

A. Vibert Douglas

Manuscripts

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Manuscripts
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Box 1

A. E.'s DREAMS

In the year 1867 George William Russell was born near Dublin in Lurgan, Co. Armagh. About sixty-five years later he came to Montreal where he gave an unforgettable lecture in the Unitarian Church, frequently used for such special events. In my mind's eye I can still see him standing in the pulpit looking like some prophet of old who has just stepped from the pages of the Old Testament; and I can still hear his soft lilting voice with its lovely long stress on the vowels as he would say from time to time throughout his lecture, "I shall now speak you my poem".

The subject of his address was Dreams. Some forty years have ^{not} greatly dimmed my memory of some of these, so vividly were they described. He was a firm believer in the power of the sub-conscious, but its creativity must be given full freedom; it can not be commanded to obey orders - this he proved in his early youth.

A. E. began his address with a grim picture of a rather unhappy childhood and youth in a very drab part of Dublin. One night he dreamed that he was walking through a forest. No sunlight was there but every tree, every leaf and twig, every stone, every blade of grass and clump of moss glowed as if ^{lit} ~~illuminated~~ from within. The beauty was so intense that he awoke determined to escape every night from the hard unbeautiful realities of daily life into this mystical wood of unearthly loveliness. But try as he would, he never again entered in dreams this enchanted forest, and at length one night the realization that his dream life must not be ordered by the will was borne in upon him.

Dreams were divided into two categories, those which appeared to be pure nonsense, sometimes amazingly inventive, and those which provided an experience of lasting value and significance. A. E. then proceeded to give ~~us~~ two examples of each, if there were more they have passed from my memory.

In the early years of the moving picture, he dreamed one night that he was in a cinema where a picture of wild animals was being shown. In due time a lion came on the screen and with photographic illusion it seemed to approach closer and closer as its image grew greater and greater until it bounded right out of the screen into the hall. Terrified the audience rushed from the hall and scattered in panic, Russell among them. Glancing back over his shoulder as he tore down the street he realized that the lion was chasing him and gaining on him. He turned down the first side street but the lion followed and drew closer every minute. Suddenly an idea struck him and he took the next turn and doubled back to the cinema. Rushing in with the lion close on his heels he shouted to the operator, "Reverse the film, reverse the film!" Promptly the operator did this - and the lion was drawn back into the screen.

Another dream of ludicrous absurdity was of finding himself in a completely unfamiliar hotel lobby. He approached the office, behind the desk of which sat an elderly little grey haired lady dressed in grey silk with a soft lace ~~f~~issure about her throat. He asked for his account which she made out and handed to him. In his dream he seemed to find difficulty in seeing it and he moved out under the central lobby light to read it in detail. The old lady came out from behind the counter, came over to where he stood, put up her hands in supplication and said gently, "Dear Sir, please do not say, What a hell of a bill".

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One morning he awoke suddenly with the conviction that he had been composing a poem of which one line only remained in his waking thoughts, and this line gave him no clue whatever to what had preceded it nor what was to follow. He was in the west of Ireland at the time. Day after day he walked the Sligo and Donegal hillsides and vales. A poem began to come into his thoughts and he wrote it down, line after line feeling not that he was consciously composing it but rather recalling lines already formulated. After many lines, the one remembered from his dream fell naturally into place, and from there he was able to complete the poem.

For a long time A. E. had tried in vain to capture on canvas a certain iridescent translucent quality which he sometimes saw in the sky. One night he dreamed that he entered an Art Gallery. Paintings were hanging on both sides of the long wide gallery, but his eye was immediately caught by a small painting on an easel centrally placed at the far end. Curiosity tinged with a vague expectancy led him to walk towards it, glancing neither to right nor to left. As he approached he saw to his astonishment the very sky effect he had unsuccessfully tried to achieve. Wondering how the artist had obtained this effect, he moved closer. Then the miracle happened - the picture enlarged and enlarged before his eyes until he could see every finest brush stroke and the combination and alternation of colours. In this excitement of discovery he awoke. "I got up, went to my studio and painted that picture. And when it was finished I had the audacity to sign it 'A. E.'"

In this lecture on Dreams George Russell did not talk about another kind of dream, the mystical visionary type of reverie into which he might often fall, particularly in the magic west of Ireland. The lights and shadows playing on mountain, hill and vale, ^{The Wexford Coast; The Kildare Coast; The Dreams and Vales,} the rushes and the golden gorse all intoxicated him. He felt the living throb of the earth, and fairies, gnomes and mystic music became as realities in his soul. Some of these visionary dreams he attempted to express in poetic prose,

as in "The Song of a Star."

"At first silence and then an inner music, and then the sounds of song throught the vastness of its orbit grew as many in number as there were stars at gaze. Avenues and vistas of sound! They reeled to and fro. They poured from a universal stillness quick with unheard things. They rushed forth and broke into a myriad voices gay with childhood. From age and the eternal they rushed forth into youth. They filled the void with revelling and exultation. In rebellion they then returned and entered the dreadful Fountain. Again they came forth, and the sounds faded into whispers; they rejoiced once again, and again died into silence."

A well-known cartoon depicts William Butler Yeats walking along a Dublin street, hands clasped behind his back, eyes skyward turned, lost in his own meditations; passing him is George William Russell who with bowed head is equally lost in his world of thought. The caption reads: "W. B. Yeats on his way to call on A. E. passes George Russell on his way to call on Yeats". When Russell died in 1935 Ireland lost a rarely gifted son of great versatility. He strove valiantly to improve the rural policies of his country and to encourage more efficient agricultural practices. In this work he exhibited practical common sense. As poet, essayist and artist he allowed his imagination to roam freely like the wind "which bloweth where it listeth and ye know not whence it cometh nor whither it goeth", and in this realm he was most himself, a true seer.

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In silence alone I catch the tone
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Up the ladder of sound I climb,
A Jacob's ladder, to Truth sublime.
On holy ground the Logos found -
The Master-Singer, The Bard Divine,

Albert Einstein
April 20
1972

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Astronomy a Century Ago
ASTRONOMY 101 YEARS AGO

a book which is
~~that is~~ perhaps the first ^{work} book on astronomy to be written in Canada, appeared in 1862 from the press of Alexander Strachan and Co., London. The author was the fourth Principal of Queen's University, the Rev. William Leitch, D.D., "Principal and Primarius Professor of Theology, University of Queen's College, Canada". The runner-up to Dr. Caird for the Chair of Divinity at Glasgow, Dr. Leitch came to Canada in the year 1860 as the chosen successor to Principal Cook.

In his Preface, the author states: "The object of the work is to present a survey of recent astronomical discovery and speculation, in connexion with the religious questions to which they give rise. These questions impart a new interest to astro-theology, and the present contribution is intended to meet, in some measure, the felt necessity of a better adjustment between the arguments of the theologian and the discoveries of the astronomer". With this object in view the author chose as his title God's Glory in the Heavens.

In the first of twenty chapters which cover 330 pages, we read that "the grand lesson of astronomy is that man's true dignity does not consist in the mere outward and physical. The more that the discoveries of astronomy make this world shrink into insignificance, the more amazing is the view of man's spiritual dignity". No opportunity is passed over to point out how every newly attained fact of astronomy displays afresh

the glory of the Creator; the pages contain many such phrases as 'the necessity of Divine contrivance', 'Designing Intelligence', 'the hand of Omnipotence', 'Divine procedure', 'Divine power', 'the one great Architect'.

Dr. Leitch was obsessed with the idea, so prevalent amongst thinking men in the middle of the last century, of the plurality of inhabited worlds. In his chapters on the moon, he dwells on the lack of atmosphere and extremes of temperature on the side visible to the earth, and then recounts "a recent discovery" which prevents us from ruling out the moon as a possible "theatre for the display of all the activities of animated and intelligent beings". The 'discovery' he attributes to M. Hansen of Denmark working on Greenwich data supplied, he supposes, by the Astronomer Royal, Airy, namely that the moon's centre of gravity and centre of figure are 37 miles apart. If the hemisphere turned away from the earth is so much heavier than that facing the earth that air and water are held to it by the greater gravitational attraction, then life may exist there and ~~there~~ ^{may have developed} a flourishing civilization. The author then lets his imagination take wings as he pictures an intrepid lunar explorer travelling to the limit of his inhabitable hemisphere and viewing with amazement this earth of ours coming into view on his horizon - "what a tale of wonder will the traveller have to tell, when, after his perilous adventures, he returns to the bosom of his family!" Our author tells us that this chapter was written in 1860.

The next chapter is entitled "The Discovery of the New Planet Vulcan". Leverrier had informed the French Academy of Science in September 1859 that the unexplained motion of Mercury might be accounted for by the existence of a small planet between the Sun and Mercury. In December of that year he received a letter from Dr. Lescarbault, physician in the little town of Orgères (Eure et Loire), informing him that nine months earlier he had observed a small planet crossing the disc of the Sun. "The village-doctor humbly inquired of nature what is. The high priest of science had oracularly declared what must be." So writes Dr. Leitch and proceeds to quote the Abbé Moigno's account of Leverrier's visit to Orgères: "One would require to have seen M. Lescarbault, so simple, so modest, so timid, to comprehend the agitation with which he was seized, when the interrogator, drawing himself up to his full height, and with that brusque intonation, which he can assume when he pleases, said to him, with severe look, 'Is it you, sir, who pretend to have discovered the intra-mercurial planet?.....' The lamb trembled all over at this rude summons of the lion; he tried to speak, but he only stammered out the following reply: 'At four o'clock on the 26th of March, faithful to my constant habit, I looked through my telescope and observed the disc of the sun, when, all at once, I detected near the eastern edge a small black point, perfectly round and sharply defined, passing across the disc with a very sensible motion.....!'. After some anxious searching the doctor found a square powder-paper and a board

on both of which he had scribbled observations and calculations. He showed Leverrier his little telescope and his watch explaining how he subdivided the minutes by means of his own pulse beats. "The time had now come", says the Abbé Moigno, "for the lion to soften down, and to give heart to the trembling lamb. Leverrier did this with perfect grace - with a dignity full of kindness". Evidently convinced by the evidence given him, Leverrier published the 'discovery' to the world, and the Emperor decorated the village-doctor with the order of the Legion of Honour. The period of Vulcan was said to be 19 days 17 hours.

In three chapters on the sun, the author discusses the then current argument as to whether the corona surrounds the sun or the moon. Father Secchi of the Vatican Observatory is quoted as favouring the latter but Dr. Leitch considers the arguments for the former are more cogent. The mystery of the red prominences is discussed and their possible connection with sunspots, "funnels in the luminous envelope, through which inflammable gases rise, and are burned in the region of the corona or atmosphere, where they appear as red flames". The expectation that at the next total solar eclipse the limitations of the human eye will be replaced "by applying a sensitive photographic surface to the telescope" is hailed with enthusiasm.

Applied spectroscopy was a thrilling new line of research a hundred years ago. Bunsen and Kirchhoff were explaining the Fraunhofer lines in the solar spectrum and the chemistry of the sun was being revealed - iron, magnesium, chromium, sodium and

nickel; but why not silver, copper, zinc, aluminium, cobalt and mercury "though they have very characteristic spectra"?

Comets provided a host of problems. The older people remembered the great comet of 1811, "spanning half the circuit of the heavens with its tail. Biela's comet attracted wide attention in 1846 and then came the great comet of 1858, Donati's, with its developing fan-like tail, its multiple envelopes ~~lead-~~ ^{causing} international disputes as to the forces involved.

Chapters on the current knowledge of the planets lead up to the Nebular Hypothesis which "must be dealt with purely as a question of science.....natural theology can only gain by the discovery of another wisely-adapted wheel in the celestial mechanism".

A brief discussion of stellar grouping is based largely on the work of Lord Rosse. Nebulae, of course, was then an inclusive term for "the ring nebula, the crab, the dumb-bell, and various forms of spiral nebulae". The resolution of the great nebula in Andromeda by Lord Rosse's telescope leads the astronomer "now to contemplate streams of bright suns hastening on along their spiral course to some unknown destiny." The attempted proof by Maedlar that "our firmament revolves round the bright star Alcyone in the Pleiades.....is by no means satisfactory". Nevertheless in the Synoptical Tables at the end of his book, the author includes the item that the Sun's distance from Alcyone, the centre of the stellar system (Maedlar) is 34,000,000 times the radius of the earth's orbit. In these Tables other items are of interest: in 1860 only the

four Galilean satellites of Jupiter were known but eight of Saturn are recorded, four of Uranus and one of Neptune; the number of binary stars for which periods were known was 15; the number of planetary nebulae recorded was 25, of asteroids (1861) 71, and of periodic comets 27; the velocity of light was believed to be 192,000 miles per second.

In his final chapter, the author returns to the topic of the plurality of worlds. Are the other planets inhabited? Their similarities and dissimilarities to our earth are discussed and four types of argument are outlined. First, the "a priori argument" that because of the nature of God, the other planets must be inhabited - this he solemnly repudiates. Second, the "metaphysical argument" that where there are objects of sense, there must be sentient beings - this too he rejects as nonsense. Third, the argument from Scripture, by selecting passages here and there and drawing what he considers unjustifiable conclusions. Fourth, the "analogical or astronomical argument founded simply on the estimation of probabilities and independent of any genetic theories regarding the introduction of life". Considering the range of variation of terrestrial conditions within which life exists, he concludes that "the probability certainly is that some of the bodies of the system, such as Mars, Jupiter and Saturn, do not so far vary from the normal [Earth] conditions as to render life improbable". Realizing that all bodies of the solar system are "in transition", the author points out that the favourable epoch

for life on any one planet is unlikely to occur simultaneously on another.

Eleven pages at the close are given over to criticisms of the writings of Dr. Whewell, Master of Trinity College, Cambridge, of Thomas Paine, of Sir David Brewster of Edinburgh, and of Dr. Chalmers - in fact the book ends in a sermon on sin and redemption. "The universe is a great harp, and each orb a string in that harp; but one string, at least, is untuned. Sin has broken that stringThe whole universe felt the fall of man... the whole universe will feel the effects of redemption....This world is no longer the material centre of the universe, but revelation teaches us that it is still the spiritual centre".

A strange book this is, when viewed in the light of knowledge and attitudes in 1963, and yet since it was published also in New York and ran to three editions by 1866, we must conclude that it spoke to its own times in accents which were understandable and stimulating. A theologian by training and vocation, ~~astronomy was for~~ ^{found in astronomy} Principal Leitch an intensely interesting hobby. On arrival at Queen's University he found Professor (Rev.) James Williamson in the chair of Mathematics and Natural Philosophy to which he had been appointed in 1842, and as Williamson was keenly interested and active in astronomy, he and ~~Dr.~~ Leitch together made the first careful determination of the longitude of Kingston. Their value was $76^{\circ}32'07''$ which compares favourably with the subsequent geodetic survey value of $76^{\circ}28'12''$. Knowing of this pioneer work in observational astronomy, we turn back with enhanced interest to Dr. Leitch's book

wherein the theological mind ~~of the mid-eighties~~ dominates the presentation and the hand of an artist illustrates the work with delightful diagrams and drawings of many of the glories of the heavens.

The copy of this book, now housed in the Treasure Room of the Douglas Library of Queen's University, is inscribed on the fly leaf, "To the Library of Queens College from the author, 1 Dec. 1862", and on the title page facing a Frontispiece showing drawings of what are obviously M 51 and M 33 is written "Queens College Library from the author".

AND
1963 Oct, 19

The Influence of
Astronomy .

I — V

Ar.D. in 1930's .

Influence of Astronomy

THE INFLUENCE OF ASTRONOMY

- I -

Astronomical knowledge, theories and speculations, have exerted an influence upon the actions and thinkings of mankind that have been both varied and profound. This influence must have been already operating before the dawn of what we call civilization; for two of the fundamental needs of mankind living even in the most primitive groups or communities, are dependent upon accurate observation of the heavens - the motions, or apparent motions, of the sun, moon, and stars provide the natural units of time and the basis of any system of chronology; and the relative positions of the stars make possible the determination of direction and position upon the earth.

Herodotus makes reference to the year of the Egyptians being three hundred and sixty-five days; twelve months of thirty days each, and five extra days to keep the year of chronology in step with the year of the seasons. Summer and winter, seed-time and harvest shall not cease; and it has been the astronomers' task in all ages to formulate a practical leap-year rule that shall successfully keep this basic cycle of man's experience in agreement with his year of chronology.

Homer, some ten centuries B. C., wrote of Ulysses on his raft that "...at the helm he sat and marked the skies." Diodorus Siculus recorded that travellers on the sandy deserts of Arabia directed their steps by the Bears - the star groups in the northern sky known

as the constellations of the Great and Lesser Bears. In the Koran it is written that God hath given the stars to be guides in the dark, both by land and by sea. This dependence upon astronomical observation of all who would navigate on land, sea, or in the air, and of all who would establish geodetic lines and positions, international or local boundaries, need not be stressed further.

Neither need we stress the basic importance of an accurate time service in modern life, when we see every civilized country maintaining out of public funds a government observatory charged with this task. In the Egypt of 1500 B.C. the hours of daylight were twelve, and the hours of night were twelve; and elaborate water-clocks were in use, and were improved upon (according to records of that era) so that the varying length of these hours might be accurately measured off, whether it were the long day and short night of the summer solstice, the period of the equinox, or the lengthening nights towards the winter solstice. In recent years, in the reign of Charles II, it was in collaboration with the astronomers of the Royal Observatory at Greenwich ^{and to meet the urgent need of navigators} that the art of accurate chronometry was given a tremendous impulse leading by one improvement after another to the peerless Shortt clocks of to-day.

That the influence of astronomy is not limited on the one hand to mere prosaic practical needs undertaken as a matter of routine necessity by governments, and on the other to the academic theorizings of professional astronomers, of significance only to the few, is too

obvious a fact on this continent to warrant more than briefest mention. An influence must be potent indeed if it have power to unlock the rich man's strong box and ^{the vaults of Institutes,} drawing forth dollars by the thousands, by the hundreds of thousands, and quite literally by the millions for the establishment of observatories, for the setting up of planetaria, for experimentation in quartz and in pyrex so that newer and larger and more efficient instruments of astronomical research may be constructed.

II

~~History~~ The picture of the Universe, that the astronomers have been able to throw upon the canvas of man's mind from age to age, has at all times aroused a responsive interest and awakened a curiosity far beyond the merely practical applications of this knowledge. Curiosity is one of the divinely implanted characteristics of mankind and it is the tragedy of misguided education that it too often dulls, blunts and thwarts natural curiosity instead of stimulating it. But mere stimulation of curiosity is not enough; it may soon degenerate into harmful credulity unless there is gradually developed a calm critical judgment. These two pulling in double harness are essential attributes of the mind if the value of knowledge is to be realized.

In every age, there are a few men endowed with exceptional powers of observation and unbounded curiosity. Where these qualities are accompanied by winged imagination, indomitable perseverance, a deep-rooted faith that there is order underlying even the apparent chaos of the Universe, and a wholesome scepticism, an honest critical questioning that refuses to accept as necessarily true the obvious or the traditional answers to the great riddles of nature - here we have the qualities of mind and spirit that go to make a great man of science. Where the winged imagination is unaccompanied by the honest critical judgment, we have the magician, the astrologer, the alchemist - deceiving himself and too often descending to play upon the ignorance, fear, superstition, and credulity of his fellow men.

The astronomers and the astrologers, the good, the bad, and the indifferent, taken all in all, have exercised a tremendous influence upon human thought and action. We see this influence in philosophy, in religion, in the cult of astrology, in literature, in the very words of our language. We see the influence of astronomy in science, as a helpmate of physics and of chemistry, a bringer of new knowledge, new ideas, new stimulus into the realm of natural philosophy.

To trace this influence in detail upon the development of the kindred sciences would be to set forth the history of science from pre-Greek, through Greek times and on past the dark ages into the renaissance of learning, the era of experimentation, the period of Newton, and on as a swelling tide into the present century.

In ancient Babylon, ^{the heavens were mapped by} men with keen powers of observation and the ability to make and hand on accurate records to succeeding generations, ~~mapped the heavens~~. They marked off the star groups as constellations to be identified with names of beasts, birds, imaginary creatures or mythological persons. They plotted the particular paths of sun, moon, and five visible planets against the background of the stars, and formulated rules of recurrence of phenomena such as eclipses. Alongside of true astronomical knowledge there developed the cult of astrology. The aspect of the heavens, rightly interpreted, was said to reveal the significance of dreams, to forecast the future welfare of the ruler or dynasty, to portend victory, pestilence or

disaster. Nebuchadnezzar, King of Babylon, "commanded to call the magicians, and the astrologers, and the sorcerers, and the Chaldeans, for to shew the King his dreams."

When astronomical learning was brought to Greece from Babylon, astrological lore came also. In the hands of the Greeks, astrology greatly widened its influence by producing the individual horoscope. The association of ideas whereby a certain metal was identified with each of the planets, and gold with the sun and silver with the moon, led to research in alchemy becoming closely linked with astrology. This went on until astrology began to fall into disrepute in the seventeenth century. In spite of the general tendency amongst recognized men of science to relegate astrology to the category of a pseudo-science, and to discount its basic assumptions, methods and claims, nevertheless astrology is far from dead as an influence at the present time.

Pure astronomy has exerted an influence on scientific thought and imagination that has been entirely wholesome from the time of the Ionian philosophers to the present. Attempts to understand the motions of the sun, moon, and planets stimulated geometry and brought into being the complexities of the cycle and epicycle theories. Attempts to measure the diameter of the earth required the applications of trigonometry, as did in later centuries Galileo's measurement of the height of lunar mountains. Newton's sublime edifice of celestial mechanics required the invention

of new mathematical tools. Newton's analysis of sunlight, Fraunhofer's observation of the dark lines in the solar spectrum, Kirchhoff's explanation of these lines, led to the development of spectroscopy, both stellar and terrestrial. Helium was discovered by spectrum analysis of light from the edge of the solar disc at a time of eclipse in 1868. Here was a challenge to the chemists which was only answered in 1895 when Ramsay identified helium as a constituent also of the terrestrial atmosphere. And in more recent years, astrophysics has pressed atomic theory into deep channels of fruitful research by its insistence on the existence, under stellar conditions of temperature far exceeding anything attainable in the laboratory, of matter so dense that our densest terrestrial substances, our osmiums, irridiums and platinums, seem by comparison to be mere "airy nothings." The astronomer describes the nature of a dense dwarf star like the Companion of Sirius; and the mathematical physicist sits down at his desk and produces paper after paper in an effort to explain this star in terms of the behaviour of a "degenerate" gas.

III

When we turn to the influence of astronomy upon our language, we find that many words in common use derive their meaning from ancient astrological dogmas and superstitions. Thus 'saturnine', 'jovial', 'mercurial' are reminders of the characteristics ascribed to the planets. Saturn partook of the nature of lead; Mercury moved fastest relative to the Sun, and was associated in astrological thought with the substance quick-silver or mercury, hence so called; Jupiter, ^{associated with tin,} was the lusty, self-reliant King of gods, a planet bright and glorious in the night sky. ^{How are the mighty fallen! Ironical indeed is the change in significance of the phrase - a tin god!} In 'disastrous' we have the antithesis of the optimism in the phrase, "the gods to-day stand friendly." Some positions of the heavenly hosts spelled success and some spelled calamity. In the word 'quintessence' we touch upon fundamental Greek thought - the four elements, earth, air, fire, water, of which all things terrestrial were compounded, and the fifth, the perfect, unchanging, and unchangeable substance of which, in the teachings of Aristotle, the stars, sun, moon, and planets were composed.

The influence of astronomy upon literature is a topic of vast range and it can provide unending interest both to the serious student and to the casual vagrant reader. The approach is two fold. Literature has been enriched tremendously by metaphor and by simile, in verse and in prose, passages that have been inspired by the simple

spectacle of the pageantry of the skies, the nightly march past of the battalions of heaven. Any number of such passages come to mind almost unsought - passages in the Psalms of David; in the Book of Job where "the morning stars sang together"; in the Book of Daniel where the writer is searching for the noblest and loftiest possible expression of acclaim for him whose life is lived in the light of wisdom and whose influence is on the side of righteousness, "They that be wise shall shine as the brightness of the firmament; and they that turn many to righteousness as the stars forever and ever"; passages in Shakespeare such as "the floor of heaven is thick inlaid with patines of bright gold;" in Tagore for whom "Life is a constellation, an unplumbed dark strewn with starry moments"; in Keats whose every changing mood can find expression by some reference to the stars, "those silver lamps that burn on high"; in Shelley where passage after passage bears testimony to the influence of the stars upon his thoughts, "those mighty spheres that gem infinity", "eternal orbs that beautify the night."

The Pythagoreans dwelt much upon the "harmony of the spheres", and it was their geocentric model of the universe with its concentric spheres whose differing motions carried planets, sun, moon and stars around the earth, that gave rise to their beautiful conception that the universe sings - high notes where motion is swift, and deeper notes where it is slow. This "music of the spheres" still captivates poetic

fancy. We think at once of the words of Lorenzo to Jessica, "There's not the smallest orb....." We think of Alfred Noyse's definition of poetry, "...thought in passionate tune with those great rhythms that steer the moon and sun". Or with Alfred Austin we hear "planet with punctual planet chiming clear, and unto star star cadencing aright." Or we turn to the Prometheus Unbound and listen with Panthea and Ione to "the deep music of the rolling world."

IV

There is a second, and quite different influence which we find in literature, an influence due not to the simple contemplation of the stars as objects of beauty in the night sky, but to man's effort to understand the stars, to formulate a theory of the Universe, to realize the significance ^{and think in terms} of the knowledge slowly amassed by astronomers regarding the numbers and natures, the distances and motions, the distribution and the origin of stars. It is an intellectual influence bound up with man's hunger and thirst after knowledge, and reflecting in each age the cosmological theories and dogmas of that age.

We see a fine example of this in the first chapter of Genesis. ^{The dramatic picture we owe to early Hebrew thought; the stately English translation, to Tindale.} Void - darkness - waters; and our thoughts go to Thales of Miletus for whom the material cause of all things, the "first principle" is water, and to ancient Egyptian records of "a primordial liquid mass in the limitless depths of which floated the germs of things", to quote from Sir Thomas Heath. But returning to the first page of Holy Writ, we find the evolution of the Universe thus coming about; first light, then the firmament of Heaven, then the dry land of Earth, and on the fourth day "God made two great lights,.... He made the stars also."

In a remarkably interesting work of the pre-Rabbinic Palestinian Jews, the non-canonical Book of Enoch, there is a section entitled the Book of the

Courses of the Heavenly Luminaries. In this we read a detailed account of the changing length of day and night throughout the year, according to the positions on the horizon of sunrise and sunset. "I saw six portals in which the sun rises and six portals in which the sun sets; and the moon rises and sets in these portals, and the leaders of the stars and those whom they lead..... There goes forth the great luminary, and he is filled with illuminating and heating fire. The chariot on which he ascends, the wind drives, and the sun goes down from heaven and returns through the north in order to reach the east and is so guided that he comes to the appropriate portal and shines in the face of heaven." The changing path of the moon is described and her phases and how she borrows of the sun's light "in measure... to the seventh part of the light of the sun." Twelve winds blow upon the earth through twelve portals of heaven, eight are hurtful and four are winds of blessing and prosperity. The sin of man has dire effects upon the precise movements of the heavenly bodies and indeed "the whole order of the stars shall be concealed from sinners!" If there be anywhere in literature a reference to the Man in the Moon earlier than appears to be found in this work of the second century B.C., such reference will be very gratefully received! "At night she appears like a man for twenty days each time, and by day she appears like the heaven, and there is nothing else in her save her light."

(These quotations are taken from the scholarly translation of The Book of Enoch by Dr. R. H. Charles, Canon of Westminster.)

Coming down the years to the beginning of the fourteenth century, we pause to consider how the framework of Dante's Paradiso is the Ptolemaic map of the Universe, the eight concentric spheres about the earth. First is the heaven of the Moon, the blest abode of those who were forced to break holy vows. Then the heaven of Mercury - "this sphere that oft from mortal ken is veiled by other's beams" - a true astronomical description. Here Dante recognizes the Emperor Justinian. The third heaven is Venus "that star, which views now obvious, now averse, the sun". Here are the souls of King Charles Martel of Hungary, and of Rahab of Jerico. The fourth sphere is the heaven of "the great minister of nature, thatdoles out Time for us with his beam." Amongst the twelve blessed spirits whom the Poet sees here in the Sun are Thomas Aquinas, Solomon, and the Venerable Bede. Beyond the sun is the heaven of Mars, where he finds the godly warriors, the Crusaders, and Judas Maccabeus, Joshua and Charlemagne. In Jupiter, "that temperate star whose sixth orb now enfolded us", he recognizes David, Trajan, Hezekiah, Constantine and others. Entering "the seventh splendour", the heaven of Saturn, where dwell the spirits of those who passed their lives in holy retirement and contemplation, the Poet holds converse with

St. Pietro Damiano and St. Benedict. He next enters the eighth heaven, the Ptolemaic sphere of the fixed stars - "O glorious stars! O light impregnate with exceeding virtue!" He converses with some of the Apostles and with Adam, and is then led upward into the ninth heaven by Beatrice. This ninth heaven wherein is the Divine Essence is both circumference and centre of the Universe. "Heaven and all nature hangs upon that point." "Here is the goal whence motion on his race starts; motionless the centre, and the rest all moved around." The Poet is caught up into "that abyss of radiance" the vision of the Trinity. "Here vigour failed", but though physical endurance is broken down, "the will rolled onward... by the love impelled, that moves the sun in heaven and all the stars."

Three hundred years before Dante, we find Al Biruni in his book entitled "Astrology" written at Ghaznah in 1029 debating the existence of a ninth sphere. As translated by Dr. Ramsay Wright, it reads in part thus: "A number of people consider that beyond the eighth sphere there is a ninth entirely quiescent; it is this which the Hindus call in their language Brahmānda, because the prime mover must not be moved.... But it is possible that it is not a body like the other spheres, otherwise its existence could be demonstrated. Many of our ancestors considered that beyond the eight spheres there is an infinite empty space, others a boundless quiescent substance, while

according to Aristotle, there is neither substance nor void beyond the revolving bodies."

When Milton was writing *Paradise Lost*, the cosmology of the past, the geocentric Ptolemaic Universe, could no longer be accepted unquestioningly. Neither could most men grasp with confidence the new and often violently opposed theory of Copernicus, that the Sun was the centre of the system of planets, the Earth being merely a minor planet moving in an orbit between the orbits of Venus and Mars. It was known that Galileo had declared the astronomical evidence to be in favour of the newer theory, but that he had refrained from dogmatically reasserting his belief when faced by ecclesiastical opposition. Bruno had asserted the truth of the Copernican theory with courage and conviction in England and throughout western Europe - and he had come to a martyr's stake in Rome. Milton talked with Galileo in Italy when the latter was an old man nearing the close of life, but the poet evidently was far from feeling sure which theory would eventually be proven correct. This chaotic, uncertain state of mind is vividly portrayed for us in *Paradise Lost* where Adam questions the angel energetically regarding the true nature of the Universe and "whether earth move or sun." The quibbling, inconclusive answer of the archangel Raphael is a masterly piece of evasion!

We shall not linger to consider the efforts of more

recent writers to crystallize in literary form, whether in poetry or in prose, the modern conceptions of the Universe. The facts and the fancies, the achievements in stellar measurements, and in cosmic chemistry, the revolution in cosmological thought introduced by the theory of relativity, the daring speculations culminating in the Lemaitrian Expanding Universe, all this and the vast picture of the great revolving galaxies of many thousand millions of stars have had their repercussions upon the thoughts of men; and sooner or later men's thoughts upon most topics find literary expression.

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THE INFLUENCE OF ASTRONOMY

- V -

The influence of astronomy upon philosophical and upon religious thought is not a subject that can be briefly and categorically stated, for it offers an outstanding example of the truth contained in the old maxim, - Quot homines tot sententiae - or in more modern phraseology, the same stimuli produce very different mental reactions in different individuals. "The ancient world takes its stand," says Professor A. N. Whitehead, "upon the drama of the Universe, the modern world upon the inward drama of the soul." Yet the inward drama of the soul is often profoundly influenced by the drama of the physical world where the actors are radiations, electrons, atoms, and stars.

In the ancient world with its geocentric outlook, it was natural for very great importance to be attached to man. For him the sun and moon rose and set, for him the stars shone forth, for him the rains fell and the earth produced her increase - "Thou madest him to have dominion over the works of thy hands, Thou hast put all things under his feet." If to-day, man be regarded as of great intrinsic worth, it must be for spiritual reasons; it is no longer an obvious deduction from a survey of the

physical universe. To some types of mind in whatever age, it always was for spiritual not physical reasons; but there are also types of mind to whom it comes as a great shock that man appears to be but an accidental development in very recent ages upon this little old earth, a minor planet, revolving about one quite ordinary dwarf star whose position is somewhere far out from the centre of one of the many millions of galaxies of stars. To minds of this type the Copernican cosmology represents a major upheaval of what had become traditional thought.

Astronomy thereafter pictured man as a mere speck in the immensity of space. Then geology joined forces with astronomy to measure out time by aeon upon aeon, so that the average span of a human life is to the estimated age of the earth as one second of time to three score years and ten. Biology added to the mental upheaval by appearing to present a rigidly mechanistic view of life - the great conceptions of evolution, of natural selection, the discoveries of physiological and psychological sciences being swallowed, unmasticated and often misunderstood, by a hungry or a gullible multitude. The effect of all these ideas upon the religious imagination, says the late Bishop Gore, can hardly be exaggerated. "They seemed as represented in popular literature almost to obliterate God, behind a self developing universe, and to reduce the position of man to insignificance." In our own day the great challenge to what one may call "orthodox" religious faith is once more

coming from astronomy, according to Bishop Headlam. The great popularity of various non-technical books dealing with the recent discoveries in astronomy, astrophysics and atomic physics has evidently brought thousands of people face to face with some of these facts for the first time; and they are mentally and spiritually staggered by the immensities of time and space, and by what seems to them the grandeur or the grimness of inexorable law. It is worth noting that it is the readers rather than the authors who react in this manner. The average reader will frequently draw extreme conclusions and be swayed into adopting an essentially illogical attitude of mind very far from the position which the author himself really holds and intended to convey.

It is strange that men are so easily appalled by large numbers - but it is none the less certain that this is a very usual reaction. One blade of grass is intrinsically quite as wonderful as a thousand blades of grass, and ten thousand million stars are no more wonderful than is one star, yet man is overawed by mere number. We see this in Shelley, for whom "the plurality of worlds - the indefinite immensity of the universe is a most awful subject of contemplation. He who rightly feels its mystery and grandeur is in no danger ----- of deifying the principle of the universe." Yet the men who actually count the

stars, measure their distances, and time their revolutions are very rarely the men who deny God, the Creator. Contemplating the evidence for cause and effect - the reign of law - in the physical universe, Shelley ejaculates, "Necessity! thou mother of the world!" and in his footnote he draws this conclusion "The doctrine of Necessity tends ---- utterly to destroy religion."

Our thoughts go back three centuries to a deeper thinker than Shelley, to Leonardo da Vinci, who likewise contemplated a universe in which he found evidence of law and order, cause and effect. He saw it not only with the eyes and mind of an artist, but with the eyes and mind of a man of science - and his reaction, the antithesis to that of Shelley, is expressed in some such words as these - "O divine justice of Thee, Thou Prime Mover. To no force hast Thou permitted lack of the order and quality of its necessary effects. Thrice marvellous Necessity! ----- Great love is the daughter of great Knowledge. Perfect knowledge of the universe and perfect love of God are one and the same thing."

The dynamic phrase, The Prime Mover, is one of Aristotle's great contributions to metaphysical thought. The Greek philosophers were steeped in the astronomical knowledge of their day, and cosmological speculation flourished in their midst. Asked what was the chief object

of being born into this world, Anaxogoras replied - To investigate the sun, moon and heaven. And Plato impressed upon his students that theirs was the high task of finding "what are the uniform and ordered movements by assuming which the motions of the planets can be explained." That the sun, moon, planets and stars moved, and moved in obedience to some law, was an observation of tremendous significance to the Greek philosophers. When Aristotle sought to complete his Metaphysics, he was driven inevitably and inexorably by the force of dispassionate logic to postulate the great Prime Mover. The significance of this can scarcely be overemphasised. It has influenced much philosophic thought down to the present day. It is one of the strongest influences playing upon the mind of Professor Whitehead when he undertakes the difficult task of restating a metaphysics in terms of modern language in the light of modern knowledge. With the passing of the very limited and artificial cosmology of the Greeks, the metaphysical need of God, the Prime Mover, has disappeared. Motion, in the thought of the natural philosopher of the 20th Century is simply one of the many forms of energy. But an analagous metaphysical need does arise, and Professor Whitehead is led to the conclusion that "the general character of things requires that there be such an entity" - "God as the Principle of Concretion."

The Sport of Kings (the Master cosmological thinkers) during the past twenty years has been to devise mathematical

equations representing various geometries of space and time, equations from which would arise, or within which are embedded, so to speak, as identities the mathematical representations of the laws of nature as the astronomer and as the physicist sees them. This means that the so called laws of nature are not edicts imposed from without - the law of gravitation for example, is not what it is because the Prime Mover propels the planets around certain orbits with certain velocities. The laws of nature are what they are because the universe is what it is - a sentence that is inspired by Professor Whitehead's remark that "the electron does what it does because it is what it is," which saying can be glibly made, but carries a meaning not entirely on the surface.

Now each one of these proposed cosmological equations may represent a theoretically possible universe and there may well be an infinity of such possibilities, but no one of the entries (whether of Einstein, or de Sitter, or Lemaître or other) has won the blue ribbon, because no one of their equations truly and completely represents the actual universe. Furthermore even if such an equation be formulated, this fact still remains obvious that this equation is only one of the many representing theoretically possible universes. "We conceive actuality as in essential relation to unfathomable possibility."

The prime command and its result, are set forth in the Book of Genesis with stately simplicity - " And God said,

Let there be light, and there WAS light." - not any kind of light, with any of the many different properties one might imagine that light could conceivably display; but the particular kind of light that plays so basic a part in our physical experience, the light whose properties are so beautifully set forth in the Maxwellian equations. "----- every actual occasion is a limitation imposed on possibility;" to quote again from the author of the phrase, God, the Principle of Concretion, "God is the ultimate limitation ----- God is not concrete, but he is the ground for concrete actuality."

While Shelley was writing his negations in footnotes to Queen Mab, the very same astronomical discoveries were influencing the thoughts of Immanuel Kant; but very different were his reactions. The grandeur of a planetary world, the Milky Way, the nebulae, super-systems of stars - "the infinite field of Creation ---- the work of God ---- the great Builder of the Universe *----- We see the first members of a progressive relationship of worlds and systems ----- an abyss of real immensity in presence of which all the capability of human conception sinks exhausted, although it is supported by the science of number. The Wisdom, the Goodness, the Power which have been revealed are infinite."

In Pascal we see a philosopher overwhelmed equally by the vastness of the visible world, which is itself

"but an imperceptible speck in the ample bosom of nature" and by the abyss within the smallest conceivable particle of matter. Between these two extremes, he stands silent. For him there is no easy acceptance of a God revealed by Nature - a reign of Law, yes; the sublime triumphs of mathematical expression of natural law in the outer universe were in progress. Copernicus, Bruno, Galileo, Descartes, these were the influences so potent upon thought in the 17th Century, and on Pascal and Spinoza these influences made deep impression. But while the former turns from the outer world of nature to find God in the spirit of man, the latter finds Him "the immanent cause of all things." "From the infinite nature of God, all things follow by necessity."

Given a completely random assemblage of all the energy of the stellar system, what is the probability of the present state of organization having come about by pure chance? This is the question asked and answered by Sir James Jeans whose calculation showed that the probability was so incomprehensibly small as to indicate rather impressively the logical need for a Creator. Bruno arrived at a similar conclusion without climbing up a ladder of mathematical reasoning - "For things have not come about by mere accident, but through the determining mind." Professor Whitehead likewise reaches this conclusion by no devious path - "The order of the world is no accident ---- the religious insight is the grasp of this truth."

There is a class of public speakers and writers who misunderstand and misuse modern scientific thought in an effort to obtain oratorical effect or to bring into sharp relief the contrast between the physical and the moral order. A stock phrase is that the physical universe is "a soulless repetitive mechanism." The picture conjured up before the mind is of stars and planets endlessly circling about their appointed orbits for ever and ever and ever and a day - a picture of futility and changelessness; and against this mechanistic principle of nature the spirit of man is urged to fight. This conception is contrary to the true astronomical and physical picture, and much loose thinking is woven about it.

No one can ponder upon the solar system, upon the great multiple star systems, or upon the beautiful photographs of the spiral galaxies, and argue that this is a static universe. It is obviously a dynamic universe; but it is not the arena either of haphazard change nor of mere repetition - it is a dynamic universe of directed change. All the change that goes on in the physical universe is towards unavailability of energy; "physically wasting but spiritually ascending," to quote the comment of Professor Whitehead who in those five words reveals himself as both physicist and philosopher. In spite of the optimism expressed in writings of an American scientist and of an English theologian to the contrary, there is not one jot of evidence in the whole range of physical phenomena that the

reverse physical process is taking place. Herbert Spencer

Thinking not only of cosmological changes but more especially of the geological and biological changes which

the centuries and eras reveal, ^{arrived at a principle framed his evolution formula, postulating that development in all things proceeds from a state which may be briefly generalized thus:- Nature tends to of "indefinite unstable homogeneity" towards a "definite stable heterogeneity":}
~~pass gradually from simple forms which are unstable to complex forms which exhibit greater stability.~~ ~~It is important to note that in this famous metaphysical speculation there is~~ ~~view, likewise, we find~~ no suggestion of mere repetition.

Another erroneous conception which is still a live influence, in much general thought is determinism. It is no new idea in philosophic thought, though it rose to its peak perhaps in the last century. In recent years it has dropped completely from Natural Philosophy because it has been shown by Heisenberg to be without foundation in physical fact. There is a striking contrast between the high degree of predictability of phenomena relating to the positions and motions of satellites, planets or stars, and the relative unpredictability of both these quantities simultaneously for an electron. This is a very deep-seated limitation of our knowledge and one can scarcely over-estimate the importance and significance of this fact, - that the indeterminacy is not merely qualitative, it is quantitative. "The principle of indeterminism" writes Sir A. S. Eddington, "is epistemological,----- to-day physical theory is not mechanistic, and it is built on a foundation that knows nothing of this supposed determinism-----"
A further sentence is here quoted because it represents an

attitude the very antithesis of that so frequently expressed and advocated a generation ago. "I think there is no longer any need to doubt our intuition of free will----- we are scarcely likely to accept a theory which would make the human spirit more mechanistic than the physical universe."

The impact upon philosophy of science's rejection of the law of causality is not yet fully evident, but it will inevitably alter the momentum of philosophy, which implies amongst other things, a possible change in the direction along which philosophy will progress in the near future.

Two of the baffling mysteries which challenge the mind of the philosopher are space and time. Into what category is he to put them? how define them? Newton, Leibnitz and Kant strove to clarify these terms. Newton took them for granted as things-in-themselves, - eternal, infinite, self-subsisting - a point of view that drew fire from Kant. Leibnitz classified them as ordinary concepts, to which Kant raised the objection that ordinary concepts have instances, whereas there is but one space and one time. Kant regarded space and time as the forms of perception, external and internal, respectively; in no sense things-in-themselves, yet not illusions; transcendently ideal, but empirically real. While this critical sifting of words and ideas went on and on, the absolute Euclidean space, and "absolute, true and mathematical time"

accepted explicitly by Newton, provided the frame-work within which the Newtonian celestial mechanics functioned with spectacular success for nearly two hundred years. Then the triumphant chorus of astronomical approval of absolute space and time began to falter. The motion of the perihelion of Mercury's orbit refused to conform to Newtonian calculations. Physics likewise provided food for thought - the earth's motion relative to the ether could not be detected, and the apparent mass of an electron was found to be a function of its velocity.

Einstein's Theory of Relativity swept absolute space and absolute time from the astronomical, the physical and the philosophical horizons. Three out of four crucial tests of this theory were astronomical; and it is the astronomers, naturally, who are providing the observational data that is hurling out the frontiers of explored space to inconceivable distances. The velocity of light being finite, the astronomer is looking backward in time as he looks outward in space. How far he is justified in interpreting what he sees in the stellar universe in terms of physical laws established in a "Here-Now" environment is a question upon which it is not wise to be dogmatic. P. W. Bridgman has ^{warned that such a procedure applied at the limits of} ~~referred to~~ the astronomical time scale is a "hair raising extrapolation"! ~~of our immediate time perception and~~

The advent of non-Euclidean geometry of four dimensional space-time into cosmological thought has one very interesting feature that must be mentioned. It has brought back pre-

Copernican egocentricism in a new sense, for no point in the vastness of space has more right to be regarded as central than has any other point. In the light of present day cosmology, every man can legitimately regard himself as the centre of the universe!

In the Dynasts, Thomas Hardy presents the Spirit of the Years hovering above the earth contemplating the doings of mankind and exclaiming "- This terrestrial tragedy," whereat the Spirit Ironic adds - "or comedy." It is only as one sees this earth in its astronomical setting and in the perspective of the astronomical time scale that it is possible to begin to evaluate and assess the record of history. Viewing thus the page upon which mankind is writing his hieroglyphics, with the long vista of the physical world stretching far out both before and after, Herbert Spencer was oppressed and the apparent unimportance and futility of much human effort weighed very heavily upon his mind.

The intolerance, superstition and barbaric savagery of so much of human behaviour not only oppressed the keenly sensitive spirit of Voltaire but goaded him into action. In one of his rapier-like efforts to tear the veil from men's eyes that they might see and act with sanity and justice instead of making this earth a hell through war, greed, and fanaticism, he conjures up a man from Sirius, and another from Saturn, in order to bring into sharp focus in its

universal space-time setting "this terrestrial tragedy." One of the greatest thinkers of our own day, General Smuts, likewise feels the necessity for this cosmical perspective. In his *Holism and Evolution* he makes it clear that a satisfying philosophy must bring into one field of view the problems of the physical world, of life, of mind, and of spirit. "In ever varying degree," he writes, "the universe is holistic and organic through and through----- The great values and ideals retain their unfading glory and derive new interest and force from a cosmic setting."

Thus the mind of man traverses the whole gamut of human experience and inquiry, and from earliest ages to the present time philosophers and men of science alike have appealed to reason - "Trust in reason," says Clement of Alexandria through the pen of Dean Inge, "which rests ultimately upon faith in the divine Logos, the self-revealing spirit of the universe."

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THE INFLUENCE OF ASTRONOMY

- I -

Astronomical knowledge, theories and speculations, have exerted an influence upon the actions and thinkings of mankind that have been both varied and profound. This influence must have been already operating before the dawn of what we call civilization; for two of the fundamental needs of mankind living even in the most primitive groups or communities, are dependent upon accurate observation of the heavens - the motions, or apparent motions, of the sun, moon, and stars provide the natural units of time and the basis of any system of chronology; and the relative positions of the stars make possible the determination of direction and position upon the earth.

Herodotus makes reference to the year of the Egyptians being three hundred and sixty-five days; twelve months of thirty days each, and five extra days to keep the year of chronology in step with the year of the seasons. Summer and winter, seed-time and harvest shall not cease; and it has been the astronomers' task in all ages to formulate a practical leap-year rule that shall successfully keep this basic cycle of man's experience, in agreement with his year of chronology.

Homer, some ten centuries B. C., wrote of Ulysses on his raft that "...at the helm he sat and marked the skies." Diodorus Siculus recorded that travellers on the sandy deserts of Arabia directed their steps by the Bears - the star groups in the northern sky known

The Influence of Astronomy.

as the constellations of the Great and Lesser Bears. In the Koran it is written that God hath given the stars to be guides in the dark, both by land and by sea. This dependence upon astronomical observation of all who would navigate on land, sea, or in the air, and of all who would establish geodetic lines and positions, international or local boundaries, need not be stressed further.

Neither need we stress the basic importance of an accurate time service in modern life, when we see every civilized country maintaining out of public funds a government observatory charged with this task. In the Egypt of 1500 B.C. the hours of daylight were twelve, and the hours of night were twelve; and elaborate water-clocks were in use, and were improved upon (according to records of that era) so that the varying length of these hours might be accurately measured off, whether it were the long day and short night of the summer solstice, the period of the equinox, or the lengthening nights towards the winter solstice. In recent years, in the reign of Charles II, it was in collaboration with the astronomers of the Royal Observatory at Greenwich ^{and to meet the urgent needs of navigators} that the art of accurate chronometry was given a tremendous impulse leading by one improvement ^{and refinement} after another to the ^{remarkably reliable} peerless Shortt clocks of ^{This century} to-day, and in the last few years ^{to the still more accurate time keeping of crystal oscillators, in particular the quartz clock developed at the N.P.S.} That the influence of astronomy is not limited on the one hand to mere prosaic practical needs undertaken as a matter of routine necessity by governments, and on the other to the academic theorizings of professional astronomers, of significance only to the few, is too ^{The first paper on the performance of this new clock was given in 1854 to the R.A.S.}

obvious a fact on this continent to warrant more than briefest mention. An influence must be potent indeed if it have power to unlock the rich man's strong box and ^{the vaults of Institutes,} drawing forth dollars by the thousands, by the hundreds of thousands, and quite literally by the millions for the establishment of observatories, for the setting up of planetaria, for experimentation in quartz and in pyrex so that newer and larger and more efficient instruments of astronomical research may be constructed.

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II

The picture of the Universe that the astronomers have been able to throw upon the canvas of man's mind from age to age, has at all times aroused a responsive interest and awakened a curiosity far beyond the merely practical applications of this knowledge. Curiosity is one of the divinely implanted characteristics of mankind and it is the tragedy of misguided education that it too often dulls, blunts and thwarts natural curiosity instead of stimulating it. But mere stimulation of curiosity is not enough; it may soon degenerate into harmful credulity unless there is gradually developed a calm critical judgment. These two pulling in double harness are essential attributes of the mind if the value of knowledge is to be realized.

In every age, there are a few men endowed with exceptional powers of observation and unbounded curiosity. Where these qualities are accompanied by winged imagination, indomitable perseverance, a deep-rooted faith that there is order underlying even the apparent chaos of the Universe, and a wholesome scepticism, an honest critical questioning that refuses to accept as necessarily true the obvious or the traditional answers to the great riddles of nature - here we have the qualities of mind and spirit that go to make a great man of science. Where the winged imagination is unaccompanied by the honest critical judgment, we have the magician, the astrologer, the alchemist, ^{the imposter} - deceiving himself and too often descending to play upon the ignorance, fear, superstition, and credulity of his fellow men.

The astronomers and the astrologers, the good, the bad, and the indifferent, taken all in all, have exercised a tremendous influence upon human thought and action. We see this influence in philosophy, in religion, in the cult of astrology, in literature, in the very words of our language. We see the influence of astronomy in science, as a helpmate of physics and of chemistry, a bringer of new knowledge, new ideas, new stimulus into the realm of natural philosophy.

To trace this influence in detail upon the development of the kindred sciences would be to set forth the history of science from pre-Greek, through Greek times and on past the dark ages into the renaissance of learning, the era of experimentation, the period of Newton, and on as a swelling tide into the present century.

In ancient Babylon, ^{the heavens were mapped by} men with keen powers of observation and the ability to make and ^{to} hand on accurate records to succeeding generations, ~~and to the present~~. They marked off the star groups as constellations to be identified with names of beasts, birds, imaginary creatures or mythological persons. They plotted the particular paths of sun, moon, and five visible planets against the background of the stars, and formulated rules of recurrence of phenomena such as eclipses. Alongside of true astronomical knowledge there developed the cult of astrology. The aspect of the heavens, rightly interpreted, was said to reveal the significance of dreams, to forecast the future welfare of the ruler or dynasty, to portend victory, pestilence or

disaster. Nebuchadnezzar, King of Babylon, "commanded to call the magicians, and the astrologers, and the sorcerers, and the Chaldeans, for to shew the King his dreams."

When astronomical learning was brought to Greece from Babylon, astrological lore came also. In the hands of the Greeks, astrology greatly widened its influence by producing the individual horoscope. The association of ideas whereby a certain metal was identified with each of the planets, and gold with the sun and silver with the moon, led to research in alchemy becoming closely linked with astrology. This went on until astrology began to fall into disrepute in the seventeenth century. In spite of the general tendency amongst recognized men of science to relegate astrology to the category of a pseudo-science, and to discount its basic assumptions, methods and claims, nevertheless astrology is ^{unfortunately} far from dead as an influence at the present time.

Pure astronomy has exerted an influence on scientific thought and imagination that has been entirely wholesome from the time of the Ionian philosophers to the present. Attempts to understand the motions of the sun, moon, and planets stimulated geometry and brought into being the complexities of the cycle and epicycle theories. Attempts to measure the diameter of the earth required the applications of trigonometry, as did in later centuries Galileo's measurement of the height of lunar mountains. Newton's sublime edifice of celestial mechanics required the invention

of new mathematical tools. Newton's analysis of sunlight, Fraunhofer's observation of the dark lines in the solar spectrum, Kirchhoff's explanation of these lines, led to the development of spectroscopy, both stellar and terrestrial. Helium was discovered by spectrum analysis of light from the edge of the solar disc at a time of eclipse in 1868. Here was a challenge to the chemists which was only answered in 1895 when Ramsay identified helium as a constituent also of the terrestrial atmosphere. And in more recent years, astrophysics has pressed atomic theory into deep channels of fruitful research by its insistence on the existence, under stellar conditions of temperature far exceeding anything attainable in the laboratory, of matter so dense that our densest terrestrial substances, our osmiums, irridiums and platinums, seem by comparison to be mere "airy nothings." The astronomer describes the nature of a dense dwarf star like the Companion of Sirius; and the mathematical physicist sits down at his desk and produces paper after paper in an effort to explain this

star in terms of the behaviour of a "degenerate" gas, or as a one whose core is now devoid of hydrogen by the synthesis of helium through operation of the carbon cycle. Similarly the mysteries of nebulae + coronium have been largely solved in recent years but in solving these problems new questions have arisen to challenge astrophysicists to further research. Thus Eddington's paper on dilute radiation and metastable states followed Bowen's paper, and latterly Nature by Hunter and by Vand are sequels to Eddie's work.

Expans

III

When we turn to the influence of astronomy upon our language, we find that many words in common use derive their meaning from ancient astrological dogmas and superstitions. Thus 'saturnine', 'jovial', 'mercurial' are reminders of the characteristics ascribed to the planets. Saturn partook of the nature of lead; Mercury moved fastest relative to the Sun, and was associated in astrological thought with the substance quick-silver or mercury, hence so called; Jupiter, ^{associated with tin,} was the lusty, self-reliant King of gods, a planet bright and glorious in the night sky. ^{How are the mighty fallen! Ironic indeed is the change in significance of the phrase - a tin god!} In 'disastrous' we have the antithesis of the optimism in the phrase, "the gods to-day stand friendly." Some positions of the heavenly hosts spelled success and some spelled calamity. In the word 'quintessence' we touch upon fundamental Greek thought - the four elements, earth, air, fire, water, of which all things terrestrial were compounded, and the fifth, the perfect, unchanging, and unchangeable substance of which, in the teachings of Aristotle, the stars, sun, moon, and planets were composed.

The influence of astronomy upon literature is a topic of vast range and it can provide unending interest both to the serious student and to the casual vagrant reader. The approach is two-fold. Literature has been enriched tremendously by metaphor and by simile, in verse and in prose, passages that have been inspired by the simple

spectacle of the pageantry of the skies, the nightly march past of the battalions of heaven. Any number of such passages come to mind almost unsought - passages in the Psalms of David; in the Book of Job where "the morning stars sang together"; in the Book of Daniel where the writer is searching for the noblest and loftiest possible expression of acclaim for him whose life is lived in the light of wisdom and whose influence is on the side of righteousness, "They that be wise shall shine as the brightness of the firmament; and they that turn many to righteousness as the stars forever and ever"; passages in Shakespeare such as "the floor of heaven is thick inlaid with patines of bright gold;" In Tagore for whom "Life is a constellation, an unplumbed dark strewn with starry moments"; in Keats whose every changing mood can find expression by some reference to the stars, "those silver lamps that burn on high"; in Shelley where passage after passage bears testimony to the influence of the stars upon his thoughts, "those mighty spheres that gem infinity", "eternal orbs that beautify the night."

The Pythagoreans dwelt much upon the "harmony of the spheres", and it was their geocentric model of the universe with its concentric spheres whose differing motions carried planets, sun, moon and stars around the earth that gave rise to their beautiful conception that the universe sings - high notes where motion is swift, and deeper notes where it is slow. This "music of the spheres" still captivates poetic

fancy. We think at once of the words of Lorenzo to Jessica,
"There's not the smallest orb....." We think of Alfred
Noyse's definition of poetry, "...thought in passionate
tune with those great rhythms that steer the moon and sun".
Or with Alfred Austin we hear "planet with punctual planet
chiming clear, and unto star star cadencing aright."
Or we turn to the Prometheus Unbound and listen with
Panthea and Ione to "the deep music of the rolling world."

Miller

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IV

There is a second, and quite different influence which we find in literature, an influence due not to the simple contemplation of the stars as objects of beauty in the night sky, but to man's effort to understand the stars, to formulate a theory of the Universe, to realize the significance ^{and think in terms} of the knowledge slowly amassed by astronomers regarding the numbers and natures, the distances and motions, the distribution and the origin of stars. It is an intellectual influence bound up with man's hunger and thirst after knowledge, and reflecting in each age the cosmological theories and dogmas of that age.

We see a fine example of this in the first chapter of Genesis. ^{The dramatic picture we owe to early Hebrew thought; the stately English translation, to Tindale.} Void - darkness - waters; and our thoughts go to Thales of Miletus for whom the material cause of all things, the "first principle" is water, and to ancient Egyptian records of "a primordial liquid mass in the limitless depths of which floated the germs of things", to quote from Sir Thomas Heath. But returning to the first page of Holy Writ, we find the evolution of the Universe thus coming about; first light, then the firmament of Heaven, then the dry land of Earth, and on the fourth day "God made two great lights,.... He made the stars also."

In a remarkably interesting work of the pre-Rabbinic Palestinian Jews, the non-canonical Book of Enoch, there is a section entitled the Book of the

Courses of the Heavenly Luminaries. In this we read a detailed account of the changing length of day and night throughout the year, according to the positions on the horizon of sunrise and sunset. "I saw six portals in which the sun rises and six portals in which the sun sets; and the moon rises and sets in these portals, and the leaders of the stars and those whom they lead..... There goes forth the great luminary, and he is filled with illuminating and heating fire. The chariot on which he ascends, the wind drives, and the sun goes down from heaven and returns through the north in order to reach the east and is so guided that he comes to the appropriate portal and shines in the face of heaven." The changing path of the moon is described and her phases and how she borrows of the sun's light "in measure... to the seventh part of the light of the sun." Twelve winds blow upon the earth through twelve portals of heaven, eight are hurtful and four are winds of blessing and prosperity. The sin of man has dire effects upon the precise movements of the heavenly bodies and indeed "the whole order of the stars shall be concealed from sinners!" If there be anywhere in literature a reference to the Man in the Moon earlier than appears to be found in this work of the second century B.C., such reference will be very gratefully ^{welcomed} received! "At night she appears like a man for twenty days each time, and by day she appears like the heaven, and there is nothing else in her save her light."

Fidelity Canyon Skin

(These quotations are taken from the scholarly translation of The Book of Enoch by Dr. R. H. Charles, Canon of Westminster.)

Coming down the years to the beginning of the fourteenth century, we pause to consider how the framework of Dante's Paradiso is the Ptolemaic map of the Universe, the eight concentric spheres about the earth. First is the heaven of the Moon, the blest abode of those who ^{through sanctity} were forced to break holy vows. Then the heaven of Mercury - "this sphere . . . that oft from mortal ken is veiled by other's beams" - a true astronomical description. Here Dante recognizes the Emperor Justinian. The third heaven is Venus "that star, which views now obvious, now averse, the sun". Here are the souls of King Charles Martel of Hungary, and of Rahab of Jerico. The fourth sphere is the heaven of "the great minister of nature, that . . . doles out Time for us with his beam." Amongst the twelve blessed spirits whom the Poet sees here in the Sun are Thomas Aquinas, Solomon, and the Venerable Bede. Beyond the sun is the heaven of Mars, where he finds the godly warriors, the Crusaders, and Judas Maccabeus, Joshua and Charlemagne. In Jupiter, "that temperate star whose sixth orb now enfolded us", he recognizes David, Trajan, Hezekiah, Constantine and others. Entering "the seventh splendour", the heaven of Saturn, where dwell the spirits of those who passed their lives in holy retirement and contemplation, the Poet holds converse with

St. Pietro Damiano and St. Benedict. He next enters the eighth heaven, the Ptolemaic sphere of the fixed stars - "O glorious stars! O light impregnate with exceeding virtue!" He converses with some of the Apostles and with Adam, and is then led upward into the ninth heaven by Beatrice. This ninth heaven, wherein is the Divine Essence, is both circumference and centre of the Universe. "Heaven and all nature hangs upon that point." "Here is the goal whence motion on his race starts; motionless the centre, and the rest all moved around." The Poet is caught up into "that abyss of radiance" the vision of the Trinity. "Here vigour failed", but though physical endurance is broken down, "the will rolled onward... by the love impelled, that moves the sun in heaven and all the stars."

Three hundred years before Dante, we find Al Biruni in his book entitled "Astrology" written at Ghaznah in 1029 debating the existence of a ninth sphere. As translated by Dr. Ramsay Wright, it reads in part thus: "A number of people consider that beyond the eighth sphere there is a ninth entirely quiescent; it is this which the Hindus call in their language Brahmānda, because the prime mover must not be moved.... But it is possible that it is not a body like the other spheres, otherwise its existence could be demonstrated. Many of our ancestors considered that beyond the eight spheres there is an infinite empty space, others a boundless quiescent substance, while

according to Aristotle, there is neither substance nor void beyond the revolving bodies."

When Milton was writing *Paradise Lost*, the cosmology of the past, the geocentric Ptolemaic Universe, could no longer be accepted unquestioningly. Neither could most men grasp with confidence the new and often violently opposed theory of Copernicus, that the Sun was the centre of the system of planets, the Earth being merely a minor planet moving in an orbit between the orbits of Venus and Mars. It was known that Galileo had declared the astronomical evidence to be in favour of the newer theory, but that he had refrained from dogmatically reasserting his belief when faced by ecclesiastical opposition. Bruno had asserted the truth of the Copernican theory with courage and conviction in England and throughout western Europe - and he had come to a martyr's stake in Rome. Milton talked with Galileo in Italy when the latter was an old man nearing the close of life, but the poet evidently was far from feeling sure which theory would eventually be proven correct. This chaotic, uncertain state of mind is vividly portrayed for us in *Paradise Lost* where Adam questions the angel energetically regarding the true nature of the Universe and "whether earth move or sun." The quibbling, inconclusive answer of the archangel Raphael is a masterly piece of evasion!

We may note that the heliocentric theory was not openly taught in Oxford or in Paris until about 1740.

We shall not linger to consider the efforts of more

recent writers to crystallize in literary form, whether in poetry or in prose, the modern conceptions of the Universe. The facts and the fancies, the achievements in stellar measurements, and in cosmic chemistry, the revolution in cosmological thought introduced by the theory of relativity, the daring speculations culminating in the Lemaitrian Expanding Universe, all this and the vast picture of the great revolving galaxies of many thousand millions of stars have had their repercussions upon the thoughts of men; and sooner or later men's thoughts upon most topics find literary expression.

THE INFLUENCE OF ASTRONOMY

- V -

The influence of astronomy upon philosophical and upon religious thought is not a subject that can be briefly and categorically stated, for it offers an outstanding example of the truth contained in the old maxim, - Quot homines tot sententiae - or in more modern phraseology, the same stimuli produce very different mental reactions in different individuals. "The ancient world takes its stand," says Professor A. N. Whitehead, "upon the drama of the Universe, the modern world upon the inward drama of the soul." Yet the inward drama of the Soul is often profoundly influenced by the drama of the physical world where the actors are radiations, electrons, atoms, and stars.

In the ancient world with its geocentric outlook, it was natural for very great importance to be attached to man. For him the sun and moon rose and set, for him the stars shone forth, for him the rains fell and the earth produced her increase - "Thou madest him to have dominion over the works of thy hands, Thou hast put all things under his feet." If to-day, man be regarded as of great intrinsic worth, it must be for ^{intellectual and moral} spiritual reasons; it is no longer an obvious deduction from a survey of the

physical universe. To some types of mind in whatever age, it always was for spiritual not physical reasons; but there are also types of mind to whom it comes as a great shock that man appears to be but an accidental development in very recent ages upon this little old earth, a minor planet, revolving about one quite ordinary dwarf star whose position is somewhere far out from the centre of one of the many millions of galaxies of stars. To minds of this ^{latter} type the Copernican ⁿ cosmology represents a major upheaval of what had become traditional thought.

Astronomy thereafter pictured man as a mere speck in the immensity of space. Then geology joined forces with astronomy to measure out time by aeon upon aeon, so that the average span of a human life is to the estimated age of the earth as one second of time to three score years and ten. Biology added to the mental upheaval by appearing to present a rigidly mechanistic view of life - the great conceptions of evolution, of natural selection, the discoveries of physiological and psychological sciences being swallowed, unmasticated and often misunderstood, by a hungry or a gullible multitude. The effect of all these ideas upon the religious imagination, says the late Bishop Gore, can hardly be exaggerated. "They seemed as represented in popular literature almost to obliterate God, behind a self developing universe, and to reduce the position of man to insignificance." In our own day the great challenge to what one may call "orthodox" religious faith is once more

coming from astronomy, according to Bishop Headlam. The great popularity of various non-technical books dealing with the recent discoveries in astronomy, astrophysics and atomic physics has evidently brought thousands of people face to face with some of these facts for the first time; and they are mentally and spiritually staggered by the immensities of time and space, and by what seems to them the grandeur or the grimness of inexorable law. It is worth noting that it is the readers rather than the authors who react in this manner. The average reader will frequently draw extreme conclusions and be swayed into adopting an essentially illogical attitude of mind very far from the position which the author himself really holds and intended to convey.

II.

It is strange that men are so easily appalled by large numbers - but it is none the less certain that this is a very usual reaction. One blade of grass is intrinsically quite as wonderful as a thousand blades of grass, and ten thousand million stars are no more wonderful than is one star, yet man is overawed by mere number. We see this in Shelley, for whom "the plurality of worlds - the indefinite immensity of the universe is a most awful subject of contemplation. He who rightly feels its mystery and grandeur is in no danger ----- of deifying the principle of the universe." Yet the men who actually count the

stars, measure their distances, and time their revolutions are very rarely the men who deny God, the Creator. Contemplating the evidence for cause and effect - the reign of law - in the physical universe, Shelley ejaculates, "Necessity! thou mother of the world!" and in his footnote he draws this conclusion "The doctrine of Necessity tends ---- utterly to destroy religion."

Our thoughts go back three centuries to a deeper thinker than Shelley, to Leonardo da Vinci, who likewise contemplated a universe in which he found evidence of law and order, cause and effect. He saw it not only with the eyes and mind of an artist, but with the eyes and mind of a man of science - and his reaction, the antithesis to that of Shelley, is expressed in some such words as these - "O divine justice of Thee, Thou Prime Mover. To no force hast Thou permitted a lack of the order and quality of its necessary effects. Thrice marvellous Necessity! ---- Great love is the daughter of great Knowledge. Perfect knowledge of the universe and perfect love of God are one and the same thing."

iii

The dynamic phrase, The Prime Mover, is one of Aristotle's great contributions to metaphysical thought. The Greek philosophers were steeped in the astronomical knowledge of their day, and cosmological speculation flourished in their midst. Asked what was the chief object

of being born into this world, Anaxogoras replied - To investigate the sun, moon and heaven. And Plato impressed upon his students that theirs was the high task of finding "what are the uniform and ordered movements by assuming which the motions of the planets can be explained." That the sun, moon, planets and stars moved, and moved in obedience to some law, was an observation of tremendous significance to the Greek philosophers. When Aristotle sought to complete his *Metaphysics*, he was driven inevitably and inexorably by the force of dispassionate logic to postulate the great Prime Mover. The significance of this can scarcely be overemphasised. It has influenced much philosophic thought down to the present day. It is one of the strongest influences playing upon the mind of Professor Whitehead when he undertakes the difficult task of restating a metaphysics in terms of modern language in the light of modern knowledge. With the passing of the very limited and artificial cosmology of the Greeks, the metaphysical need of God, the Prime Mover, has disappeared. Motion, in the thought of the natural philosopher of the 20th Century is simply one of the many forms of energy. But an analogous metaphysical need does arise, and Professor Whitehead is led to the conclusion that "the general character of things requires that there be such an entity" - "God as the Principle of Concretion."

The Sport of Kings (the master cosmological thinkers) during the past twenty years has been to devise mathematical

metaphysics

8

That which makes the actual world actual
and by Kings there mean the

equations representing various geometries of space and time, equations from which would arise, or within which are embedded, so to speak, as identities the mathematical representations of the laws of nature as the astronomer and as the physicist see them. This means that the so called laws of nature are not edicts imposed from without - the law of gravitation for example, is not what it is because the Prime Mover propels the planets around certain orbits with certain velocities. The laws of nature are what they are because the universe is what it is - a sentence that is inspired by Professor Whitehead's remark that "the electron does what it does because it is what it is," which saying can be glibly made, but carries a meaning not entirely on the surface.

Now each one of these proposed cosmological equations may represent a theoretically possible universe and there may well be an infinity of such possibilities, but no one of the entries (whether of Einstein, or de Sitter, or Lemaitre or other) has won the blue ribbon, because no one of their equations truly and completely represents the actual universe. Furthermore even if such an equation be formulated, this fact still remains obvious that this equation is only one of the many representing theoretically possible universes. "We conceive actuality as in essential relation to unfathomable possibility."

The prime command and its result, are set forth in the Book of Genesis with stately simplicity - " And God said,

Let there be light, and there WAS light." - not any kind of light, with any of the many different properties one might imagine that light could conceivably display; but the particular kind of light that plays so basic a part in our physical experience, the light whose properties are so beautifully set forth in the Maxwellian equations. "----- every actual occasion is a limitation imposed on possibility!" to quote again from the author of the phrase, God, the Principle of Concretion, "God is the ultimate limitation ----- God is not concrete, but he is the ground for concrete actuality."

of limiting agents?

While Shelley was writing his negations in footnotes to Queen Mab, the very same astronomical discoveries were influencing the thoughts of Immanuel Kant; but very different were his reactions. The grandeur of a planetary world, the Milky Way, the nebulae, super-systems of stars - "the infinite field of Creation ---- the work of God ---- the great Builder of the Universe +---- We see the first members of a progressive relationship of worlds and systems ----- an abyss of real immensity in presence of which all the capability of human conception sinks exhausted, although it is supported by the science of number. The Wisdom, the Goodness, the Power which have been revealed ^{are} ~~is~~ infinite."

2 things more

In Pascal we see a philosopher overwhelmed equally by the vastness of the visible world, which is itself

10
11

"but an imperceptible speck in the ample bosom of nature" and by the abyss within the smallest conceivable particle of matter. Between these two extremes, he stands silent. For him there is no easy acceptance of a God revealed by Nature - a reign of Law, yes; the sublime triumphs of mathematical expression of natural law in the outer universe were in progress. Copernicus, Bruno, Galileo, Descartes, these were the influences so potent upon thought in the 17th Century, and on Pascal and Spinoza these influences made deep impression. But while the former turns from the outer world of nature to find God in the spirit of man, the latter finds Him "the immanent cause of all things." "From the infinite nature of God, all things follow by necessity."

12

Given a completely random assemblage of all the energy of the stellar system, what is the probability of the present state of organization having come about by pure chance? This is the question asked and answered by Sir James Jeans whose calculation showed that the probability was so ^{exceedingly} incomprehensibly small as to indicate rather impressively the logical need ^{to rule out pure chance} for a Creator. Bruno arrived at a similar conclusion without climbing up a ladder of mathematical reasoning - "For things have not come about by mere accident, but through the determining mind." Professor Whitehead likewise reaches this conclusion by no devious path - "The order of the world is no accident ---- the religious insight is the grasp of this truth."

13

There is a class of public speakers and writers who misunderstand and misuse modern scientific thought in an effort to obtain oratorical effect or to bring into sharp relief the contrast between the physical and the moral order. A stock phrase is that the physical universe is "a soulless repetitive mechanism." The picture conjured up before the mind is of stars and planets endlessly circling about their appointed orbits for ever and ever and ever and a day - a picture of futility and changelessness; and against this mechanistic principle of nature the spirit of man is urged to fight. This conception is contrary to the true astronomical and physical picture, and much loose thinking is woven about it.

No one can ponder upon the solar system, upon the great multiple star systems, or upon the beautiful photographs of the spiral galaxies, and argue that this is a static universe. It is obviously a dynamic universe; but it is not the arena either of haphazard change nor of mere repetition - it is a dynamic universe of directed change. All the change that goes on in the physical universe is towards unavailability of energy; "physically wasting but spiritually ascending," to quote the comment of Professor Whitehead who in those five words reveals himself as both physicist and ^{mystic} philosopher. In spite of the optimism expressed in writings of an American scientist and of an English theologian to the contrary, there is not one jot of evidence in the whole range of physical phenomena that the

reverse physical process is taking place. Herbert Spencer thinking not only of cosmological changes but more especially of the geological and biological changes which the centuries and eras reveal, arrived at a principle which may be briefly generalized thus:- Nature tends to pass gradually from simple forms which are unstable to complex forms which exhibit greater stability. In this view, likewise, we find no suggestion of mere repetition.

Another erroneous conception which is still a live influence, in much general thought is determinism. It is no new idea in philosophic thought, though it rose to its peak perhaps in the last century. In recent years it has dropped completely from Natural Philosophy because it has been shown by Heisenberg to be without foundation in physical fact. There is a striking contrast between the high degree of predictability of phenomena relating to the positions and motions of satellites, planets or stars, and the relative unpredictability of both these quantities simultaneously for an electron. This is a very deep-seated limitation of our knowledge and one can scarcely over-estimate the importance and significance of this fact, - that the indeterminacy is not merely qualitative, it is quantitative. "The principle of indeterminism" writes Sir A. S. Eddington, "is epistemological,----- to-day physical theory is not mechanistic, and it is built on a foundation that knows nothing of this supposed determinism-----"

A further sentence is here quoted because it represents an

attitude the very antithesis of that so frequently expressed and advocated a generation ago. "I think there is no longer any need to doubt our intuition of free will----- we are scarcely likely to accept a theory which would make the human spirit more mechanistic than the physical universe."

The impact upon philosophy of science's rejection of the law of causality ^{with narrowest sense} is not yet fully evident, but it will inevitably alter the momentum of philosophy, which implies amongst other things, a possible change in the direction along which philosophy will progress in the near future.

vi.

Two of the baffling mysteries which challenge the mind of the philosopher are space and time. Into what category is he to put them? how define them? Newton, Leibnitz and Kant strove to clarify these terms. Newton took them for granted as things-in-themselves, - eternal, infinite, self-subsisting - a point of view that drew fire from Kant. Leibnitz classified them as ordinary concepts, to which Kant raised the objection that ordinary concepts have instances, whereas there is but one space and one time. Kant regarded space and time as the forms of perception, external and internal, respectively; in no sense things-in-themselves, yet not illusions; transcendently ideal, but empirically real. While this critical sifting of words and ideas went on and on, the absolute Euclidean space, and "absolute, true and mathematical time"

accepted explicitly by Newton, provided the frame-work within which the Newtonian celestial mechanics functioned with spectacular success for nearly two hundred years. Then the triumphant chorus of astronomical approval of absolute space and time began to falter. The motion of the perihelion of Mercury's orbit refused to conform to Newtonian calculations. Physics likewise provided food for thought - the earth's motion relative to the ether could not be detected, and the apparent mass of an electron was found to be a function of its velocity.

Einstein's Theory of Relativity swept absolute space and absolute time from the astronomical, the physical and the philosophical horizons. Three out of four crucial tests of this theory were astronomical; and it is the astronomers, naturally, who are providing the observational data that is hurling out the frontiers of explored space to inconceivable distances. The velocity of light being finite, the astronomer is looking backward in time as he looks outward in space. How far he is justified in interpreting what he sees in the stellar universe in terms of physical laws established in a "Here-Now" environment is a question upon which it is not wise to be dogmatic. P. W. Bridgman has ^{warned that this procedure applied at the limit of} ~~referred to~~ the astronomical time scale as a "hair raising extrapolation". ~~of course, this is a very dangerous~~
~~assumption.~~

The advent of non-Euclidean geometry of four dimensional space-time into cosmological thought has one very interesting feature that must be mentioned. It has brought back pre-

Copernican egocentricism in a new sense, for no point in the vastness of space has more right to be regarded as central than has any other point. In the light of present day cosmology, every man can legitimately regard himself as the centre of the universe!

20

same sort?
hardly

vii.

In the Dynasts, Thomas Hardy presents the Spirit of the Years hovering above the earth contemplating the doings of mankind and exclaiming "- This terrestrial tragedy," whereat the Spirit Ironical adds - "or comedy." It is only as one sees this earth in its astronomical setting and in the perspective of the astronomical time scale that it is possible to begin to evaluate and assess the record of history. Viewing thus the page upon which mankind is writing his hieroglyphics, with the long vista of the physical world stretching far out both before and after, Herbert Spencer was oppressed and the apparent unimportance and futility of much human effort weighed very heavily upon his mind.

21

The intolerance, superstition and barbaric savagery of so much of human behaviour not only oppressed the keenly sensitive spirit of Voltaire but goaded him into action. In one of his rapier-like efforts to tear the veil from men's eyes that they might see and act with sanity and justice instead of making this earth a hell through war, greed, and fanaticism, he conjures up a man from Sirius, and another from Saturn, in order to bring into sharp focus in its

d

f

superstitions

universal space-time setting "this terrestrial tragedy." One of the greatest thinkers of our own day, General Smuts, likewise feels the necessity for this cosmical perspective. In his Holism and Evolution he makes it clear that a satisfying philosophy must bring into one field of view the problems of the physical world, of life, of mind, and of spirit. "In ever varying degree," he writes, "the universe is holistic and organic through and through----- The great values and ideals retain their unfading glory and derive new interest and force from a cosmic setting."

Thus the mind of man traverses the whole gamut of human experience and inquiry, and from earliest ages to the present time philosophers and men of science alike have appealed to reason - "Trust in reason," says Clement of Alexandria through the pen of Dean Inge, "which rests ultimately upon faith in the divine Logos, the self-revealing soul of the universe."

22

Code
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THE INFLUENCE OF ASTRONOMY

- I -

Astronomical knowledge, theories and speculations, have exerted an influence upon the actions and thinkings of mankind that have been both varied and profound. This influence must have been already operating before the dawn of what we call civilization; for two of the fundamental needs of mankind living even in the most primitive groups or communities, are dependent upon accurate observation of the heavens - the motions, or apparent motions, of the sun, moon, and stars provide the natural units of time and the basis of any system of chronology; and the relative positions of the stars make possible the determination of direction and position upon the earth.

Herodotus makes reference to the year of the Egyptians being three hundred and sixty-five days; twelve months of thirty days each, and five extra days to keep the year of chronology in step with the year of the seasons. Summer and winter, seed-time and harvest shall not cease; and it has been the astronomers' task in all ages to formulate a practical leap-year rule that shall successfully keep this basic cycle of man's experience in agreement with his year of chronology.

Homer, some ten centuries B. C., wrote of Ulysses on his raft that "...at the helm he sat and marked the skies." Diodorus Siculus recorded that travellers on the sandy deserts of Arabia directed their steps by the Bears - the star groups in the northern sky known

First volume of Astronomical

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- 1 -

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Page 2.
Page 3.

The Influence of Astronomy.

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the Koran it is written that God hath given the stars to
be guides in the dark, both by land and by sea. This is
dependence upon astronomical observation of all who would
navigate on land, sea, or in the air, and of all who would
establish geodetic lines and positions, international or of
local boundaries, need not be stressed further. For
Neither need we stress the basic importance of an
accurate time service in modern life, when we see every
civilized country maintaining out of public funds a
government observatory charged with this task. In the
Egypt of 1500 B.C. the hours of daylight were twelve,
and the hours of night were twelve; and elaborate water-
clocks were in use, and were improved upon (according to
records of that era) so that the varying length of these
hours might be accurately measured off, whether it were
the long day and short night of the summer solstice, the
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the winter solstice. In recent years, in the reign of
Charles II, it was in collaboration with the astronomers
of the Royal Observatory at Greenwich ^{and to meet the urgent need of navigators} that the art of
accurate chronometry was given a tremendous impulse
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That the influence of astronomy is not limited on the one hand to mere precise practical needs undertaken as a matter of routine necessity by governments, and on the other to the academic theorizings of professional astronomers, of significance only to the few, is too

obvious a fact on this continent to warrant more than briefest mention. An influence must be potent indeed if it have power to unlock the rich man's strong box ^{and the vaults of Institutes,} and drawing forth dollars by the thousands, by the hundreds of thousands, and quite literally by the millions for the establishment of observatories, for the setting up of planetaria, for experimentation in quartz and in pyrex so that newer and larger and more efficient instruments of astronomical research may be constructed.

instinct of stimulating it. The only stimulus to invent is not enough; it may be necessary to have a certain amount of stimulus to get the work done. These are pulling in both directions and the result is of the mind if the value of the work is to be measured.

In every age, there are men who are distinguished by exceptional powers of observation and invention. Where these qualities are developed by education, inevitable perseverance, and a certain amount of isolation in order to give the mind a chance to develop a new and a wholesome scepticism, the result is a man who is not content to accept the traditional ideas of his age, but who is determined to have the truth for itself. It is this quality of mind that is necessary for the advancement of science, and it is this quality that is necessary for the advancement of art. It is this quality that is necessary for the advancement of literature, and it is this quality that is necessary for the advancement of all the other arts and sciences. It is this quality that is necessary for the advancement of the human race.

Influence of Astronomers

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~~Astronomy~~ The picture of the Universe, that the
 astronomers have been able to throw upon the canvas of
 man's mind from age to age, has at all times aroused a
 responsive interest and awakened a curiosity far beyond
 the merely practical applications of this knowledge.
 Curiosity is one of the divinely implanted characteristics
 of mankind and it is the tragedy of misguided education
 that it too often dulls, blunts and thwarts natural curiosity
 instead of stimulating it. But mere stimulation of curiosity
 is not enough; it may soon degenerate into harmful credulity
 unless there is gradually developed a calm critical judgment.
 These two pulling in double harness are essential attributes
 of the mind if the value of knowledge is to be realized.

In every age, there are a few men endowed with
 exceptional powers of observation and unbounded curiosity.
 Where these qualities are accompanied by winged imagination,
 indomitable perseverance, a deep-rooted faith that there
 is order underlying even the apparent chaos of the Universe,
 and a wholesome scepticism, an honest critical questioning
 that refuses to accept as necessarily true the obvious
 or the traditional answers to the great riddles of nature -
 here we have the qualities of mind and spirit that go to
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The astronomers and the astrologers, the good, the
 bad, and the indifferent, taken all in all, have exercised
 a tremendous influence upon human thought and action. We
 see this influence in philosophy, in religion, in the cult
 of astrology, in literature, in the very words of our
 language. We see the influence of astronomy in science,
 as a helpmate of physics and of chemistry, a bringer of
 new knowledge, new ideas, new stimulus into the realm of
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To trace this influence in detail upon the develop-
 ment of the kindred sciences would be to set forth the
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 on past the dark ages into the renaissance of learning, the
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In ancient Babylon, ^{the heavens were mapped by} men with keen powers of observation
 and the ability to make and hand on accurate records to
 succeeding generations, ~~mapped the heavens~~. They marked
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 and five visible planets against the background of the
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To trace this influence in detail upon the development of the kindred sciences would be to set forth the history of science from pre-Greek, through Greek times and on past the dark ages into the renaissance of learning, the era of experimentation, the period of Newton, and on as a swelling tide into the present century.

In ancient Babylon, men with keen powers of observation and the ability to make and hand on accurate records to succeeding generations, ~~they marked~~ off the star groups as constellations to be identified with names of beasts, birds, imaginary creatures or mythological persons. They plotted the particular paths of sun, moon, and five visible planets against the background of the stars, and formulated rules of recurrence of phenomena such as eclipses. Alongside of true astronomical knowledge there developed the art of astrology. The aspect of the heavens, rightly interpreted, was said to reveal the significance of dreams, to forecast the future welfare of the ruler or dynasty, to portend victory, pestilence or

of new mathematical tools. Newton's analysis of sunlight, disaster. Nebuchadnezzar, King of Babylon, "commanded to call the magicians, and the astrologers, and the sorcerers, and the Chaldeans, for to shew the King his dreams."

When astronomical learning was brought to Greece from Babylon, astrological lore came also. In the hands of the Greeks, astrology greatly widened its influence by producing the individual horoscope. The association of ideas whereby a certain metal was identified with each of the planets, and gold with the sun and silver with the moon, led to research in alchemy becoming closely linked with astrology. This went on until astrology began to fall into disrepute in the seventeenth century. In spite of the general tendency amongst recognized men of science to relegate astrology to the category of a pseudo-science, and to discount its basic assumptions, methods and claims, nevertheless astrology is far from dead as an influence at the present time.

Pure astronomy has exerted an influence on scientific thought and imagination that has been entirely wholesome from the time of the Ionian philosophers to the present. Attempts to understand the motions of the sun, moon, and planets stimulated geometry and brought into being the complexities of the cycle and epicycle theories. Attempts to measure the diameter of the earth required the applications of trigonometry, as did in later centuries Galileo's measurement of the height of lunar mountains. Newton's sublime edifice of celestial mechanics required the invention

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of new mathematical tools. Newton's analysis of sunlight, Fraunhofer's observation of the dark lines in the solar spectrum, Kirchhoff's explanation of these lines, led to the development of spectroscopy, both stellar and terrestrial. Helium was discovered by spectrum analysis of light from the edge of the solar disc at a time of eclipse in 1868. Here was a challenge to the chemists which was only answered in 1895 when Ramsay identified helium as a constituent also of the terrestrial atmosphere. And in more recent years, astrophysics has pressed atomic theory into deep channels of fruitful research by its insistence on the existence, under stellar conditions of temperature far exceeding anything attainable in the laboratory, of matter so dense that our densest terrestrial substances, our osmiums, irridiums and platinums, seem by comparison to be mere "airy nothings." The astronomer describes the nature of a dense dwarf star like the Companion of Sirius; and the mathematical physicist sits down at his desk and produces paper after paper in an effort to explain this star in terms of the behaviour of a "degenerate" gas.

Such is the healthy & stimulating influence of one science upon another

The influence of astronomy upon literature is a topic which has attracted the interest of the serious student and the casual vagrant reader. The approach is two fold. Literature has been enriched tremendously by metaphors and by simile, in verse and in prose, passages that have been inspired by the stars

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III

When we turn to the influence of astronomy upon our language, we find that many words in common use derive their meaning from ancient astrological dogmas and superstitions. Thus 'saturnine', 'jovial', 'mercurial' are reminders of the characteristics ascribed to the planets. Saturn partook of the nature of lead; Mercury moved fastest relative to the Sun, and was associated in astrological thought with the substance quick-silver or mercury, hence so called; Jupiter was the lusty, self-reliant King of gods, a planet bright and glorious in the night sky. In 'disastrous' we have the antithesis of the optimism in the phrase, "the gods to-day stand friendly." Some positions of the heavenly hosts spelled success and some spelled calamity. In the word 'quintessence' we touch upon fundamental Greek thought - the four elements, earth, air, fire, water, of which all things terrestrial were compounded, and the fifth, the perfect, unchanging, and unchangeable substance of which in the teachings of Aristotle, the stars, sun, moon, and planets were composed.

*Keppler's words
phrase little to
be considered
one which has
ironic ring
an astronomer*

associated with tin

Ironical indeed is the change in the significance of the phrase - atom god!

words

The Pythagoreans held that the "harmony of the spheres", and it was their geocentric model of the universe with its crystalline spheres.

The influence of astronomy upon literature is a topic of vast range and it can provide unending interest both to the serious student and to the casual vagrant reader. The approach is two fold. Literature has been enriched tremendously by metaphor and by simile, in verse and in prose, passages that have been inspired by the simple

When we turn to the influence of astronomy upon our language, we find that many words in common use derive their meaning from ancient astronomical dogmas and superstitions. The names of the planets, the stars, and the constellations are reminders of the characteristics ascribed to the planets. Saturn partook of the nature of lead; Mercury moved fastest relative to the Sun, and was associated in astrological thought with the substance quick-silver or mercury, hence so called. Jupiter was the last, self-reliant King of gods, a planet bright and glorious in the night sky. In 'distraction' we have the antithesis of the optimism in the phrase, 'the gods to-day stand friendly.' Some positions of the heavenly hosts spelled success and some spelled calamity. In the word 'quintessence' we look upon fundamental Greek thought - the four elements earth, air, fire, water, of which all things terrestrial were compounded, and the fifth, the perfect, unchanging, and unchangeable substance of which in the teachings of Aristotle, the stars, sun, moon, and planets were composed.

The influence of astronomy upon literature is a topic of vast range and it can provide manifold interest both to the serious student and to the casual, voracious reader. The approach is two fold. Literature has been enriched tremendously by metaphor and by simile, in verse and in prose, passages that have been inspired by the simple

spectacle of the pageantry of the skies, the nightly march past of the battalions of heaven. Any number of such passages come to mind almost unsought - passages in the Psalms of David; in the Book of Job where "the morning stars sang together"; in the Book of Daniel where the writer is searching for the noblest and loftiest possible expression of acclaim for him whose life is lived in the light of wisdom and whose influence is on the side of righteousness, "They that be wise shall shine as the brightness of the firmament; and they that turn many to righteousness as the stars forever and ever"; passages in Shakespeare such as "the floor of heaven is thick inlaid with patines of bright gold;" in Tagore for whom "Life is a constellation, an unplumbed dark strewn with starry moments"; in Keats whose every changing mood can find expression by some reference to the stars, "those silver lamps that burn on high"; in Shelley where passage after passage bears testimony to the influence of the stars upon his thoughts, "those mighty spheres that gem infinity", "eternal orbs that beautify the night."

The Pythagoreans dwelt much upon the "harmony of the spheres", and it was their geocentric model of the universe with its concentric spheres whose differing motions carried planets, sun, moon and stars around the earth, that gave rise to their beautiful conception that the universe sings - high notes where motion is swift, and deeper notes where it is slow. This "music of the spheres" still captivates poetic

T. W. Bland
Dover

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fancy. We think at once of the words of Lorenzo to Jessica,
 "There's not the smallest orb....." We think of Alfred
 Noyse's definition of poetry, "...thought in passionate
 tune with those great rhythms that steer the moon and sun".
 Or with Alfred Austin we hear "planet with punctual planet
 chiming clear, and unto star star cadencing aright."
 Or we turn to the Prometheus Unbound and listen with
 Panthea and Ione to "the deep music of the rolling world."

*What there beheld, but in his motion like an
 angel pump, still quivering to the firmament's cherubim
 Swiftly, in a moment, with a whirlwind's
 This earth, it seems, is a vast, dark, and
 hold as in the command, "Hear it"*

... We think at once of the words of Lorenz to Descartes
 "There's not the smallest orb...". We think of Alfred
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Courses of the Heavenly Luminaries. In this we read a
 detail. There is a second, and quite different influence which
 we find in literature, an influence due not to the simple
 contemplation of the stars as objects of beauty in the
 night sky, but to man's effort to understand the stars, to
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 motions, the distribution and the origin of stars. It is
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 thirst after knowledge, and reflecting in each age the
 cosmological theories and dogmas of that age.

We see a fine example of this in the first chapter of
 Genesis. ^{The dramatic picture we owe to early Hebrew thought; the stately English translation, to Tinsdale}
 Void - darkness - waters; and our thoughts go
 to Thales of Miletus for whom the material cause of all
 things, the "first principle" is water, and to ancient
 Egyptian records of "a primordial liquid mass in the
 limitless depths of which floated the germs of things",
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 first page of Holy Writ, we find the evolution of the
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 on the fourth day "God made two great lights,.... He work
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The Influence of Astronomy

VI

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We see a fine example of this in the first chapter of Genesis. "Void - darkness - waters; and our thoughts go to those of Milton for whom the material cause of all things, the 'first principle' is water, and to ancient Egyptian records of 'a primordial fluid mass in the limitless depths of which floated the germs of things'." To quote from Sir Thomas Heath. But returning to the first page of Holy Writ, we find the evolution of the Universe thus comes about: first light, then the firmament of Heaven, then the dry land of Earth, and on the fourth day "God made two great lights.... He made the stars also."

In a remarkably interesting work of the pre-Rabbinic Palestinian Jews, the non-canonical Book of Enoch, there is a section entitled the Book of the

Courses of the Heavenly Luminaries. In this we read a detailed account of the changing length of day and night throughout the year, according to the positions on the horizon of sunrise and sunset. "I saw six portals in which the sun rises and six portals in which the sun sets; and the moon rises and sets in these portals, and the leaders of the stars and those whom they lead.... There goes forth the great luminary, and he is filled with illuminating and heating fire. The chariot on which he ascends, the wind drives, and the sun goes down from heaven and returns through the north in order to reach the east and is so guided that he comes to the appropriate portal and shines in the face of heaven." The changing path of the moon is described and her phases and how she borrows of the sun's light "in measure... to the seventh part of the light of the sun." Twelve winds blow upon the earth through twelve portals of heaven, eight are hurtful and four are winds of blessing and prosperity. The sin of man has dire effects upon the precise movements of the heavenly bodies and indeed "the whole order of the stars shall be concealed from sinners!" If there be anywhere in literature a reference to the Manikin in the Moon earlier than appears to be found in this work of the second century B.C., such reference will be very gratefully received! "At night she appears like a man for twenty days each time, and by day she appears like the heaven, and there is nothing else in her save her light." *

* Footnote sup. 13.

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 There goes forth the great luminary, and he is filled
 with illuminating and heating fire. The chariot on
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These quotations are taken from the scholarly translation of The Book of Enoch by Dr. R. H. Charles, Canon of Westminster.

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Coming down the years to the beginning of the
 fourteenth century, we pause to consider how the framework
 of Dante's Paradiso is the Ptolemaic map of the Universe,
 the eight concentric spheres about the earth. First is the
 heaven of the Moon, the blest abode of those who were forced
 to break holy vows. Then the heaven of Mercury - "this
 sphere that oft from mortal ken is veiled by other's
 beams" - a true astronomical description. Here Dante
 recognizes the Emperor Justinian. The third heaven is Venus
 "that star, which views now obvious, now averse, the sun".
 Here are the souls of King Charles Martel of Hungary, and of
 Rahab of Jerico. The fourth sphere is the heaven of "the
 great minister of nature, that....doles out Time for us
 with his beam." Amongst the twelve blessed spirits whom
 the Poet sees here in the Sun are Thomas Aquinas, Solomon,
 and the Venerable Bede. Beyond the sun is the heaven of
 Mars, where he finds the godly warriors, the Crusaders, and
 Judas Maccabeus, Joshua and Charlemagne. In Jupiter, "that
 temperate star whose sixth orb now enfolded us", he recognizes
 David, Trajan, Hezekiah, Constantine and others. Entering
 "the seventh splendour", the heaven of Saturn, where dwell
 the spirits of those who passed their lives in holy retire-
 ment and contemplation, the Poet holds converse with

The Influence of Astronomy

(These quotations are taken from the scholarly translation of The Book of Esch by Dr. R. H. Charles, Canon of Westminster.)

Coming down the years to the beginning of the fourteenth century, we pause to consider how the framework of Dante's Paradise is the Ptolemaic map of the universe, the eight concentric spheres about the earth. First is the heaven of the Moon, the least abode of those who were forced to break holy vows. Then the heaven of Mercury - "this sphere . . . that of mortal men is valued by other's beams" - a true astronomical description. Here Dante recognizes the Emperor Justinian. The third heaven is Venus "that star, which views new opinions, now reverse, the sun". Here are the souls of King Charles Martel of Hungary, and of Raimond of Tripoli. The fourth sphere is the heaven of the great minister of nature, that . . . glides out time for us with his beam." Amongst the twelve blessed spirits whom the poet sees here in the firmament are Thomas Aquinas, Solomon, and the Venerable Bede. Beyond the sun is the heaven of Mars, where he finds the godly warriors, the Gracchus, and John Macchabees, Joshua and Chusdranese. In Jupiter, "that temperate star whose sixth orb now enfolded us", he recognizes David, Israhel, Hezekiah, Constantine and others. In Saturn "the seventh splendour", the heaven of Saturn, where dwell the spirits of those who passed their lives in holy retirement and contemplation, the poet holds converse with

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 Adam and is then led upward into the ninth heaven by Beatrice.
 This ninth heaven wherein is the Divine Essence is both circumference and centre of the Universe.
 "Heaven and all nature hangs upon that point."
 "Here is the goal whence motion on his race starts; motionless and the centre, and the rest all moved around."
 The Poet is caught up into "that abyss of radiance" - the vision of the Trinity.
 "Here vigour failed", but though his physical endurance is broken down, "the will rolled on had onward... by the love impelled, that moves the sun in age heaven and all the stars."
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 and Three hundred years before Dante, we find Al Biruni in his book entitled "Astrology" written at Ghaznah in 1029 debating the existence of a ninth sphere. As soon translated by Dr. Ramsay Wright, it reads in part thus:
 "A number of people consider that beyond the eighth sphere there is a ninth entirely quiescent; it is this which the Hindus call in their language Brahmānda, because the prime mover must not be moved... But it is possible that it is not a body like the other spheres, otherwise its existence could be demonstrated. Many of our ancestors considered that beyond the eight spheres there is an infinite empty space, others a boundless quiescent substance, while

St. Pietro Damiano and St. Benedict. He next enters the old eighth heaven, the Ptolemaic sphere of the fixed stars - "O glorious stars! O light impregnate with exceeding virtue!" He converses with some of the Apostles and with Adam, ^{who then disappears with the 9th heaven} and is then led upward into the ninth heaven by Beatrice. This ninth heaven wherein is the Divine Essence is both circumference and centre of the Universe. "Heaven and all nature hangs upon that point." "Here is the goal whence motion on his race starts; motionless and the centre, and the rest all moved around." The Poet is caught up into "that abyss of radiance" - the vision of the Trinity. "Here vigour failed", but though his physical endurance is broken down, "the will rolled on had onward... by the love impelled, that moves the sun in age heaven and all the stars." and throughout western Europe - and Three hundred years before Dante, we find Al Biruni in his book entitled "Astrology" written at Ghaznah in 1029 debating the existence of a ninth sphere. As soon translated by Dr. Ramsay Wright, it reads in part thus: "A number of people consider that beyond the eighth sphere there is a ninth entirely quiescent; it is this which the Hindus call in their language Brahmānda, because the prime mover must not be moved... But it is possible that it is not a body like the other spheres, otherwise its existence could be demonstrated. Many of our ancestors considered that beyond the eight spheres there is an infinite empty space, others a boundless quiescent substance, while

Handwritten notes at the bottom:
 St. Peter
 also Milton & Raphael (Adam)
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according to Aristotle, there is neither substance nor void beyond the revolving bodies."

When Milton was writing Paradise Lost, the cosmology of the past, the geocentric Ptolemaic Universe, could no longer be accepted unquestioningly. Neither could most men grasp with confidence the new and often violently opposed theory of Copernicus, that the Sun was the centre of the system of planets, the Earth being merely a minor planet moving in an orbit between the orbits of Venus and Mars. It was known that Galileo had declared the astronomical evidence to be in favour of the newer theory, but that he had refrained from dogmatically reasserting his belief when faced by ecclesiastical opposition. Bruno had asserted the truth of the Copernican theory with courage and conviction in England and throughout western Europe - and he had come to a martyr's stake in Rome. Milton talked with Galileo in Italy when the latter was an old man nearing the close of life, but the poet evidently was far from feeling sure which theory would eventually be proven correct. This chaotic, uncertain state of mind is vividly portrayed for us in Paradise Lost where Adam questions the angel energetically regarding the true nature of the Universe and "whether earth move or sun." The quibbling, inconclusive answer of the archangel Raphael is a masterly piece of evasion!

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recent writers to crystallize in literary form, whether in poetry or in prose, the modern conceptions of the Universe. The facts and the fancies, the achievements in stellar measurements, and in cosmic chemistry, the revolution in cosmological thought introduced by the theory of relativity, the daring speculations culminating in the Leibnizian Expanding Universe, all this and the vast picture of the great revolving galaxies of many thousand millions of stars have had their repercussions upon the thoughts of men; and sooner or later men's thoughts upon most topics find literary expression.

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THE INFLUENCE OF ASTRONOMY

physical universe. To some types of mind in whatever age, it always was and always will be a spiritual rather than a physical fact. There are also types of mind - V - in which it seems as if a great shock that man appears to be but an accidental development in very recent ages upon this little old earth, a minor planet revolving about one quite ordinary star, and whose position in the vastness of space is of no more importance than that of a speck of dust.

The influence of astronomy upon philosophical and upon religious thought is not a subject that can be briefly and categorically stated, for it offers an outstanding example of the truth contained in the old maxim, - Quot homines tot sententiae - or in more modern phraseology, the same stimuli produce very different mental reactions in different individuals. "The ancient world takes its stand," says Professor A. N. Whitehead, "upon the drama of the Universe, the modern world upon the inward drama of the soul." Yet the inward drama of the soul is often profoundly influenced by the drama of the physical world where the actors are radiations, electrons, atoms, and stars.

In the ancient world with its geocentric outlook, it was natural for very great importance to be attached to man. For him the sun and moon rose and set, for him the stars shone forth, for him the rains fell and the earth produced her increase - "Thou madest him to have dominion over the works of thy hands, Thou hast put all things under his feet." If to-day, man be regarded as of great intrinsic worth, it must be for spiritual reasons; it is no longer an obvious deduction from a survey of the

physical universe. To some types of mind in whatever age, it always was for spiritual not physical reasons; but there are also types of mind to whom it comes as a great shock that man appears to be but an accidental development in very recent ages upon this little old earth, a minor planet, revolving about one quite ordinary dwarf star whose position is somewhere far out from the centre of one of the many millions of galaxies of stars. To minds of this type the Copernican cosmology represents a major upheaval of what had become traditional thought.

Astronomy thereafter pictured man as a mere speck in the immensity of space, ^{and a late comer in time}. Then geology joined forces with astronomy to measure out time by aeon upon aeon, so that the average span of a human life is to the estimated age of the earth as one ^{minute} ~~second~~ of time to ^{ten} ~~three~~ score years. ~~and ten~~. Biology added to the mental upheaval by appearing to present a rigidly mechanistic view of life - the great conceptions of evolution, of natural selection, the discoveries of physiological and psychological sciences ~~being~~ being swallowed, unchewed and often misunderstood, by a hungry or a gullible multitude. ^{Bishop Gore thought} The effect of all these ideas upon the religious imagination, ^{says} ~~says~~ the late Bishop Gore, ^{could} ~~can~~ hardly be exaggerated: - "They seemed as represented in popular literature almost to obliterate God, behind a self developing universe, and to reduce the position of man to insignificance." In our own day the great challenge to ~~what one may call~~ "orthodox" religious faith is once more

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coming from astronomy, according to Bishop Headlam. The great popularity of various non-technical books dealing with the recent discoveries in astronomy, astrophysics and atomic physics, has ~~recently~~ brought thousands of people face to face with some of these facts for the first time; and they are mentally and spiritually staggered by the immensities of time and space, and by what seems to them the grandeur or the grimness of inexorable law.

It is worth noting that it is the readers rather than the authors who react in this manner. The average reader will frequently draw extreme conclusions and be swayed into adopting an essentially illogical attitude of mind very far from the position which the author himself really holds and intended to convey.

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It is strange that men are so easily appalled by large numbers - but it is none the less certain that this is a very usual reaction. One blade of grass is intrinsically quite as wonderful as ^{ten} a thousand blades of grass, and ten thousand million stars are no more wonderful than is one star, yet man is overawed by mere number. We see this in Shelley, for whom "the plurality of worlds - the infinite immensity of the universe is a most awful subject of contemplation. He who rightly feels its mystery and grandeur is in no danger ----- of deifying the principle of the universe." Yet the men who actually count the

of being born into this world, Anaxagoras replied - To stars, measure their distances, and time their revolutions investigate the sun, moon and heaven. And Plato ^{Symposium of the Universe} are very rarely the men who deny God, the Creator. Contemplating the evidence for cause and effect - the reign of law - in the physical universe, Shelley ejaculates, "Necessity! thou mother of the world!" and in his footnote he draws this conclusion "The doctrine of Necessity tends to utterly to destroy religion."

Our thoughts go back three centuries to a deeper thinker than Shelley, to Leonardo da Vinci, who likewise contemplated a universe in which he found evidence of law and order, cause and effect. He saw it not only with the eyes and mind of an artist, but with the eyes and mind of a man of science - and his reaction, the antithesis to that of Shelley, is expressed in some such words as these - "O divine justice of Thee, Thou Prime Mover. To no force hast Thou permitted lack of the order and quality of its necessary effects. Thrice marvellous Necessity! ----- Great love is the daughter of great Knowledge. Perfect knowledge of the universe and perfect love of God are one and the same thing." *Zimmerman speaks for us when he says "Let Knowledge grow from more to more, yet more and more."*

* The dynamic phrase, The Prime Mover, is one of Aristotle's great contributions to metaphysical thought. The Greek philosophers were steeped in the astronomical knowledge of their day, and cosmological speculation flourished in their midst. Asked what was the chief object

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equations representing various geometries of space and time; equations from which would arise, or within which are embedded, so to speak, as identities the mathematical representations of the laws of nature as the astronomer and as the physicist see them. This means that the so called laws of nature are not edicts imposed from without - the law of gravitation for example, is not what it is because the Prime Mover propels the planets around certain orbits with certain velocities. The laws of nature are what they are because the universe is what it is - a sentence that is inspired by Professor Whitehead's remark that "the electron does what it does because it is what it is," which saying can be glibly made, but carries a meaning not entirely on the surface. Shelley was writing his negations in foot-

Now each one of these proposed cosmological equations may represent a theoretically possible universe and there may well be an infinity of such possibilities, but no one of the entries (whether of Einstein, or de Sitter, or Lemaître or other) has won the blue ribbon, because no one of their equations truly and completely represents the actual universe. Furthermore even if such an equation be formulated, this fact still remains obvious that this equation is only one of the many representing theoretically possible universes. "We conceive actuality as in essential relation to unfathomable possibility."

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The prime command and its result, are set forth in the Book of Genesis with steady stability - "And God said,

Let there be light, and there WAS light." - not any kind of light, with any of the many different properties one might imagine that light could conceivably display; but the particular kind of light that plays so basic a part in our physical experience, the light whose properties are so beautifully set forth in the Maxwellian equations. "----- every actual occasion is a limitation imposed on possibility"; to quote again from the author of the phrase, God, the Principle of Concretion, "God is the ultimate limitation ----- God is not concrete, but he is the ground for concrete actuality."

* While Shelley was writing ^{these} his negations in footnotes to Queen Mab, the very same astronomical discoveries were influencing the thoughts of Immanuel Kant; but very different were his reactions. The grandeur of a planetary world, the Milky Way, the nebulae, super-systems of stars - "the infinite field of Creation ---- the work of God ---- the great Builder of the Universe w---- We see the first members of a progressive relationship of worlds and systems ---- an abyss of real immensity in presence of which all the capability of human conception sinks exhausted, although it is supported by the science of number. The Wisdom, the Goodness, the Power which have been revealed ^{are} infinite." *Kant's famous affirmation is well known - Two things move me to reverence - In Pascal we see a philosopher overwhelmed equally by the vastness of the visible world, which is itself*

the starry heavens without and the moral consciousness within.

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"but an imperceptible speck in the ample bosom of nature" and by the abyss within the smallest conceivable particle of matter. Between these two extremes, he stands silent. For him there is no easy acceptance of a God revealed by Nature - a reign of Law, yes; the sublime triumphs of mathematical expression of natural law in the outer universe were in progress. Copernicus, Bruno, Galileo, Descartes, these were the influences so potent upon thought in the 17th Century, and on Pascal and Spinoza these influences made deep impression. But while the former turns from the outer world of nature to ^{seek} find God in the spirit of man, the latter finds Him "the immanent cause of all things." "From the infinite nature of God, all things follow by necessity."

Given a completely random assemblage of all the energy of the stellar system, what is the probability of the present state of organization having come about by pure chance? This is the question asked and answered by Sir James Jeans whose calculation showed that the probability was so incomprehensibly small as to indicate rather impressively the logical need for a Creator, ^{a local architect of the Universe.} Bruno arrived at a similar conclusion without climbing up a ladder of mathematical reasoning - "For things have not come about by mere accident, but through the determining mind." Professor Whitehead likewise reaches this conclusion by no devious path - "The order of the world is no accident - the religious insight is the grasp of this truth."

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There is a class of public speakers and writers who misunderstand and misuse modern scientific thought in an effort to obtain oratorical effect or to bring into sharp relief the contrast between the physical and the moral order. A stock phrase is that the physical universe is "a soulless repetitive mechanism." The picture conjured up before the mind is of stars and planets endlessly circling about their appointed orbits for ever and ever and ever and a day - a picture of futility and changelessness; and against this mechanistic principle of nature the spirit of man is urged to fight. This conception is contrary to the true astronomical and physical picture, and much loose thinking is woven about it.

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No one can ponder upon the solar system, upon the great multiple star systems, or upon the beautiful photographs of the spiral galaxies, and argue that this is a static universe. It is obviously a dynamic universe; but it is not the arena either of haphazard change nor of mere repetition - it is a dynamic universe of directed change. All the change that goes on in the physical universe is towards unavailability of energy; "physically wasting but spiritually ascending," to quote the comment of Professor Whitehead who in those five words reveals himself as both physicist and philosopher. In spite of the optimism expressed in writings of an American scientist and of an English theologian to the contrary, there is not one jot of evidence in the whole range of physical phenomena that the

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Order's importance

reverse physical process is taking place. Herbert Spencer

* Thinking not only of cosmological changes but more also especially of the geological and biological changes which the centuries and eras reveal, arrived at a principle which may be briefly generalized thus:- Nature tends to pass gradually from simple forms which are unstable to "heterogeneity" towards a "definite stable complex forms which exhibit greater stability." It is important to note that in this view, likewise, we find no suggestion of mere repetition.

Another erroneous conception which is still a live influence, in much general thought is determinism. It is no new idea in philosophic thought, though it rose to its peak perhaps in the last century. In recent years it has dropped completely from Natural Philosophy because it has been shown by Heisenberg to be without foundation in physical fact. There is a striking contrast between the high degree of predictability of phenomena relating to the positions and motions of satellites, planets or stars, and the relative unpredictability of both these quantities simultaneously for an electron. This is a very deep-seated limitation of our knowledge and one can scarcely over-estimate the importance and significance of this fact, - that the indeterminacy is not merely qualitative, it is quantitative. "The principle of indeterminism" writes Sir A. S. Eddington, "is epistemological,----- to-day physical theory is not mechanistic, and it is built on a foundation that knows nothing of this supposed determinism-----"

A further sentence is here quoted because it represents an ideal, but empirically real, while the ideal is a lifting of words and ideas and on the other hand Euclidean space, and "absolute, true and mathematical time"

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 been shown by Hertz and others to be without foundation in
 physical fact. There is a striking contrast between the
 high degree of predictability of phenomena relating to the
 positions and motions of satellites, planets or stars, and
 the relative unpredictability of both these quantities
 simultaneously for an electron. This is a very deep-
 seated limitation of our knowledge and one can scarcely
 over-estimate the importance and significance of this fact.
 That the indeterminacy is not merely qualitative, it is
 quantitative. "The principle of indeterminacy" writes Sir
 A. S. Eddington, "is epistemological, and it is built on a foundation
 theory is not mechanistic, and it is built on a foundation
 that knows nothing of this supposed determinism."
 A further sentence is here quoted because it represents an

Omit

attitude the very antithesis of that so frequently ex-
 pressed and advocated a generation ago. "I think there
 is no longer any need to doubt our intuition of free
 will----- we are scarcely likely to accept a theory
 which would make the human spirit more mechanistic than
 the physical universe."

The impact upon philosophy of science's rejection
 of the law of causality is not yet fully evident, but it
 will inevitably alter the momentum of philosophy, which
 implies amongst other things, a possible change in the
 direction along which philosophy will progress in the
 near future.

OMIT

Two of the baffling mysteries which challenge
 the mind of the philosopher are space and time. Into
 what category is he to put them, and how define them?
 Newton, Leibnitz and Kant strove to clarify these terms.
 Newton took them for granted as things-in-themselves, -
 eternal, infinite, self-subsisting - a point of view that
 drew fire from Kant. Leibnitz classified them as ordinary
 concepts, to which Kant raised the objection that ordinary
 concepts have instances, whereas there is but one space and
 one time. Kant regarded space and time as the forms of
 perception, external and internal, respectively; in no
 sense things-in-themselves, yet not illusions; transcen-
 dentially ideal, but empirically real. While this critical
 sifting of words and ideas went on and on, the absolute
 Euclidean space, and "absolute, true and mathematical time"

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 space and time began to falter. The motion of the perihelion
 of Mercury's orbit refused to conform to Newtonian calcula-
 tions. Physics likewise provided food for thought - the
 earth's motion relative to the ether could not be detected,
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 function of its velocity. - This terrestrial tragedy, where
 Einstein's Theory of Relativity swept absolute space
 and absolute time from the astronomical, the physical and
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 has warned that such a procedure applied at the limits of
 the astronomical time scale is a "hair-

raising extrapolation!" ~~It is in this connection that~~
 Into the thought of many cosmologists has come the idea that what appears
 as laws of nature are relationships between phenomena which are the
 result of the same laws or physical conditions as they now are.
 The advent of non-Euclidean geometry of four dimensional
 space-time into cosmological thought has one very interesting
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Perhaps later
 MB →

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Einstein's Theory of Relativity swept absolute space and absolute time from the astronomical, the physical and the philosophical horizons. Three out of four essential tests of this theory were astronomically and it is the astronomers, naturally, who are providing the observational data that is hurrying out the frontiers of explored space to inconceivable distances. The velocity of light being finite, the astronomer is looking backward in time as he looks outward in space. How far he is justified in interpreting what he sees in the stellar universe in terms of physical laws established in a "Here-Now" environment is a question upon which it is not wise to be dogmatic. E. W. Bridgman has written that such procedure applied in the limits of the astronomical time scale is a "hair-raising extrapolation".

The advent of non-Euclidean geometry of four dimensional space-time into cosmological thought has one very interesting feature that must be mentioned. It has brought back

in a finite but unbounded universe

Copernican egocentricism in a new sense, for no point in the vastness of space has more right to be regarded as central than has any other point. In the light of present-day cosmology, every man can legitimately regard himself as the centre of the universe!

In the Dynasts, Thomas Hardy presents the Spirit of the Years hovering above the earth contemplating the doings of mankind and exclaiming "- This terrestrial tragedy," whereat the Spirit Ironic adds - "or comedy." It is only as one sees this earth in its astronomical setting and in the perspective of the astronomical time scale that it is possible to begin to evaluate and assess the record of history. Viewing thus the page upon which mankind is writing his hieroglyphics, with the long vista of the physical world stretching far out both before and after, Herbert Spencer was oppressed and the apparent unimportance and futility of much human effort weighed very heavily upon his mind.

The intolerance, superstition and barbaric savagery of so much of human behaviour not only oppressed the keenly sensitive spirit of Voltaire but goaded him into action. In one of his rapier-like efforts to tear the veil from men's eyes that they might see and act with sanity and justice instead of making this earth a hell through war, greed, and fanaticism, he conjures up a man from Sirius, and another from Saturn, in order to bring into sharp focus in its

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universal space-time setting "this terrestrial tragedy." and The Comedy
One of the greatest thinkers of our own day, General Smuts,
likewise feels the necessity for this cosmical perspective.
In his Holism and Evolution he makes it clear that a satis-
fying philosophy must bring into one field of view the
problems of the physical world, of life, of mind, and of
spirit. "In ever varying degree," he writes, "the
universe is holistic and organic through and through-----
The great values and ideals retain their unfading glory
and derive new interest and force from a cosmic setting."

Thus the mind of man traverses the whole gamut of
human experience and inquiry, and from earliest ages to
the present time philosophers and men of science alike
have appealed to reason - "Trust in reason," says
Clement of Alexandria through the pen of Dean Inge,
"which rests ultimately upon faith in the divine
Logos, the self-revealing soul of the universe."

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