have within their walled plains compact groups of cone-shaped hills, which attain in some instances heights of several thousand feet, *but never rise so high as the encircling ramparts,* which sometimes reach the imposing altitude of nearly 4 miles.

2. MOUNTAINS. These appear in various forms, isolated, in groups, and in ranges, and I shall take the liberty of quoting a description of them from a well-known authority:*

> "In turning our attention to these features (mountain ranges, peaks, and hill-chains) we are at the outset struck with the paucity on the lunar surface of extensive mountain systems as compared with its richness in respect of crateral formations, and a field of speculation is opened by the recognition of the remarkable contrast which the moon thus presents to the earth, where mountain ranges are the rule and craters like the lunar ones are decidedly exceptional. Another conspicuous but inexplicable fact is that the most important ranges upon the moon occur in the

*The Moon. Nasmyth and Carpenter, Chap. X.

northern half of the visible hemisphere where the craters are fewest and the comparatively featureless districts termed seas are found. The finest range is that named after our Apennines. It extends for about 450 miles and has been estimated to contain 3000 peaks, one of which—Mount Huyghens—attains the altitude of 18,000 feet. * * * Another considerable range is the Alps situated between the Caucasus and the crater Plato. It contains 700 peaked mountains and is remarkable for its immense valley 180 miles long and about 5 broad that cuts it with seeming artificial straightness and that, were it not for the flatness of its bottom, might set one speculating upon the probability of some extraneous body having rushed by the moon at an enormous velocity, gouging the surface tangentially at this point and cutting a channel through the impeding mass of mountains. * * * At first thought it might appear that the great mountain ranges were produced by bodily upthrustings of the crust of the moon by some sub-surface convulsions. But such an explanation could hardly hold in relation to the isolated peaks, for it is difficult if not impossible, to conceive that these abrupt mountains, almost resembling a sugarloaf in steepness, could have been protruded *en masse* through a smooth region of the crust. * * * We believe they may be regarded as true mountains of exudation, produced by the comparatively gentle oozing of lava from a small orifice and its solidification around it; the vent, however, remaining open and the summit or discharging

orifice continually rising with the growth of the mountains."

3. WHITE RAYS. These are brilliant white streaks which radiate in every direction from some of the chief craters, the system emanating from Tycho being the most impressive. These rays are obscure when close to the moon's limbs, but flash out strongly when the sun is on the meridian. At such times they reach out hundreds of miles, traversing with apparently equal ease mountains and plains.

4. The surface is believed to consist mainly of lava flows from the craters, which however appear to have become extinct. The hemisphere experiencing day is supposed to be baked to the temperature of boiling water, while the other side undergoing night is undoubtedly reduced to well-nigh the absolute zero.

SOLUTION

There is no sound reason that science has yet adduced, save only the undeniable evidence of sight, why the surface of the moon should be more rugged than that of Mars. Even those who may still be disposed to echo Mr. Darwin's views as to the original unity of earth and moon, must concede that only by resorting to violent assumptions can the character of either's topography be held to resemble that of the other enough to justify his inference. To every crater on our planet, the moon can show fifty; and a comparison of these craters' individual sizes yields a contrast no less startling. Were the conditions exactly reversed, Mr. Darwin's hypothesis would be no less false, but at least it would possess more plausibility.

In beginning my discussion of the planet Mars, I argued the presence of oceans from the mere fact of its axial rotation; and here, applying the converse of the rule, we might conclude, were the fact not al-

ready obvious, that the moon is devoid of seas because it does not rotate. In critically examining the great dark splotches on the lunar surface, we cannot fail to believe that they are the emptied beds of former oceans. But if so, what has become of the water that once filled them? To this question Dr. Johnston Stoney has suggested an answer. According to the molecular theory of matter, the atoms, or molecules, or electrons, as the case may be, are believed to acquire tremendous speeds, which vary with the several elements, the molecules of hydrogen (which is one of the essential chemical components of water) for instance, being capable of higher velocities than perhaps those of any other terrestrial element. Of course there is no way of proving this conclusion, and after all it may be only another speculation. But assuming it to be true, Dr. Stoney has the distinction of being the first to indicate, as a logical sequence, the probable escape of hydrogen from bodies of small size, like Mars and the moon, and their consequent dearth of seas. Another supposition is that the water has percolated down through the volcanic crevices to interior hollows.

It may be set down as well established that there is very little humidity in the moon's atmosphere, and that the latter too is exceedingly rare. It is also a fact that the moon's surface gravity is only one-sixth that of our planet. Taking these three things together, it can be shown that any water there may be on the lunar surface would evaporate freely at about 50° F.

Paradoxical as it may sound, the real surface of the moon is as smooth as that of Mars. Equally paradoxical may ring the statement that the lunar oceans have risen from their beds, and taken up their permanent abode on the dry land. *In plain English, they have disappeared, not into outer space but into* SNOW, and

the mountains and craters that we see are nothing more nor less than the fantastic sculpturings of one Jack Frost. An inch of water is said to be equivalent to ten of snow, hence the distinguished artist has not lacked plastic material.

Consider the ideal conditions for this glacial effect: a fortnight day of evaporation followed by a night of equal length and unspeakable cold. Under such conditions in what other form should we expect to find water than as snow and ice? And where, other than on the land?

Of course the condition of the moon's surface in this year of 1912, by long continuance, has reached a stage of uniformity, so that snowscape changes have been reduced to a trifling minimum. But, conceivably, the water may once have been fluid and occupied its natural basins, and, if so, and in sufficient quantity, the planet must have rotated on its axis. These suppositions do not affect my solution one way or the other; but I think that by picturing a definite beginning, the crateral and other forms can be more graphically reconstructed, and the surface, as now visible, be better understood.

Let us imagine the planet, then, as naturally possessed of a comparatively flat surface exhibiting all the diversified forms of land and water, except probably mountains, and enjoying, as we do, a 24-hour day. By some freak of nature, as, for example, by a shifting of the moon's axis so as to point its original north pole earthward, let us say, the entire economy of the planet was changed, and its day become as we know it.

It is plain now that until the bottoms of the oceans were *licked dry* by the sun's hot rays, the planet must have been enveloped by great clouds of vapor, which being carried around to the dark side condensed into snow and ice, until the transformation became com-

plete. Perhaps if the day and night were now each a month instead of only a fortnight long, the sun could entirely thaw the snow every recurring day; but the potent fact is that it does not so suffice, *and that the thaw never succeeds in baring any part of the natural surface. Hence now, despite the daily thaws, no noticeable clouds of vapor can arise, because the universal snow absorbs its own liquefactions as soon as formed, like a sponge, and keeps them chilled below the point of evaporation.* However, we have here to do with no common terrestrial thaw that is quickly checked by an early nightfall, but with one whereby perhaps a depth of 10 feet of snow is made to disappear between dawn and sundown. Most of this melting is doubtless drunk up and retained, but a good deal of it manages to seep down through the snow blanket *into the original channels and basins,* thus periodically flushing them and keeping them clear of snow accumulations. In this way the snow is prevented from reducing the whole prospect to a dead level, but, on the direct contrary, *it greatly accentuates the asperities by adding the depth of the empty basins to that of the snow mountains risen genii-like out of them.* Hence we have the explanation of the *cavernous effect* so conspicuous in the deeper craters.

The general flatness of the moon's true surface precludes such great glacial movements as our earth once experienced; but snow-slides of considerable size are nevertheless liable to occur and thereby obliterate prominent features. *This is doubtless the explanation of the curious transformations of the great crater Linnaeus,* whose vicissitudes have been the subject of so many controversies between selenologists.

Lands nearly level with the sea are always extensively diversified by shallow, *rough-bottomed* ponds and straits, and deep snows resting upon such a base should

show an exceedingly rough topography diametrically contrasting with the natural one. The surface of the snow is therefore necessarily deeply cut and furrowed. When the daily thaws come on, the melting (not evaporation) takes place, as a matter of course, only on the surfaces directly exposed to the sun's rays; but the water, being many times heavier than an equal bulk of snow, instantly abandons the sharp pinnacles and crests, leaving them pure white, but sops the furrows, which anyhow are in shadow, *thus creating the general appearance of white rays against a drab background of slush*, and thereby incidentally explaining another of the lunar mysteries that has long resisted solution.

Naturally the melted water that manages to seep back into the basins must, while the sun is still high, immediately undergo again the process of evaporation. Owing however to the frigidity of the planet's quiescent atmosphere, as well as to its own self-built prison walls, the rising mist changes into snow before it escapes from the caverns, in which condition it is of course undetectable as vapor. Some of this snow spreads promiscuously over the planet's surface, but a proper share of it remains to restore and heighten those very walls. This piling-up process cannot go on indefinitely without eventually causing the peaks to telescope upon themselves from time to time, partly on account of their own overgorged weight and partly because of the undermining of their bases by the periodical flooding of the bottoms. This telescoping process gives us the key to the *terraced effect* so generally observed on the inner sides of the crateral ramparts, and supplies the reason for the otherwise surprising *precipitousness of their faces*. It also explains why the mountains and ramparts automatically preserve a maximum uniformity of height.

By applying the principles thus far gained the reader should find little difficulty, by the exercise of his scientific imagination, in accounting for at least the simpler forms of the moon's asperities. A "sugar-loaf" mountain, for instance, is a snow-bedecked solitary island in the midst of a former sea; the Appennines, a very longitudinal island, similarly located, and upholding a similar burden, and so on. But while the mountains are thus growing, the sea level is correspondingly falling, thereby bringing to light the higher and then less high prominences on the ocean bottoms, *each new emerging island furnishing a fresh base for the flakes to build upon; the whole process ending in a multitude of squat formations exactly corresponding to their taller brethren on the mainland.*

BUT THE CRUCIAL TEST OF MY THEORY IS ITS COMPLETE AND SATISFYING ABILITY TO RE-CREATE THE CRATERAL FORMS, BIG AND LITTLE, OF EVERY CAPRICIOUS VARIETY.

In elucidating a general principle it is usually much simpler and more satisfactory to choose a concrete example. Let us picture to ourselves, therefore, a circular cistern twelve feet in depth and a hundred feet in diameter. Instead of the walls being vertical, however, let us imagine them sloping downward toward the center of the bottom, but so as to leave a circular flat space, say 25 feet in diameter. Now, for the sake of easy reference conceive of this slope as cut into four steps, each a yard in height. We shall then have a structure resembling the pit of a Roman amphitheater. Again, let us picture standing on the bottom a number of granite blocks respectively 2, 4, 8 and 10 feet in height, to represent natural protuberances. Let us now fill the cistern to the brim with water, thus submerging all the blocks, and start the natural process of evaporation and snowing, limiting at the same time

the snowfall radius to, say, a thousand feet, for we must not overlook the quiescent nature of the moon's atmosphere, on account of which the snows spread but slightly.

Now until the water in the cistern has evaporated down to the level of the first tread (beginning from the top) the falling snow cannot gain a footing on the water surface, but must settle only on the brim and beyond, its depth gradually decreasing to our prescribed snowfall limit. A yard's depth of water, area for area, being equivalent to ten times that heighth of snow, we shall have gained by the evaporation of the first yard a snow rampart all around the brim, say five feet high, sloping gradually backward to nothing. I have just stated that the snow could settle only on the brim, but this is not precisely true, for we must not forget the tallest of the granite blocks, which for one third of this time has been exposed. It too is capped with snow, say to the depth of two feet.

Now suppose another equal period to elapse, and the cistern's depth reduced to the level of the second tread. This time the brim's cap has increased by another five feet in heighth, and the slope behind it in slightly less proportion, because the *rising snow brim has in a measure blocked the spread of the snow.* Again, the first tread having all this time been clear of the water, it too is covered, and to a depth of five feet; the tallest granite island has also gained six more feet in height; and the second one of eight feet, having been above water two thirds of the period, disports a snow cap of four feet. Thus the process goes on till we reach the circular area at the bottom. In this area we have finally four islands standing in a shallow pool of water less than a yard deep. But note that the first block uncovered is not the tallest now, for its pinnacle being, let us say, only two feet square, lacks the area neces-

sary to sustain a taller column. As a matter of fact the third block has much the broadest top of any, and though still shorter than either the first or second must in time, as the result of future processes of evaporation and snowfall grow to a great height, yet, being itself limited also, *can never reach the altitude of the encircling rampart*, which by now has risen to the imposing altitude of possibly thirty feet, and will continue rising, given the necessary supply of snow, until it telescopes upon itself by its own weight.

I hope the reader will understand that I have not introduced the stair as representing nature, or in order to account for the "terraces." The terraces are actually produced by collapses of the top-heavy main walls falling in on the lake margins, as these latter gradually become exposed owing to the steady lowering of the water level by evaporation. *Eventually a small pit is left that gathers water every recurring thaw, and this water it is which perpetually trims the bases of the ramparts and keeps their faces sheer by constant undermining, or "swilling."*

Of course natural lakes are not round like cisterns, nor their brims even, and many have broad straits connecting them with other lakes, or with the ocean itself. *All of these conditions are reflected in the moon's glacial features.* Several cases occur where craters overlap, and in part obliterate the outlines of their neighbors, a phenomenon which readily yields to the supposition that *one of the lakes is deeper than its companion and goes on building after the water supply of the first has been exhausted.*

Some may argue that if the moon be covered with snow, its albedo should be much higher than the tests show. If the snow surface stayed as flat as the planet's natural one, the point were well taken. But the mountains not only cast great shadows, but cause the solar

rays to "ricochet," as it were, and so transmit them to us weakened by repeated reflections. Besides, the *slushy bottoms* materially bring down the average of the general luminosity.

Whether the moon's atmosphere be extra dense, or especially rare, seems to me to have little bearing on my diagnosis of lunar conditions one way or the other; but my theory may throw some light on the query as to just how rare it is, *and why*. Undoubtedly the refraction of star rays in occultations is the surest test we have of a planet's atmospheric density, but in the moon's case due weight has not been given to the circumstance that it is the mountain summits, where the air is thinnest, and not the ball of the planet, that intercepts the light,—in this respect furnishing a contrast to Mars. The chief point, however, is that *snowflakes absorb considerable air in their formation, and when we reflect that practically the planet's entire quota of water is transformed into snow*, the importance of this factor on the density of the lunar atmosphere may be appreciated.

The failure of the various scientific tests to discover evidence of any considerable quantity of humidity in the moon's atmosphere might lead the precipitate reader erroneously to question the sufficiency of my theory on that account. Now it is a well known fact that a block of ice placed in a narrow vessel, and exposed to a warm atmosphere, will keep its own water of thaw at the freezing point until the last vestige of ice has disappeared. This is practically what takes place on the moon, except that there *the water is instantly absorbed by the underlying layers of snow, so that a* CRYSTALLINE SURFACE *is perpetually presented to the sky. It is therefore a physical impossibility for vapor to rise, save in the lowest spots where the surplus water accumulates* in pools and where, also, the snow

on that very account cannot gain a footing. Herein may also be found an explanation of the heretofore *unaccountable coldness of the moon's light, for the snow in changing its state to liquid absorbs practically all the solar heat radiated upon it,* which heat, as the physicists say, thereupon becomes "latent" and can neither be perceived nor instrumentally detected.

Summary

Summing up, then, my theory as to the moon's rotation and surface-character is as follows:

First. That the earth and moon are twin births of one and the same solar or stellar disruption.

Second. That from their very inception as independent bodies they began to circulate around their common center of gravity, while at the same time revolving around the sun in obedience to the Prime Resultant.

Third. That both bodies were originally in a gaseous or molten state, from which state they instantly began to cool.

Fourth. That the moon, being all the while subjected to the earth's attraction, precipitated its heavier substances toward that body.

Fifth. That as it disposed itself while still viscid, so it remained after it became rigid; hence its one side is permanently listed in our direction.

Sixth. That before reaching this rigid state, a crust was formed over the still warm surface, and the moisture gradually condensed into the oceans that once filled the now emptied basins. During this stage the moon rotated on its axis by tidal action.

Seventh. That when the original heat became exhausted, the planet was thrown altogether upon its own gravistatic heat resources, which, on account of the

moon's limited size, proved insufficient to maintain its waters above freezing.

Eighth. That as its oceans congealed, the moon's axial rotation gradually slowed until the body reassumed its original list. During this stage glaciation of the surface became complete.

Ninth. That the natural surface of the moon is flat, like that of Mars, its irregular topography being due to snow formations that accentuate the land areas while at the same time hollowing out the original water basins.

Tenth. That the rarity of the lunar atmosphere is chiefly due to its absorption into snowflakes; and the absence of atmospheric humidity, to thaw-absorption and chilling by the universal covering of snow.

VIII

MISCELLANEOUS PROBLEMS

VIII

MISCELLANEOUS PROBLEMS

Beautiful though some of them are, the comets have ever been regarded by the ignorant as forerunners of disaster; and as disasters have an unfortunate habit of occurring "right along," the comets have not failed of sustaining their unevitable repute. Scientifically, they are now looked upon as strays from other systems, and this character they undoubtedly merit, notwithstanding that many of them have succeeded in insinuating themselves as permanent members of our solar hearth. Their manners it is that proclaim them strangers; they move with a certain nervous haste, redden when they near the sun, and presently turn tail and hurry away, perhaps never to return. But what in truth are they? Why do they behave as they do?

The reader will recall my version of planetary motions,—how our system is to be regarded as an entity poised in space, with its great, invisible, gravitational arms outstretched, each bearing in its palm a celestial body, automatically preserving an even balance by the continual readjustment of its multitudinous parts. Into this orderly system is sometimes shot without warning a burning ember from an exploding star, which, by having perished in the act, has lost its power of recall. The comets are just such embers.

Now, it is quite improbable that the comet so expelled would be all of one piece, but rather would it be in the form of a coarse spray (which would speedily congeal in separate particles, thus occluding its gases) and, under the Newtonian law of inertia, would proceed as a single unit indefinitely onward, with a uniform motion in a straight line, until deflected by an extraneous force. However, the instant of the comet's liberation into an independent body becomes the signal for a coalition of all the gravitational forces in the universe to teach it the way it should go. Its motion, both as to velocity and direction, being in its inception both chance and arbitrary, offends from instant to instant against the uniform law of gravitation. The comet cuts across current, as it were, from the sluggish drift of Neptune's path to that of flying Mercury, and thence is flung back and outward again by the great gravitational maelstrom whose chastening hand it can never escape, and must ultimately obey by falling into the orderly orbit for which it is predestined.

The comet, thus summarily ejected, in endeavoring to regain and maintain its disturbed equilibrium no sooner enters that state than it is whisked out of it again by its projectile momentum, and by its consequent shifting relative to the comparatively stationary forces acting upon it from without. This anomalous condition causes the comet's component particles to collide with each other with ever increasing frequency and violence as they near the sun, the center of greatest disturbance, until they shatter and become intensely heated, thereby *liberating more and more of their imprisoned gases* and so giving rise to those remarkable phenomena of glowing nuclei, jets, envelopes, coma, and tail with which we are now familiar. The shape, length, and position of the tail are the ordinary effect of gravitational equilibrium.

This process of planetary schooling is bound in time to shorten the period of comets, so that we become altogether relieved from the peril, though peril now no longer, of hypothesizing the existence of a resisting medium just in order to explain their vagaries, as, for example, the acceleration of Eucke's comet. Furthermore, it demonstrates why comets, as such, are so short-lived. For one thing, the imprisoned gases will eventually all be liberated, thus shearing away the comet's beautiful tresses; and, for another, approximation to orbital circularity will increasingly tend to abate the comet's internal commotion, and thereby render it non-luminous and consequently invisible.

Saturn's Rings

Should the comet by chance have one great dominating ball in its composition, with a mass considerably excelling the combined mass of all the other particles, the result will be a system like that of the sun or Jupiter. And if we go a little further, and imagine the small particles discrete and close to their primary, we shall have a miniature Saturn, though hardly luminous, since the minuter the particles the sooner will they lose their inflammable gases. In Saturn's case, however, the rings are so dense, and the friction due to the differentiation of the orbital speed of, and the elbowing for position among, the constituent particles, is so great, as possibly to raise the rings to the point of incandescence and keep them so.

New and Variable Stars

Our sun, I take it, is a variable star with a periodicity corresponding to its maculae period. The cause, I believe, is due to a sort of "knot" in its otherwise homogeneous constitution, which with approximate

regularity reaches its volatile point at a much greater depth than the average, and so results in cataclysmic eruptions. What the constitution of this knot may be I cannot undertake to say, but I would suggest careful spectroscopic analysis of sun-spot spectra as the likely means of ascertaining the fact. There may, of course, be more knots than one, and of different substances, so that any variety or degree of irregular variability may readily be accounted for. The precisely regular variables, I should say, are due to eclipses, as indeed astronomers generally agree.

New stars, such as Nova Persei, are variables in their final act of transformation. They flare up suddenly from a very low to a very high magnitude, and then gradually fade away, never to reappear. They are neither more nor less than exploding suns, suicides by their self-generated passions, passing back again into their nebulous ghosts: thus closing the enthralling drama of Nature, and supplying the final link in the cycle of celestial change.

If the Newtonian first law of inertia be even approximately true, which I am persuaded it is, we have here the explanation of the marvelous celerity exhibited in the spread of the nebula from Nova Persei, for an exploding sun may not unreasonably be conceived to drive its particles through vacuous space with a velocity comparable to and perhaps exceeding that of light. The nebulæ thus formed being but random clouds, their degrees of nebulosity and capriciousness of form lose much of their significance, and consequently much of their interest, to the scientist. The nuclei seen in spiral nebulae are either the larger fragments of the original sun, or else the planets that circled it in the past, growing fat from feeding upon its disintegrated carcass.

The Corona and the Zodiacal Light

These I look upon as parts of the same phenomenon, the former being the spray, and the latter the spreading mist, from the perpetual seething Niagara of the sun. Yet spray and mist not of water, but of the more ethereal elements such as helium, nebulium, and hydrogen, which by the violence of the sun's commotion have been temporarily expelled beyond the pale of his controlling attraction. Or, in other words, they form a veritable nebula, of the most extreme tenuosity, having its origin, not in one great explosion involving the destruction of our sun, but in those minor eruptions that are normal and, so to speak, functional to it.

Nebula and Star Spectra

The manner of the formation of nebulae as just described seems to me to supply the key to the peculiarities of their spectra. For the freshly liberated gases will be expelled to unequal distances, and the lighter elements the farther. The outer envelopes of the nebula should therefore, if this reasoning be correct, consist largely of hydrogen and similar gases; and if the envelopes be sufficiently dense so as to be opaque to the light of the other incandescent elements ranged behind them, the predominance of such lines in celestial spectra should cease to surprise. Given sufficient allowance of time in which to act, gravitation would dispose the elements in the same order, that is, the lighter on the outside.

The double spectra of stars are never visible except where two bright stars are knowingly examined at one time, as in the case of binaries, or where there is evidence of some special eruption in progress on the body under examination. In the latter case the confusion

of spectra is due, I opine, to the violent geyser-like ejection of gas from one section, while the other part of the surface remains normal. A faint illustration of this may be seen in certain comets, which now and again exhibit luminous spurs, or jets, directed toward the sun.

Star Ages

We may set it down as a fact that the ages of stars are exactly the reverse of what science heretofore has concluded. The older the star the hotter. And we may be quite positive that there are no "cold" stars of large mass, and no "dark" stars, except in the sense that they are rendered faint by their great distance, and by comparison with their more brilliant companions or neighbors.

The Planet Venus

In the preceding chapters it has been shown that the proportion of water, in one or another of its forms, to the solid ball is practically the same in the cases of the moon, Mars, and the earth; and we seem therefore obliged to conclude that the same thing is true of Venus. Now, since Venus is almost as large as the earth, its gravistatic heat suffices to preserve its oceans in a fluid state, the more so from the fact that it receives about twice as much solar heat as does our planet. Venus therefore rotates on its axis. Again, since the planet is so close to the sun, its atmosphere is immensely more humid than ours, and its surface consequently shrouded in perpetual and universal fog; so that we can never hope to obtain even a glimpse of its real face.

If now we assume that life is not a happy accident of Nature's, but the inevitable outcome of her inherent energies and laws, we are driven to admit the existence of life on Venus, but not necessarily of *intelligent* life.

Judging from terrestrial analogy it should rather be marine and amphibian in character, on account of the difficulty of lung-breathing; and moreover, it should be confined to the arctic regions because of the insupportable torridity of Venus's lower latitudes.

Terrestrial Magnetism

By substituting in theory tides of depression for lifting tides, we not only gain in frictional effect, but we likewise transpose the locus of it to the *floors* of the oceans instead of to their coasts. On the other hand, I have given reasons to justify the deduction that the metals, being the heaviest substances, are mainly centrally located within the earth, and ranged along its axis. The semblance of the earth, therefore, to a helix and core, taken in connection with the dynamical effect of the tides, leads easily and naturally to the conclusion that the earth's magnetism is tide-induced. If added proof be demanded, it is to be found in the remarkable coincidence of the magnetic needle's variations with those of the diurnal movements of the sun and moon, and, quite as remarkable, with the change of seasons as well. Indeed, on careful investigation it will be found that whenever the water is severely shaken in the ocean bowl, from tides or any other cause (by solar explosions, for instance, which temporarily unbalance the earth as well as all other bodies in the system), electrical phenomena are certain to follow. Heretofore, attempts have been made to connect the needle's variations with the fluctuations of the solar radiation, but unsuccessfully, because of the conflicting fact that the moon, whose radiation is comparatively nil, has been found to exercise a similar magnetic influence rivaling the sun's own. Orthodox astronomy has not dared to broach this tidal explanation, because it would involve an inad-

missible drain on inertial momentum; but the explanation becomes fully available under my own theory of *gravitational* centrifugal motions.

According to this logic, the earth's poles, being the termini of the supposed "core," should be the centers of greatest electrical activity, the charge passing from one or the other of them through the atmosphere, along meridional lines, to the opposite pole, thereby completing the circuit. This surmise accounts at once, and equally well, both for the northern lights, or aurora borealis, and for the direction and deflection of the needle; besides offering a most alluring field for speculation as to the possible future exploitation of another natural resource.

IX

A RATIONAL COSMOGONY

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He is indeed a callous soul who has never gazed at midnight into the deep vault of heaven and felt the spell of its weird mystery. What are the stars? Whence came they? What holds and propels them in their courses? Are they arranged according to some definite plan or only haphazard? What is the motif in this splendid and stupendous drama of Nature? Are we witnessing a comedy, a melodrama, a farce, or is the denouement to be a tragedy in which actors and beholders alike are destined to be engulfed in one general, irretrievable ruin? Is the universe automatic, or must it now and then be adjusted by its Creator? Can we, perhaps, by patient and unremitting watching detect the Divine Hand at work? When we shall have solved the final problem of the physical heavens, shall we be any nearer to unveiling the great Soul of All? What are the ultimate limits to man's possible knowledge, as a terrestrial being? What his purpose and destiny?

These questions have been asked over and over again, but it seems to little purpose. I reiterate them now in the hope of throwing some further light upon them.

There are certain fundamental philosophical principles which irrespective of proof compel conviction, and preclude us as a race from ever being content with their disaffirmance. Unfortunately for modern science, it has illogically allowed itself to be betrayed into constructive denial of several of these principles, as follows:

1. That the solar system is an organic part of the universe, and not an independent entity.

2. That the universe is integrally complete from instant to instant, potentially as well as physically.

3. That it is self-sustaining.

4. That it is also eternal.

A cosmogony in order to be called rational, I maintain, must not controvert any one of these postulates; and, conversely, one that logically affirms them cannot be summarily dismissed as irrational.

Our ideas of the infinitude of time and space differ from our ideas of the infinitude of matter and force (or Force) in this, that whereas we cannot conceive of the first two as ever non-existent, we can scarcely refrain from imagining a definite beginning for each of the two latter. Let us begin our work of re-creating the universe, then, by postulating matter as originally in a state of chaos, that is, as cosmic dust indiscriminately scattered either throughout all space, or only through that finite portion of it within the range of our telescopic vision.

Into this dust, next, let enter the spirit of gravitation as its final endowment. But first let us inquire, What are the attributes and potentialities of gravitation? Newton long ago revealed to us its law, namely, that it varies as the product of the masses and inversely as the square of the intervening distance. But

he and his followers have apparently been unable to utilize it save as a *destroyer of motion*: first, by *tieing* the planets to prescribed orbits, second, by *stopping* axial rotations through tidal friction, and, third, by *annihilating molecular energy* coincidently with the agglomeration of matter into planetary bodies! Is it any wonder, then, that science has doomed the universe to bankruptcy?

Gravitation as a Constructive Force

Now, when gravitation entered into matter, it made of every particle of it a permanent magnet, unchangeable, imperishable, and obedient to an unswerving law. This means, first, that whether a given body be hot or cold; gaseous, solid, or liquid; separate or in combination with something else, its inherent power to attract and be attracted by others remains identically the same. It means, second, that, unlike all other forces, it may be and is constantly being drawn upon and exercised, but like the widow's cruise stays always evenly full. It needs not to be restored, nor rested, nor fed, nor fostered. Every instant it is created afresh. The gravitational energy put forth by matter today is not the same as that of yesterday. It had no existence yesterday, whether as gravitation, or heat, or any other kind of force. It is being expended from instant to instant without depletion of itself, and without drawing upon anything else. If there be any truth in the law of the conservation of energy, the total store of energy in the universe is not decreasing but, on the contrary, is increasing exactly by the quantity of gravitational force momently put forth. Third, the force of gravitation is, in a way, multiple. The earth, for instance, attracts the sun no more nor less than it would were the moon out of the way, yet it attracts that body too, not to

speak of all the other celestial bodies—each of them with precisely the same force as though none of the rest existed. Fourth, its effect is transmitted over the abysses of space instantly, and not after a lapse of seconds or years, as in the case even of light itself. And, finally, it cannot be eclipsed, as by the interposition of one planet between two others.

Our cosmic dust, then, being actuated by this marvelous force, would proceed to combine, so that in the course of time, of which there was no stint, a miscellaneous assortment of bodies would arise in different parts of the heavens. Gravitation is a constant force, and does not defer action until psychological moments, wherefore, throughout this whole process of agglomeration, from its very inception, a given congeries of particles would feel a dominant but distant pull (being the resultant of all the forces of the universe acting upon it) in obedience to which the parts would adjust themselves spontaneously, as a weathervane does to the wind, into positions of equilibrium thereto and to each other. But plainly such an equilibrium is fickle and unstable, and the members of the forming system would have to continue to shift their relative positions according to some natural law, which, as I have previously shown, is that of the lever, or, what is the same thing, Kepler's triad of laws. Though motion of revolution would be inevitable, its initial direction would be a matter of chance, but once settled, would remain permanent and the same for all.

All planetary systems, it will be noticed, have a primary far exceeding in mass the aggregate of its satellites. There is a reason for this. When the particles are all approximately of one size, the fulcrum of the system is necessarily in the midst of the few largest, which consequently are drawn, sooner or later,

into the gravitational vortex together; for a falling fulcrum is what a vortex really is. When by these accretions the primary becomes very large, its concentration into one mass and consequently more equable motion than when divided tends to steady the system as a whole. In short, it acts on the principle of a ship's ballast, which is effective in proportion as it is ponderous, compact, and free from movable parts.

I do not think, however, that our solar system has been fashioned strictly on this plan, or that the earth is made directly out of the dust of the original chaos. Nature has a way of building on her past achievements, and it is very doubtful whether any aboriginal bodies or systems still survive. Eternity is a long while. If matter is really eternal, we are as near its beginning as to its end or to its prime. In short, half of eternity has already elapsed, if I may be permitted the solecism, and *the universe must be theoretically considered, not as just beginning but as in regular working order.*

Hence I incline strongly to the belief that the earth, or at least its nucleus, is a fragment from an exploded star, and that any accretions which have since come to it are likewise the debris of stars, probably of the same star out of which the nucleus itself sprang. I think too that its geological structure bears out this inference. The planet, then, must once have been in the molten state, and required some time for cooling; although that day was ages ago, so that our globe long since reached a condition of stable temperature. The moon, I take it, is a product of the same cataclysm, the two bodies being twins by birth and having religiously recognized their sororal relationship ever since.

On viewing the Pyramids, a dozen methods may occur to us as to how the ancients managed to trans-

port the huge blocks of stone that compose those structures; but just which of those methods was actually adopted we shall probably never learn. So when we behold the solar system. Although we may know the secrets of centripetal and centrifugal motion, and of gravistatic eruptions, we have yet to deduce the precise mode among the several possible, in which these operated to bring about our particular planetary scheme. As to this mode I have not as yet formed a final conclusion, although I incline more and more to the belief that the sun is his own legitimate successor. That is to say, that his erstwhile disruption was not total but only partial; that the planets are fragments of his former self; and that he himself is the chief fragment. This view seems to me best to coordinate the facts, first, that the outermost planets are the least dense, second, that the planetary orbits, generally, are so nearly circular, and third, that the retinues of the planets are more extensive as we proceed outward from the sun. Thus: first, the outer layers of the original body being for several reasons naturally lighter, would be apt to fly farthest; second, the fragments destined to become planets, being shot out radially, would yet be held back by the recalling power of the residual sun and finally brought gently to a full stop, in which state of exhausted motion they would be more amenable to the persuading power of the Prime Resultant that unforgettingly seeks to impose orbital circularity; and lastly, the expelled spray would be apt to be most finely divided and scattered at those points farthest from the seat of the eruption. It is quite true that Uranus and Neptune do not appear to be so plentifully attended by satellites as do Jupiter and Saturn, and to this extent the fact seems to militate against my surmise. However, let it be remembered that those two orbs are so distant as to be themselves invisible to the naked eye,

and may not improbably have countless satellites beyond the power of our telescopes to descry. Besides, it need not be affirmed that all the planets have the same individual histories; for both Uranus and Neptune may have undergone capture by gravitational "interference," as previously explained. If this is truly the specific method by which our system was formed, the appearance of the resulting nebula to a distant observer must have been of the spiral sort, exhibiting glowing nuclei of condensation.

Always an interesting subject for speculation is that of the probable age of the earth. Heretofore the astronomers have found it impossible to reconcile their cosmogonical theories with the undeniable evidences of geology. Geology demands an earth of at least 200,000,000 years, a uniform solar heat, and a uniform terrestrial heat, none of which does orthodox astronomy find itself able to supply. In lieu thereof she offers an earth aged about ten million, and as to the other two requirements advises Geology to be less finical.

Now according to these views there are three separate logical ways whereby the earth may have become a member of the solar system. One of these I have but just described. The second is by interference caused by the impingement of spheres of gravitational influence; and the third, by explosive ejection from some deceased neighboring sun. The first of these allows for an indefinite past, long or short, as geology may itself determine; but the two latter demand an all but interminable period. If the earth gained membership by the second method, its age may be judged by the fact of five other planets having come in later. If by the third, untold eons must have been required to train it down to orbital circularity. Hence I conclude that the only reliable criterion we have as to

this interesting question is to be found in Mother Earth's own diary as transcribed on her geological leaves.

The size of a planet determines its character absolutely. If over-large it generates too much gravistatic heat to make life possible on its surface; if too small, it does not generate enough to keep its oceans from freezing, and life is again rendered impossible. Since however it is the nature of planets to grow, such as are too small, like Mars and the moon, may hope one day to emulate the earth in fecundity, but the major planets are doomed to perpetual barrenness.

A close analysis of these and many other facts, such, for example, as the inclination of the earth's axis, the small eccentricity of its orbit, the nice adjustment of its size "gravistatically" to the work required of it, its favorable distance from the sun, the possible fortuity involved in the origination of life, etc., make it seem not entirely impossible that terrestrial man is the only creature in the universe capable of comprehending and appreciating its stupendous beauty and scope. The thought has its terrors as well as its inspiration, and oppresses one with its weight.

The evolutionist, the physicist, the geologist, the biologist, may all find in gravistatic heat the explanation of many of their enigmas, such, for example, as the assimilation by Nature of her heterogeneous substances into combinations beneficial to plant and animal life; or the distillation of mineral gases, oils, etc., or the internal structure of the earth; or the explanation of submarine life, etc., etc.

Having passed the habitable stage, nothing lies in store for a planet but to grow up into a sun or a star, with a retinue of planets to circle around him. Eventually his Gargantuan appetite for devouring lesser surrounding bodies will create of him a vortex menac-

ing to the integrity of the universe, and Nature in very self-defense will have to decree his extinction. One day comes the crisis. In an instant his huge bulk bursts asunder and is scattered broadcast, with the speed of light, into surrounding space. Some fragments enter other systems carrying with them more or less gravitational disturbance; but most of his substance remains within his whilom domain in the form of a nondescript nebulous cloud enveloping a hailstorm of meteors and larger pieces that instantly begin the process of equilibristic readjustment to the altered conditions, a process requiring a year of ages, and ending at last in a new system of worlds.

Here among the stars, then, do we find Nature acting consistently with her established order on earth, building only to tear down, bearing children that they may die, creating, so there may not be wanting something to decay. Or shall we not rather reverse the philosophical order and say, that she destroys only that she may improve, that she sacrifices the individual, not wantonly, but for the sake of the well-being, salvation, and evolutional development, of the universal Whole?

This destruction of stars is as sure as fate, and seemingly as fortuitous as is physical death among mankind. What star shall be the next to explode is a matter of inscrutable chance, and for this reason the stellar map is so wanting in symmetry. But symmetry never has been, nor ever will be, either a guaranty of permanence nor a consummation devoutly to be wished. That variety is the spice of life is a truth recognized by Nature long before she ever thought to create man. Ruling though she does by the most inexorable of laws, she yet manages to evolve infinite diversity, so that no two objects are ever precisely alike. Planetary systems, planets, men, flowers, snowflakes, though faithful

types in all things of their respective classes, yet possess individual traits distinguishing them from all others of their kind. *And of all Nature's wonders surely the palm must go to Gravitation!* Force emanating out of nothing, uniform, all-pervading, instant, eternal,—the Hercules condemned forever to perform the labors of the universe, to hold and draw the planets in their orbits, to turn them on their axes, to stoke the suns, to heap the tides, to scatter the rains, and even to point the mariner's compass by the magnetism of tidal friction! An unthinking, rigidly conditioned force, yet not ending in monotony or ruin, as modern science predicts, but in order, automatism, perpetuity, and kaleidoscopic change!

In reviewing what I have written I feel almost as though I had been uselessly multiplying words to prove principles that only require to be stated in order to convince. The mere forming of the questions, indeed, seem to me to prompt their true answers. Since, for example, the sun is known to be travelling rapidly through space, why should he *not* be doing so in obedience to gravitation, the only force we know capable of the feat? Since the earth is one of the sun's retinue, and falling with it, why should it *not* obey the everyday law of physics, and turn its bottom in the direction of fall? Again, If all the planets are falling in a body, why should they *not* mutually sustain and hinder each other by their gravitational guys, and so bring about a common state of progressive equilibrium? If gravitation can cause motion which by its stoppage creates heat, how could anyone ever conjure up a doubt that it can generate heat directly by its pressure? When we know so well from daily experience that balloons, ships, and objects generally dispose themselves, when free to do so, heavy end down, why must we illogically assume that the earth's tides are caused by

the solar *repulsion* of her center of gravity? How *can* molten bodies be disrupted by tides, when their centers of gravity are always nearest the attracting body? Why should we *not* seek to explain current happenings by current forces, instead of borrowing causes from the past? Why should we assume that the sun is *not* an organic part of the sideral system? Why do we say that the sun revolves around the common center of gravity of the system, and then straightway confound that revolution with an impossible axial rotation? Why do we proclaim that Mars has no oceans, in the face of his great snow-caps that belie us? Why say that the Moon has an igneous surface and no oceans, instead of leaping to the obvious truth that its oceans are missing because they have congealed? Is it possible, I ask myself, that these things, seemingly so simple, are not true? that the generality of men find them harder to believe in than whirling vacua? or everlasting inertial motions down a spiral? or suns boiling and contracting at one and the same time? or suns heated to incandescence by snow-storms more frigid still than arctic? or an earth with a core 200,000° in temperature yet immune against explosion? or a sun growing hotter and hotter by contraction due to cooling? or film tides? or earth and moon steadily receding from each other by virtue of their mutual attraction?

X

RECAPITULATION

X

RECAPITULATION

General Principles

I. The universe is continuously complete in itself, self-sustaining, and eternal.

II. The solar system is an integral part of the whole of creation.

III. Current and familiar forces are first to be exhausted before resorting to such as are remote, doubtful, or arbitrary.

Sub Principle I. *The solar system is a poised unit, falling through space in obedience to a distant gravitational pull, and maintaining its balance by the progressive equilibristic adjustment of its component parts, on the principle of the lever.*

Intelligently applied, this principle specifically answers the following enigmas:

1. Why the terrestrial continents lie almost wholly in the northern hemisphere.

2. Why Mars has a permanent snow-cap at its north pole.

3. Why the Mississippi River "flows uphill."

4. Why the earth's axis remains fixed.

5. The fundamental significance of Kepler's laws.

6. The logical basis for the "conservation of moment of momentum."

7. The secret of centrifugal motion, and why it so exactly counterbalances the centripetal.

8. Dispenses with projectile planetary motions, so that we are relieved from discovering their origin.

9. It renders purely academic the question of the existence of a resisting medium.

10. It explains why the planets and their satellites revolve and rotate in the same direction.

11. It gives a sound reason why the planets revolve in approximately circular orbits, and why they naturally gravitate toward a common plane.

12. Why Phobos' period of revolution is not logically dependent on Mars' period of rotation.

SUB PRINCIPLE II. *Heavenly bodies attract each other, not by their centers of figure but by their centers of mass (that is, of gravity).*

This principle when combined with sub principle I explains

1. Tides by depression.

2. The axial rotation of the earth and of Mars.

3. The staring attitude of Mercury, the moon, etc., with reference to their respective primaries.

4. The pseudo rotation of the sun and of the major planets.

5. The sun's and Jupiter's equatorial acceleration.

6. The moon's libration.

7. Why "Tidal Evolution" is impossible.

8. Why the earth's day has not been lengthened by "tidal retardation."

9. The cause of the excitation of comets when nearing the sun. (It is not chiefly attributable to the sun's heat, but to the comet's internal struggle for equilibrium).

10. Terrestrial magnetism due to tidal friction.

SUB PRINCIPLE III. *Gravitation being a form of energy, it is convertible into other forms; and being likewise inseparable from matter, it must continuously evince itself. This it does by pressure on matter, whose molecules fret under the strain and thereby create heat. In the case of very large bodies, like the sun, the pressure is sufficiently great to volatilize all its substances, cyclically, by percussion.*

This sub principle, when taken in connection with those previously enunciated, explains:

1. The cause of solar, stellar, and planetary heat.

2. Why heavenly bodies are hot in the ratio of their size.

3. Why the oceans of Mercury and the moon are congealed, those planets by reason of their small mass being gravistatically incapable of generating sufficient heat to keep their waters fluid.

4. Why the earth's and Mars' oceans are not frozen solid.

5. Why the earth has not exploded by reason of the enormous temperature of its interior, as predicated by current theory.

6. How the earth maintains an even temperature by means of its central water-cooling system.

7. Why it is so rigid, and its earthquakes superficial.

8. Why its temperature increases so uniformly as we descend into its depths.

9 Why, as geology shows, the earth's temperature has been approximately the same for millions of years.

10. Why the sun's temperature has also continued so uniform.

11. Why the oceans, as their marine life shows, have preserved an equable temperature throughout evolutionary time.

12. The probable cause of Mercury's excessive perihelion movement, arising from the sun's revolutional movement and lopsidedness of figure.

13. Why the whole universe does not concentrate into a single ball.

14. Why it hasn't "run down," or shown signs of doing so.

15. Why some stars are variable.

16. What new stars are.

17. Why nebulae, being but dust clouds from stellar explosions, are so capriciously formed.

18. Why some nebulae are hot and others cold, according to remoteness of the explosions that begat them.

19. The origin of comets, and why their orbits are so eccentric.

20. Why, being formed of star debris, they liberate gases as the result of internal friction on approaching the sun, thereby giving rise to coma, tail, etc. Also why their tails, being their lightest part, are tidally depressed to the rear.

21. What it is that causes the sun-spots and their periodicity.

22. How explosions on the sun can account for the terrestrial phenomena that occasionally accompany them.

23. How gravitation reverses itself.

24. Why "perpetual motion" is theoretically possible.

25. Why the structure of the sidereal system is so diversified and unsymmetrical.

26. Why the present constitution of the universe is *per se* self-sustaining, automatic, and eternal.

27. It provides practically unlimited time for the leisurely working out of geological and biological history, and, what is no less important, ensures the uniformity of temperature and of general conditions indispensable to the orderly development of evolutionary species of plant and animal life.

28 It inverts the order of star ages. The hottest are the oldest, not the youngest as heretofore supposed.

29. It gives the key to the nature of the sun's corona and the zodiacal light; they are the spray and mist from the sun's commotion, and wax, wane, and shift accordingly.

I have not attempted to make this list of solutions complete, but only representative and illustrative of the virtue anl scope of the principles elucidated. It is sufficient to say that I believe these will be found adequate to explain almost every mechanical celestial problem, and many terrestrial enigmas of geology, biology and physics not otherwise understandable.

FINIS.