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Euclid alone has looked on Beauty bare.
Let all who prate of Beauty hold their peace,
And lay them prone upon the earth and cease
To ponder on themselves, the while they stare
At nothing, intricately drawn nowhere
In shapes of shifting lineage; let geese
Gabble and hiss, but heroes seek release
From dusty bondage into luminous air.

O blinding hour, O holy, terrible day,
When first the shaft into his vision shone
Of light anatomized! Euclid alone
Has looked on Beauty bare. Fortunate they
Who, though once only and then but far away,
Have heard her massive sandal set on stone.

--- Edna St. Vincent Millay (1892-1950)

1. Adumbrations of Radiation from the Bible, Plato and Aristotle, up to Kepler

An assumption that underlies all of astrology is that there are celestial emanations, or influences, which affect what happens on our Earth. This same assumption underlies what we understand today as astronomy and physical cosmology. One has only to think of light and other kinds of radiation by means of which we detect stars and other celestial objects, and of gravitation, as well as other physical fields (or systems of particles). It is customary to say that the basis of what modern astronomers and cosmologists work with has been verified or rendered probable on the basis of observations and measurements carried out on or near earth or in spacecraft, or at least to cohere with general theories which have had some experiential confirmation. It is customary to say that the same is not true for astrology. Attempts to confirm celestial influences of the sort peculiar to astrology by means of observations, statistical analysis of data, and other methods of the sort used by the physical and other sciences, have, it appears, always failed, at least up to now, to provide convincing verification of astrological theories and predictions in the way that current astronomical and astronomical theories and observations have, at least to people who apply comparable methods of confirmation or falsification to both kinds of data and predictions.

John D. North, in an article called "Celestial Influences – the major premises of astrology" (in *'Astrologi hallucinati': Stars and the End of the World in Luther's Time*, edited by Paola Zambelli, 1986, p. 45-100), starts by discussing some passages from works of Aristotle, namely from *On Generation and Corruption*, and from the *Meteorology*. In Book 10 of the first of these, Aristotle refers to his arguments in his *Physics* to the effect that motions are the causes of what comes to be (i.e., is generated), rather than the reverse. After a discussion of consequences of this hypothesis, Aristotle says (in section 336b): "And there are facts of observation in manifest agreement with our theories. Thus we see that coming-to-be occurs as the sun approaches and decays [i.e., is corrupted] as it retreats …" (translation by H. H. Joachim, in *The Complete Works of Aristotle*, 1984, p. 551). Aristotle is referring here to the apparent back and forth motion, from a terrestrial viewpoint, of our Sun along an inclined path in the sky, the *ecliptic*, the center line (so to speak) of the zodiac, taken by Aristotle to be a circular path. From this one may infer that our Sun exerts some sort of influence on terrestrial affairs. This is not yet a proposal that there is some kind of radiation involved, but it is difficult to think of the Sun as having such an influence without it emanating something which causes the effects of such an influence. In his *Meteorology*, Aristotle speaks to this when he says: "The whole world surrounding the earth, then, the affections of which are our subject, is made up of these bodies [i.e., the elements: fire, air, water, earth] The world necessarily has a certain continuity with the upper motions [such as that of the Sun]; consequently all its power is derived from them." Here the word translated as "power" suggests an influence, or as we might now say, energy, which is transmitted from celestial objects to our Earth, as the objects move. Aristotle doesn't explicitly mention any celestial objects other than the Sun in the passage from the *On Generation and Corruption*, and North takes it (p. 46) that Aristotle need not have been claiming influences from planets, or *other* planets in ancient terminology, since astrologers customarily counted our Sun as a planet, presumably because of its apparent retrograde motion with respect to stars, or *other* stars as we would now say. However, Aristotle's argument in favor of the Sun's influences on both coming-to-be and passing-away, i.e. generation and corruption, is based in part on the apparent retrograde motion of the Sun, its apparent slipping-back along the ecliptic, and the planets known then were also seen to have apparent retrograde motions with respect to the so-called fixed stars, i.e. those visible celestial objects which exhibited no apparent retrograde motions.

This is not to say that the original source of the idea of celestial influences is to be found in Aristotle, nor, I think, does North mean to claim this. He speaks (p. 45) of the *De generatione et corruptione* (II.10) as "the fundamental text for those who tried to justify astrology in the scholastic tradition." That is, North asserts that certain medieval scholars interested in justifying astrology used Aristotle as an authority. It seems, though, that a document which can also be said to be have been fundamental for the justification, and also to some fair extent the origin, of celestial influences is the *Timaeus* of Plato, which I will now proceed to discuss in this connection. I will use the translation and commentary made by Francis M. Cornford in 1937 under the title *Plato's Cosmology, the Timaeus of Plato*, in the reprint of 1957 by The Liberal Arts Press.

In paragraphs 31B-32C (p. 43-44), Plato says: "Now that which comes to be must be bodily, and so visible and tangible; and nothing can be visible without fire, or tangible without something solid, and nothing is solid without earth. Hence the god [the Demiurge], when he began to put together the body of the universe, set about making it of fire and earth. But two things cannot be satisfactorily united without a third; for there must be some bond between them drawing them together. … Accordingly the god set water and air between fire and earth, and made them, so far as was possible, proportional to one another, so that as fire is to air, so is air to water, and as air is to water, so is water to earth, and thus he bound together the frame of a world visible and tangible." The reference to proportionality here is made on the basis of Plato's argument, which today would commonly be taken as a kind of numerology rather than a kind of mathematical physics, that the reason there are two connecting elements between the visible and tangible ones, the fire and the earth, is because there are two mean proportionals between two given cubes of whole numbers. Cube numbers are to be used, Plato says, because they relate to solids. *Note*: It is an elementary fact about integers, know to the ancient Greeks, that there is one mean proportional between two square numbers, and two mean proportionals between two cube numbers. That is, using modern methods, if p^2 and q^2 are two square numbers, then the mean proportional between them is pq, since $p^2/pq = pq/q^2$ (both equal to p/q), as for example, for 4 and 9, 4/6 = 6/9 (both equal to 2/3). If p^3 and q^3 are two cube numbers, then the two mean proportionals between them are p^2q and pq^2, since $p^3/p^2q = p^2q/pq^2 = pq^2/q^3$, as for example, for 8 and 27, 8/12 = 12/18 = 18/27 (each equal to 2/3).

Here Plato has postulated that two of the four basic elements have been used to "unite" the other two elements, forming a "bond" by "drawing them together". No doubt the original Greek could have been translated in slightly different ways, and no doubt some philologists and classicists have discussed this problem. However, interpreting Cornford's translation in the way most translations have to be interpreted, taking account of a certain degree of inevitable vagueness due not only to the translation but to the original language itself, it appears that Plato is speaking of influences which bodies which are visible because of their fire (such as stars) have on bodies which are tangible (such as earth). This is not yet radiation in the sense of traveling waves of energy, but it is a step in that direction. Plato has already stated in the *Timaeus* (30B, p. 34) that "this world came to be, by the god's providence, in very truth a living creature with soul and reason", and Cornford comments (p. 38-39): "The visible universe …is called a god (34B) in the same sense in which the term is applied to the stars, planets, and Earth – the 'heavenly gods'. All these gods are everlasting, coeval with time itself' though theoretically dissoluble, because composite of reason, soul, and body, they will never actually be dissolved (41B). Man is also composed of reason, soul, and body; but his body will be dissolved back into the elements, and the two lower parts of his soul are also mortal. Only the divine reason in him is imperishable. There is thus a contrast between macrocosm and microcosm, but also an analogy, which runs all through the discourse. The world itself, like the heavenly gods and man, is divine because it contains the divine element, reason. Reason, moreover, as Plato says here and elsewhere 'cannot be present in anything apart from soul': if it is 'present' in the body of the universe and in man's body, that body must be alive, endowed with soul, which is defined in the *Laws* and the

Phaedrus as the self-moving source of all motion. The statement is consistent with the belief that the reason, as divine and immortal, can nevertheless exist in separation from the body and divested of the mortal parts of soul. There is, then, in the soul and body of the universe a divine Reason analogous to man's, and we shall find that the unchanging movement of its thought is symbolized, or even visibly embodied, in the circular revolutions of the heavenly gods and of the universe as a whole."

From this, one might easily conclude that Plato has identified the influence which the "heavenly gods", the planets and stars, may have on earth (that which is tangible) as Reason, which operates by means of revolutions of the planets and stars, either by way of furnishing signs, or by direct causation. This, to be sure, has been made here by way of Cornford's commentary, rather than statements made by Plato, so let's see what may have led Cornford to this point of view. At paragraph 36B of the *Timaeus* (p. 73 of Cornford's translation), Plato says: "This whole fabric he [the Demiurge] split lengthwise into two halves; and making the two cross one another at their centers in the form of the letter X, he bent each round into a circle and joined it up, making each meet itself and the other at a point opposite to that where they had been brought into contact. He then comprehended them in the motion that is carried uniformly in the same place, and made the one the outer, the other the inner circle. The outer movement he named the movement of the Same; the inner, the movement of the Different. The movement of the Same he caused to revolve to the right by way of the side; the movement of the Different to the left by way of the diagonal."

In this rather obscure way, Plato is describing the ecliptic, the apparent path of the Sun from a geocentric viewpoint, with respect to the celestial equator at a given location (today we would say the celestial equator is a reference circle in the same plane as the Earth's equator). When Plato speaks of "the movement of the Same … to the right by way of the side" he is evidently referring to the apparent daily revolution of the stars from east (right) to west (left), corresponding to what we take from a heliocentric viewpoint to be the rotation of the Earth on its axis. Thus one can infer that Plato's proposal is that the celestial influence which influences mundane affairs is Reason, *logos*, and that this influence is exerted, at least in part, by way of the motions of celestial objects.

North goes on to consider views of such Stoic philosophers as Zeno of Citium, Cleanthes, and Chrysippus. (See Chapter 5 of my work *The Marriage and Divorce of Astronomy and Astrology*, on this web site). North says (p. 47-48): "In their physics as in their theology, the Stoics harmonised all with God, even to the extent of supposing God and the universe to be qualitatively identical. In proving that the universe is intelligent, Cleanthes stressed the identical character of heat in the Sun and in living things. The heat of the cosmos is not moved by another force, for there is none stronger; it is self-moved, and thus of the nature of soul. The heavenly bodies are moved by their 'sensation and divinity', not by nature nor by force, but by *will*. There are many echoes of this belief in medieval writers. The Sun was supposed by Cleanthes to be the ruling principle of the cosmos -- perhaps this is a principle somehow related to Aristotle's remarks in *De caelo* about the true centre and *archê* of the universe being at the periphery, just as an animal's heart is not at its true centre. The biological parallels in

Cleanthes are too involved for us to follow here. ... Whereas to Cleanthes the world soul was a heat permeating the cosmos, for Chrysippus ir was a permeating *pneuma* -- that which also makes man an organic, living, whole. The biological parallels are even more marked than in his predecessor's theory. As the the third century B.C. wore on, the preference shown towards the *pneuma* theory by physiologists led to the gradual decline of its predecessor. Both theories had lives of their own in medicine, of course, independently of the Stoics, in the shape of a well known antagonism between haematists and pneumatists, beginning long before the period I am discussing. (Aristophanes in the *Clouds*, for instance, indicted Socrates' pneumatism before his Athenian audiences.) These traditions with their different 'motive principles', as we may call them, cannot be very directly connected with the reasoned defences of astrology offered at a later date, but their language has much in common with the language of astrological influence."

The main body of this article by North is concerned with describing attitudes of numerous medieval thinkers about the existence and nature of celestial influences. North says of Albumasar (Abu Ma'shar), in bringing his story to the Latin West, that "There, without any doubt, the most influential writer was Abu Ma'shar (786-866 [A.D.]). Fashions came and went, but he seems to have been read and quoted constantly from the time of the translations of John of Seville and Hermann of Carinthia in the twelfth century to the decline (or at least turning native) of the subject in the seventeenth." (p. 52; see sections 34-36 of Chapter 6 of *The Marriage and Divorce of Astronomy and Astrology*). North says (p.53-55): "Albumasar (as I shall spell his name henceforth ...) began like Aristotle in noting the obvious changes on the Earth wrought by the Sun and Moon. ... Aristotle summarized what are essentially Aristotle's views on generation and corruption, adding the extra factor of a *receptivity* to planetary influences on the part of terrestrial things [i.e., not counting the Sun and Moon]. He then turned to the doctrines of *De caelo* ... to explain how *motions* in the heavens are the key to *alteration in the elements* which combine to make up natural things. ... The heavens exist in order to produce the necessary changes ... and the terrestrial world is joined with the celestial and its motions necessarily, by God's command (*iusso Dei*). The supreme circumscribing sphere, that is, the Primum Mobile, in circling the universe produces heat in it, which somehow makes the world more subtle, and changes in bodies begin to take place. ... Albumasar acknowledges two sorts of action, by contact and through a medium. In the second case, there might be voluntary action bringing contact about, through a medium, as heat through a vessel to water within. A third possibility, which he thinks applies in the case of heavenly bodies moving terrestrial ones, is where a *natural action is transmitted through an invisible intermediary*, as when a magnet attracts iron through the (invisible) air. Again there is the idea of the attracted thing being suited to receive the attraction, and perhaps here we have the source of the notion of a natural receptivity on the part of terrestrial things for the influences of celestial movements. ... In Albumasar, the effects of planetary motion, being in part, at least, rational in nature, the causes of must be rational."

With regard to present-day physics, one may naturally see lurking behind these views of Albumasar, notions of gravitation, and in this connection what is known today as *Mach's principle*. Mach says in his *Science of Mechanics* (p. 285-286 of reprint of

1960 of the 1891 (or 1907) English translation by T. J. McCormack of *Die Mechanik in ihrer Entwickelung*, 1st edn 1883, 4th edn 1901): "The comportment of terrestrial bodies with respect to the earth is reducible to the comportment of the earth with respect to the remote heavenly bodies. If we were to assert that we knew more of moving objects than this their last-mentioned, experimentally-given comportment with respect to the celestial bodies, we should render ourselves culpable of a falsity. When, accordingly, we say, that a body preserves unchanged its direction and velocity in space, our assertion is nothing more or less than an abbreviated reference to the entire universe." Of course, because of the generality of Albumasar's description, one might also think of other kinds of celestial influences -- electromagnetic radiation as detected by radio telescopes, cosmic "rays" (now regarded as particles), etc. North gives some specific details of Albumasar's explanation of the effect of the Moon on tides, after which he says (p. 59): "He might not have had the inverse square law of gravitation, but he was emphatically in direct and not retrograde motion towards that end."

North discusses Robert Grosseteste's theory of light considered as a primary celestial influence, and notes that in Grosseteste's final position on astrology as found in his *Hexaëmeron* that "he thought astrologers had failed, and must fail, because the influences they sought were so precisely focussed (if I may use this expression) in accordance with the momentary stellar configurations, that even the the most accurate astronomer would not find them. They were *real* enough." (p. 6). I have discussed some of Grosseteste's views in sections 40-48 of Chapter 6 of *The Marriage and Divorce of Astronomy and Astrology*. In section 42 of that work, I quoted North's conclusions about this final position of Grosseteste on astrology from another article by North, and in North's article being considered at present, he makes very much the same statements in this regard. As I noted in Chapter 10 of that work, it seems that the redoubtable John Dee proposed a reformation of astrology early on, based on accurate observations, for which he has often been congratulated by those who apparently take it that an important innovation in natural philosophy in the 16th and 17th centuries was concentration on experiment as opposed to theory. The situation appeared otherwise to those of us who, in the tradition of Alexander Koyré (as opposed to the tradition of Francis Bacon), believe that experimentation in natural philosophy was already emphasized by Aristotle, although usually not pursued systematically in universities, and that the scientific revolution, so far as there *was* a revolution (as opposed to an evolution), was based on theoretical changes, which led in various ways to the introduction of experimentation in natural philosophy into university settings. I proposed in section 19 of that Chapter 10 that Dee turned to the speculations found in his work *Monas hieroglyphica*, and to such techniques as conversations with angels, when he came to realize that the reforms of astrology he put forth in his earlier work, the *Propaedeumata*, were based on the possibility of observations which require more accuracy that one can hope for, even today. It appears that Robert Grosseteste had come to the same conclusion several centuries earlier. Presumably Dee, who knew some of Grosseteste's works, missed or rejected this point of view, in his earlier work. Perhaps he hoped that with instrumentation and techniques available in the 16th century, one might be able to do better than Grosseteste could envision in the 13th century.

In studying the history of theories of radiation or emission of celestial origin, the notions of *species* and *multiplication of species* are frequently met with. With regard to these terms, North says (p. 68-69): "One way and another, he [Grosseteste] did contribute a great deal to the general subject of celestial influence, rather inadvertently, through his writings on light, and his new paradigm, explaining light propagation and vision in terms of species. An alternative to the ray optics that was accepted alongside it, and that is still familiar, it is now usually regard as having been somehow the 'wrong' alternative. The concept of 'species' has been variously understood: in Augustine's *De trinitate*, for instance, it was part of a theory of human perception. The object seen gives off a likeness (species) which is perceived. Another species is given off by the first to the senses; that gives off a third species to the memory, and the third gives off a fourth to the recollection is called upon. With Grosseteste and his followers the meaning of the term was extended. It now meant the likeness of the object, regardless of the presence of a perceiving being, but it also meant the *force* or *power* by which an object acts on its surroundings. For [Roger] Bacon, even more broadly, it was the first effect of any naturally-acting thing, and *all* natural causation, for him, was attributed to the multiplication of species. This whole theory, or rather set of variant theories, gave rise to lengthy debates about what actually happens in the medium. Do the forms or species exist there? To mention only three philosophers: Averroes had said that there are forms in the medium, with an existence somehow between corporeal and spiritual existene. Albertus Magnus settled for corporeal existence. And Ockham rejected the idea of any such intermediary."

In his book *The Fire Within the Eye* (1997), David Park says on this topic (p. 101): "The word *species* was used by Augustine and other early writers as the Latin version of *eidolon*, to denote what acts on the eye to produce vision, but got Robert [Grosseteste] and his followers it was intolerable that God should have decreed more than one fundamental means of physical causation, and so species acquired a more general meaning which it kept for almost four hundred years. It was the power through which one thing acts on another, but it always had the character of light. Species are, as far as I can see, almost synonymous the *energeiai* of John Philoloponus." John Philoponus (active 520-550 A.D.) is characterized by Park (p. 71-72) as the last Greek philosopher in Egypt and one of the last Christian professors in Alexandria. John is said to have used the term *energeiai* to refer to some incorporeal substance that carries images.

North discusses at some length the views of Thomas Aquinas on celestial influences, making use of the work by Thomas Litt, *Les corps célestes dans l'univers de Thomas d'Aquin* (1963). North says (p. 75): "Aquinas was in no doubt that the celestial bodies are moved by created spirits, or separate substances, with a purely intellective life. He remained undecided over the question of whether they are united with the celestial bodies as are souls with living bodies, or are only motors to the inanimate bodies they move. Of their causal influence over the inferior world he was in no doubt, and Litt has noted more than a hundred and thirty places in Aquinas' writings where this influence is affirmed." After discussing some of the details of Aquinas' views on celestial influences, North says (p. 79-80): "Where, in all this, do the traditional theories of influence belong? What of motion and light, for example, and the 'physics' of astrology?

What of the traditional qualities of the planets, and their transmission to Earth? Aquinas was not untypical of his century in the attitudes he struck towards astrological tradition and innovation. In his *Sentences* commentary he followed something like the Grossetestian line: light (*lux*) is the active quality of celestial body just as heat is the active quality of fire, and the rays (*radii*) of different planets have different effects. They have different effects according to *their own* natures ... As for the problem of astrological prediction, it is hard to say whether he had a stronger interest [than in the Moon and tides], but he certainly spoke on many occasions of *true* predictions -- even though it was often only to attribute success to help from demons. He quoted Ptolemy's *Tetrabiblos*, but very rarely."

North also considers other medieval writers. Of Dante, North says (p. 84): "For him, every natural movement is activated by love, a 'force that unites', whether it is the love minerals may have for the place of their generation, the love of plants for their places, or the more complex love of animals, or the love that makes the magnet turn towards the pole star. It is this that marks out Dante's theory of celestial influence, if 'theory' is not too strong a term, from those that are more recognisably physical, in the modern sense."

Of John Buridan, North says (p. 86, 87): "It is clear ... that for Buridan celestial influence was not to be confused with light. He would not go along with those who had said that light from the Sun picks up heat as it passes through the sphere of fire, or with others (we recall that Grosseteste was one) who spoke as though rays emitted to the Earth's atmosphere and intersecting themselves in the air, cause it to be dispersed and rarefied and thus warmed. ... Buridan was too cautious to say much on the score of how preciseely the celestial influences work. ... He did, though, note that in their acting on things here below the heavens are not fatigued, just as the intelligences do not tire in the act of moving the heavens. This tells us a great deal about his attitude, and no doubt that of many of his contemporaries. Influences from the heavens were somehow disengaged from physical forces such as we know here on Earth. Of course it is a platitude to say that the Aristotelian philosopher thought of celestial and terrestrial regions as fundamentally different in most respects, but the influences were, after all, supposed to pass from one to the other; and it seems that for Buridan their activity was taken to be intellectual."

Of Nicole Oresme, North says (p. 90): "Bearing in mind Dante's recourse to the concept of love, to explain celestial influence, and parallels with the magnet, it is interesting to note Oresme's use of the configurations doctrine [a kind of representation of functional dependence of one quantity on another] to explain beauty, natural friendship, and hostily. It was, he said, all a matter of compatibility, or harmony of configurations. ... It is clear that Oresme thought that he had hit on an invaluable principle, giving him an insight into what previous writers had loosely described as 'harmony'. It is hardly surprising, therefore, that he extended the principle to the classic case of harmony -- as he called it, 'the figuration of celestial velocity'. The planets -- even the fixed starts, if we accept the doctrine of trepidation -- mopve with a difform velocity, as Oresme noted, and one must suppose that the velocities are 'figured properly' and 'assimilated to beautiful

figures'. 'Reason gave this harmony, as Cassiodorus says, only to the mind, nature not producing it for the ears', and 'change of this harmony or difformity can be one of the causes why sometimes heavenly bodies emit below more benign, and at other times less benign, influences'. This can be regarded as the most sophisticated reduction of celestial influence to mathematical harmony of the middle ages."

In describing works of Henry of Langenstein, North says (p. 93, 95): "Like Oresme, Henry of Langenstein was an opponent of astrology as it was practised, while believing in the causal influence by which its procedures were supposedly justified. Their strategies, though, differed in many respects. Both naturally made capital out of the iniquities and follies of astrologers, the evident inconsistencies in their procedures, and the theological dangers they courted. Henry's attack, however, had a potentially more trenchant effect, for he set out a rather complicated theory of causation that, had it been accepted by astrologers, would have implied a drastic revision of their procedures. In effect he told them to give their attention to the terrestrial end of the process of celestial causation, to the terrestrial objects from which were elicited effects already present. ...The one form of astrological prediction that Henry of Langenstein felt to be reasonably secure was meteorological astrology. This subject, in keeping with Aristotle's ideas about their terrestrial origin, included the theory of comets, but here Henry drew the line, and his *Quaestio de cometa* comes down as heavily against predictions based on the appearance of the comet of 1368 as his later tract against the astrologers was to do."

To ask about the nature and workings of celestial influences in connection with astrology is to ask by what means stars and planets act on humans and their affairs. There are some celestial influences which unquestionably act on humans. For example, the sun furnishes light and heat, the moon effects tides and appears to be correlated with female menstrual cycles, we now know that there are gravitational effects which might act on human affairs in some way, and so on. We also now know about various other kinds of radiation which may directly or indirectly affect humans or their affairs -- cosmic rays, for example. One may wonder about celestial influences on terrestrial magnetism.

In the *Timaeus*, after discussing his theory of how our eyes and vision work, Plato says: " Enough, then, of the secondary causes that have contributed to give the eyes the power they now possess; we must next speak of their highest function for out benefit, for the sake of which the god has given them to us. Sight, then, in my judgment is the cause of the highest benefits to us in that no word of our present discourse about the universe could ever have been spoken, had we never seen stars, Sun, and sky. But as it is, the sight of day and night, of months and the revolving years, of equinox and solstice, has caused the invention of number and bestowed on us the notion of time and the study of the nature of the world; whence we have derived all philosophy, than which no greater boon has ever come or shall come to mortal man as a gift from heaven. This, then, I call the greatest benefit of eyesight ... the god invented and gave us vision in order that we might observe the circuits of intelligence in the heaven and profit by them for the revolutions of our own thought, which are akin to them, though ours be troubled and they are unperturbed; and that, by learning to know them and acquiring the power to compute

them rightly according to nature, we might reproduce the perfectly unerring revolutions of the god and reduce to settled order the wandering motions in ourselves." (translated by Francis M. Cornford in *Plato's Cosmology*, p. 157-158). Thus Plato attributes to our ability to see the stars in their courses the very invention of numbers, our acquisition of the notion of time, the initiation of our study of the world, and indeed all of philosophy, by which I take it Plato meant all we know about our world.

Plato proposed, in his theory of vision, that our eyes emit light which interacts with light outside us, such as that given by the planets and stars, and by fire of various kinds. He says in the *Timaeus* (loc. cit., p. 152-153): "First of the [human] organs they [the gods] fabricated the eyes to bring us light, and fastened them there for the reason which I will now describe. Such fire as has the property, not of burning, but of yielding a gentle light, they contrived should become the proper body of each day. For the pure fire within us is akin to this, and they caused it to flow through the eyes, making the whole fabric of the eye-ball, and especially the central part (the pupil), smooth and close in texture, so as to let nothing pass that is of coarser stuff, but only fire of this description to filter through pure by itself. Accordingly, whenever there is daylight round about, the visual current issues forth, like to like, and coalesces with it and is formed into a single homogeneous body in a direct line with the eyes, in whatever quarter the stream issuing from within strikes upon any object it encounters outside. So the whole, because of its homogeneity, is similarly affected and passes on the motions of anything it comes in contact with or that comes into contact with it, throughout the whole body, to the soul, and thus causes the sensation we call seeing." Thus in Plato's theory of vision, our eyes are not just passive receptors of light, but emit a kind of light, or "pure fire" which interacts with light around us.

In his book *The Fire Within the Eye, A Historical Essay on the Nature and Meaning of Light* (1997), David Park quotes part of this passage from the *Timaeus* (in a different translation), and says of Plato's theory of vision (p. 39-40): "Evidently the process of vision requires a very complicated action in the observer, whose body receives particles of different sizes, associates them with the direction of the eyebeam's gaze, decodes messages of shape and color, and delivers the information to the mind. No wonder our eyes so often deceive us. The rainbow is an illusion; it seems very large and very close; yet it is not there. Mirrors that are not flat give crazy images, and everyone has heard about mirages even if they have not seen one. The only source of clear truth, for Plato, is contemplation of the unchanging world of ideas, with the soul as an eye and the Good as the source of light. Much later, medieval treatises on optics recall this conviction as they spend a surprising amount of their space on illusions."

Among the most influential proponents of light as a principal source of the influence of celestial bodies on humans and their affairs has been Alkindi (Al-kindi, Yaqub ibn Ishaq al-Kindi, c. 801-866 A.D.). Of him, Park says that in his book *De radiis stellarum (On Radiations from the Stars*; there is a translation into English by Robert Zoller called *On Stellar Rays*, 2000), Alkindi "shows that for him astrology was more philosophical than practical, a study of the celestial order rather than a way of reading the future. ... I [Park] think it [Alkindi's theory] ministered to the religious sense that behind

the world's chaos and suffering there is some unity, that merciful God has planned some good end to the confusion, simply because the world is One, and One must in the end be good." (loc. cit., p. 73, 75).

Alkindi says of certain unnamed wise men that, "looking up, they saw certain conditions of the many stars and they especially sought to investigate and know which of the seven planets' properties were more well-disposed than the others, for they had proved by long experience that they were the especial stewards of the world. They acquired undoubting faith, through sense, that the arrangement of the stars ordered the world of the elements and all things in it which are composed of them, comprehended in every time and place and that therefore no substance subsists here which is not figured in heaven in its own manner and that this happens by the rays of the same stewards sent down into the world is not to be doubted." (Zoller translation). Thus Alkindi proposes that the world is made orderly by radiation from the stars -- celestial influences, he says, are forms of radiation. These rays are said to be of a different natures for different celestial bodies. Alkindi goes further with his theory of influences of radiation, proposing that terrestrial influences also act by means of rays, albeit these are induced by celestial rays. For example, he says: "Now, therefore, since the world of the elements is the exemplum of the sidereal world so that each thing contained in it contains the figure of the same [i.e., of the sidereal world], it is manifest that every thing of this world, whether it be substance or accident, makes rays in its own way like a star -- otherwise it would not have the figure of the sidereal world to its fullest." (loc. cit.)

Alkindi indicates a rudimentary mathematics of such rays. He says: "In particular, the distance of one thing from another makes a difference in the effect of its rays on the things of this world. Likewise, a place more or less distant from the centre of the earth makes a difference in the effect of the rays on neighboring bodies. Likewise, the greater or lesser obliquity of the aspect produces a difference in the effect of the rays. There are, perhaps, other accidents that induce diversity in the effects of the rays of the elements. ... But this ought to be attended to, namely that certain rays are stronger in some effect and weaker in others. Likewise, certain are much much aided in their effect by other rays of another species, but some are aided little by others." (loc. cit.) Alkindi does not single out light as the principle source of celestial influence, and indeed only tacitly refers to light. He does speak explicitly of rays of heat, and rays of cold. He also develops a rather elaborate theory of the influence of words and other sounds as acting by means of rays, and also of figures and images working in this way. The latter presumably involve light in some way, as when he says: "Images of men and of diverse species of animals are also made with the observation of places, times and of other ceremonies, which having been ceremonially brought forth into actual existence by the work of man according to the theme [said by Zoller to refer to positions of celestial objects, or horoscope, of the sky at a given moment] joins some effect of motion of the One intending into the things, promoting or prohibiting [them], the celestial harmony informing the image so made through the projection of its rays." (loc. cit.)

I take it that Alkindi is asserting that celestial objects impose on the world and us, by means of radiations, harmonious schemes which depend on the positions of the celestial

objects and their different kinds of radiations and compositions of these radiations. This is not to say that Alkindi denies operations of free will which can modify these imposed schemes. For example, he says: "Moreover it is good to know that the stars and signs [constellations?] having dominion in the celestial harmony of any work of [free] will [*operis voluntarii*] rule that operation all the way to its end. Whence, if they fortunes [presumably, good acts of will], they defend that operation from impediment. But is they were infortunes [bad or incongruent acts of will], they involve the operation with impediment. And since each star and sign has it own proper names and their own characters conforming to them in virtue and effect, as has been said, their expression in the beginning of any work of will is necessary If they were naturally concordant with the stars or signs they direct the work; but if discordant, they pervert the work." (loc. cit.)

Prominent among medieval thinkers who promoted light as the primary mode of radiation, from the standpoint of natural philosophy, was Robert Grosseteste (c. 1170 or 1175-1253). Of him, David Park says: "Robert has read Alkindi and continues the thought that binds the world in a web of radiation. What was there before God's command "Let there be light" started the process that created our world? Moses tells us that something was there, but if it was matter it lacked all the qualities of matter; this means it did not even occupy space. Before it could assume any qualities of the matter that makes up the world it had to do that. It needed to acquire what Grosseteste calls corporeity, the first bodily form. And this form, he says, is light ..." Grosseteste writes in his work *De luce* (*On light*): "The first corporeal form which some call corporeity is in my opinion light. For light of its very nature diffuses itself in every direction in such a way that a point of light will produce instantaneously a sphere of light of any size whatsoever, unless some opaque object stands in the way. Now the extension of matter in three dimensions is a necessary concomitant of corporeity, and this despite the fact that both corporeity and matter are in themselves simple substances lacking all dimension. But a form that is in itself simple and without dimension could not introduce dimension in every direction into matter, which is likewise simple and without dimension, except by multiplying itself and diffusing itself instantaneously in every direction and thus extending matter in its own diffusion. ... I say that light through the infinite multiplication of itself equally in all directions extends matter on all sides equally into the form of a sphere and, as a necessary consequence of this extension, the outermost parts of matter are more extended and more rarefied than those within, which are close to the center. And since the outermost parts will be rarefied to the highest degree, the inner parts will have the possibility of further rarefaction. In this way light, by extending first matter into the form of a sphere and by rarefying its outermost parts to the highest degree, actually completely in the outermost sphere the potentiality of matter, and left the matter without any potency to further impression." (translation of *De Luce* in *Robert Grosseteste On Light or the Beginning of Forms* by Clare C. Riedl, 1942, p. 10, 13).

Shades of 20th century theories of the creation of our universe with a Big Bang! However, Grosseteste goes on to say: "And thus the first body in the outermost part of the sphere, the body which is called the firmament, is perfect, because it has nothing in its composition but first matter and first form. ... When the first body, which is the firmament, has in this way been completely actualized, it diffuses its light (*lumen*) from

every part of itself to the center of the universe. For since light (*lux*) is the perfection of the first body and naturally multiples itself from the first body, it is necessarily diffused to the center of the universe. And since this light (*lux*) is a form entirely inseparable from matter in its diffusion from the first body, it extends along with itself the spirituality of the matter of the first body. Thus there proceeds from the first body light (*lumen*), which is a spiritual body, or if you prefer, a bodily spirit." (loc. cit., p. 13) Grosseteste proceeds to sketch a theory of how thirteen spheres are generated by a process in which light (*lumen*) generates additional spheres in such a way that "light (*lux*) which is simple in the first sphere is doubled [duplicated?] in the second", and so on, so that "In this way, therefore, the thirteen spheres of this sensible world are brought into being. Nine of them, the heaven spheres, are not subject to change, increase, generation or corruption because they are completely actualized. The other four spheres have the opposite mode of being, because they are not completely actualized. ... The form (*species*) and perfection of all bodies is light, but in the higher bodies it is more spiritual and simple, whereas in the lower bodies it is more corporeal and multiples. Furthermore, all bodies are not of the same form (*species*) even though they all proceed from light, whether simple or multiplied, just as all numbers are not the same in form (*species*) despite the fact that they are all derived from unity by a greater or lesser multiplication." (loc. cit., p. 14, 15). It appears that while what is translated as "multiplication" in *De luce* might well have been translated sometimes as "propagation", Grosseteste sees some sort of analogy between the generation of whole numbers from the number one by what we would call addition, and the propagation of rays of light. In this connection, it seems that Grosseteste hedges on the speed with which light is propagated, infinite or finite, when he says "This light (*lumen*), in its passing does not divide the body through which it passes, and thus it passes instantaneously from the body of the first heaven to the center of the universe. Furthermore, its passing is not to be understood in the sense of something numerically one passing instantaneously from that heaven to the center of the universe, for this is perhaps impossible, but its passing takes place through the multiplication of itself and the infinite generation of light (*lumen*)." (loc. cit., p. 13-14)

In his book *Grosseteste and Experimental Science* (1953, 2nd impression 1962), A. C. Crombie stresses Grosseteste's devotion to the use of mathematics in natural philosophy, especially in his Chapter 5 called "Mathematical Physics". Crombie quotes there a passage from Grosseteste's commentary on Aristotle's *Posterior Analytics* in which Grosseteste says "the substance of sound is light (*lux*) incorporated in the most subtle air, and when the sounding body is struck violently parts of it are separated from their natural position in the whole sounding body. ... For every natural body has in itself a celestial luminous nature and luminous fire, and the first incorporation of it is in the most subtle air. Hence, when the sounding body is struck and vibrating, a similar vibration and similar motion must take place in the surrounding contiguous air, and this generation progresses in every direction in straight lines." (p. 114). Crombie comments that "This passage contains what was perhaps the first attempt to explain the rectilinear propagation of light as a succession of waves or pulses analogous to sound and, taken together with Grosseteste's other applications of mathematical aspects of *lux*, it foreshadowed in a striking manner a methodological principle on which much of modern mathematical physics, particularly since the seventeenth century, has been based." (p. 115)

In Part Two of his work *The Philosophy of Robert Grosseteste* (1982), James McEvoy discusses the considerable influence of Augustine on the philosophical and theological views of Robert Grosseteste. Augustine wrote in his *De civitate Dei (City of God)*, in Chapter 7: "We see, indeed, that our ordinary days have no evening but by the setting, and no morning but by the rising, of the sun; but the first three days of all were passed without sun, since it is reported to have been made on the fourth day. And first of all, indeed, light was made by the word of God, and God, we read, separated it from the darkness, and called the light Day, and the darkness Night; but what kind of light that was, and by what periodic movement it made evening and morning, is beyond the reach of our senses; neither can we understand how it was, and yet must unhesitatingly believe it. For either it was some material light, whether proceeding from the upper parts of the world, far from our sight, or from the spot where the sun was afterward kindled; or under the name of light the holy city was signified, the city of which the apostle says, "Jerusalem which is above is our eternal mother in heaven;" and in another place, "For ye are all the children of the light, and the children of the day; we are not of the night, nor of darkness." (translated by Marcus Dods). This suggests an origin for Grosseteste's distinction between two kinds of light, *lumen* and *lux*, which we saw above in the extracts from his *De luce*. McEvoy comments: "The entire process of creation is represented by Augustine as a granting of light and illumination. The Word is eternal, spiritual light, physical creation is corporeal light or form, and the illumination of intelligence by the Word perfects the luminous angelic nature by direct impression as well as by reflection from the lower creation." (p. 59). For Grosseteste, *lumen* is spiritual, non-material light, and *lux* is corporeal or material light. In the passage from the *City of God*, Augustine continues: "Yet in some respects we may appropriately speak of a morning and evening of this day also. For the knowledge of the creature is, in comparison of the knowledge of the Creator, but a twilight; and so it dawns and breaks into morning when the creature is drawn to the praise and love of the Creator; and night never falls when the the Creator is not forsaken through love of the creature." However, it can be noted that the distinction between *lux* and *lumen* changed over time. For example, in his book *All Was Light, An Introduction to Newton's Opticks* (1993), A. Rupert Hall says (p. 22): "[Isaac] Barrow [in 1669] repeated the old distinction between *lux* (that which reaches the eye directly from the luminous source) and *lumen* (the light reflected, scattered, or otherwise affected by interaction with bodies before it reaches the eye) ... ". Here there is no mention of a distinction between spiritual and physical light.

In Part 3 of his book, McEvoy studies Grosseteste's physical system, especially in order to compare it with that of Aristotle. McEvoy notes that Grosseteste's theory of corporeity has roots in work of Arabic and Jewish scholars, notable Avicenna (Ibn Sina), Algazel (Al-Gazzali), and Averroes (Ibn Rushd), who were in turn influenced by certain earlier Neoplatonic scholars. (loc. cit., p. 160-161) On p. 162, McEvoy observes that Aristotle's authority "is invoked to lay the first basis for the mathematical discussion of infinity, namely that the multiplication of a simple thing cannot generate a quantity. Grosseteste then asserts on his own initiative that an infinite multiplication of a simple thing will produce a finite quantity." (p. 162). In this connection, McEvoy summarizes some mathematical assertions of Grosseteste made in *De luce*, which McEvoy says "appear to be orignal mathematical propositions on relative infinities." (p. 152). McEvoy

says: "Light multiplied itself from a single point infinitely and equally on all sides to form a sphere, and extended matter into the dimensions of the actual universe. Two questions arise: why was an infinite multiplication of light required? And if infinite, why did it produce a finite universe? To the first: a simple thing multiplied a finite number of times cannot generate quantity, by the authority of Aristotle in *De Caelo et Mundo.* To the second: a simple thing multiplied by infinity can produce only a finite quantity. One simple thing cannot exceed another infinitely, but a *finite* thing exceeds a *simple* thing infinitely, whereas an infinite quantity would exceed a simple thing by infinity times infinity. Light, therefore, a simple thing infinitely multiplied, must extend matter (similarly a simple thing) into *finite* dimensions." (p. 152)

In a footnote to this, McEvoy says: "Alexander Birkenmajer, in his article 'Robert Grosseteste and Richard Fournival', *Med. Human.* 5 (1948), p. 39, n. 15, gives a symbolic formulation of the mathematical propositions, which, as he points out, 'are not to be judged from the standpoint of Algebra nor from that of Cantor's Theory of Sets." This is correct, but there is another standpoint from which it can be judged. In 1966, the mathematician Abraham Robinson published a work called *Non-Standard Analysis* in which a system, in mathematical terms a kind of linearly ordered non-Archimedean field, is defined and elaborated in which there are not only transfinite or infinitely large numbers of the sort Georg Cantor worked with, but also infinitesimals or infinitely small numbers (which Cantor claimed could not be used -- he once compared them to germs). Since the system has the structure of an algebraic structure that mathematicians call a *field* (different from a *field* as the term is used on physics!), operations of addition, subtraction, multiplication and division analogous to those for ordinary (standard) numbers are possible. If we interpret a *simple* thing to be a kind of infinitesimal (e.g. in a non-standard number system of the kind introduced by Abraham Robinson), it is indeed the case that the sum or product of simple things will again be infinitesimals, and never a finite (ordinary) number. Furthermore, it is the case that a finite thing (number) can be sensibly said to exceed an infinitesimal (simple thing, i.e. number) infinitely, and that an infinite quantity, i.e. an infinitely large non-standard number, can be said to exceed a simple by what one may call "infinity times infinity", meaning that as every finite number exceeds any infinitesimal number, so also does every infinitely large number exceed any finite number. In such a system, the infinitely large and infinitely small numbers are inverses of one another, in the manner that the number 2 is the inverse of the number 1/2 (the product of these is the number 1).

Other systems of this sort had been constructed before that of Robinson, but were unwieldy and not widely known. On these systems, one can see, for example, the following articles published by me: "Cauchy and the Infinitely Small", *Historia Mathematica*, v 5, 1978, p 313-331; "Cauchy's Variables and Orders of the Infinitely Small", *British Journal for the Philosophy of Science*, v 30, 1979, pp. 261-265; "The Infinite and Infinitesimal Quantities of du Bois-Reymond and their Reception:, *Archive for History of Exact Sciences*, v 24, 1981, p 101-164; article called "Veronese's non-archimedean linear continuum", p 107-145 in a book edited by Paul Ehrlich called *Real Numbers, Generalizations of the Reals, and Theories of Continua*, 1997.

In Part 3 of his work, McEvoy gives an extended analysis of the mathematical foundations of Grosseteste's work in natural philosophy. In connection with our present topic, the role of celestial influences in astrologies, McEvoy notes Grosseteste's "early attachment to astrology, unselfconsciously and unambiuously proclaimed in a series of his works from *De Artibus Liberalibus* up to the *De Cometis*. He accepted unreservedly the belief that the stars (including the planets) act upon the world in virtue of qualities -- hot and cold, dry and wet -- which they share with the elements [fire, air, earth, water], and he drew the only possible conclusion, namely, that even though the spheres [the carriers of the stars] may be quintessential [composed of the fifth element, the *ether*], never the less 'in the making of stars there is no maing of new matter, *ergo* they are made from the matter of the elements, and proceed from a different act of creation than do their spheres, not being of uniform matter with these." (p. 181)

Nevertheless, McEvoy argues in Part 3 that Grosseteste strove to eliminate Aristotle's distinction between the compositions of the sublunar and heavenly parts of the world. McEvoy says: "that radical principle, the *lux* or first corporeal form, made essentially one physical system out of what for Aristotle had been two separate ones, for it abolished the difference in principle whereby the higher universe was thought to be of an essentially different stuff from the earth. ... In asserting the unity of matter throughout the universe, blurring the difference between heaven and earth, and adumbrating the advent of a unified physical system, Grosseteste opened a radical breach in the theory of Aristotle. Later medieval critics, as is well known, were not slow to follow him through. William of Ockham seems to have been the first thinker of the fourteenth century to deny that the heavens and the sublunary world differ fundamentally in the matter and in their laws. and Jean Buridan enlarged to scope of this challenge by extending the concept of *impetus* from terrestrial into celestial mechanics. Oresme and Nicholas of Cusa further encouraged the homogenization of the cosmos: for the latter, sun and earth have *quasi* the same matter and perfection." (p. 187-188) It appears that even late in his life, Grosseteste retained a belief in celestial influences on human beings and their affairs, although he was concerned to play down the effects of such influences, in connection with the weakness of these influences as compared with human free will.

McEvoy summarizes Grosseteste's late views expressed in a work called the *Hexameron*: "Astrologers claim that the states and passions of the soul fall within the domain of prediction of their pseudo-science [presumably "pseudo-science" is McEvoy's characterization, not Grosseteste's]. Can they not be made [says Grosseteste] to understand that the body is subject both to impressions of the stars and to the actions of the soul; that when the soul is obedient to God in its proper activities, these allow it to command the body and to overrule th weaker influence of the heavenly bodies; that to Saturn's or Mar's action on the blood, conditioning the moods of sadness or anger, the well-ordered soul can oppose its resistance and, retaining its tranquility, do, dominate the physical disturbance of blood and spirits, which, when it so wishes, it can so much more easily inflame to anger, than can a planet's far-off action? If the mind is in order, neither it nor its passions, nor yet the affections of the body, fall within the domain of astrology."

Grosseteste was a cleric, and as bishop of Lincoln in England, acted as a Christian official. In his theories about light, he was guided by the Bible. The most salient passage about light occurs at the very beginning of the Christian Old Testament, the Torah, which reads in English translation in the King James Authorized Version of 1769: "1. In the beginning God created the heaven and the earth. 2. And the earth was without form, and void; and darkness *was* upon the face of the deep. And the Spirit of God moved upon the face of the waters. 3. And God said, Let there be light: and there was light. 4. And God saw the light, that *it was* good: and God divided the light from the darkness. 5. And God called the light Day, and the darkness he called Night. And the evening and the morning were the first day." After creating heaven and the dry land, earth, God created special lights: "14. And God said, Let there be lights in the firmament of the heaven to divide the day from the night, and let them be for signs, and for seasons, and for days, and years: 15. And let them be for lights in the firmament of the heaven to give light upon the earth: and it was so. 16. And God made two great lights; the greater light to rule the day, and the lesser light to rule the night: *he made* the stars also. 17. And God set them in the firmament of the heaven to give light upon the earth, 18. And to rule over the day and over the night, and to divide the light from the darkness: and God saw that *it was* good. 19. And the evening and the morning were the fourth day."

So on the first day of creation, God spoke light into existence, and on the fourth day, he created the light of the sun and moon and stars. This appears to be an ultimate source for the distinction between light as *lumen*, a spiritual light, and light as *lux*, a physical light. In his *City of God*, Augustine gives his explanation of the two kinds of light, and how one can understand that creation of the sun and other stars occurred on the fourth day of creation, and was not involved in the creation of light on the first day of creation. There are a number of verses in the Psalms which suggest an intimate connection between God and light. For example, in Psalms 36:9, we read "For with thee *is* the fountain of life: in thy light shall we see light." In Psalms 43:3, we have "O send out thy light and thy truth: let them lead me ..." Psalms 139:11, 12 reads: "11. If I say, Surely the darkness shall cover me; even the night shall be light about me. 12. Yea, the darkness hideth not from thee; but the night shineth as the day; the darkness and the light *are* both alike *to thee*." In Isaiah 60:19, 20, we read: "19. The sun shall be no more thy light by day; neither for brightness shall the moon give light unto thee: nut thje LORD shall be unto thee an everlasting light, and thy God thy glory. 20. The sun shall no more go down; neither shall thy moon withdraw itself; for the LORD shall be thine everlasting light, and the days of thy mourning shall be ended." Daniel 2:22 has: "He revealeth the deep and secret things; he knoweth what *is* in the darkness, and the llight dwelleth with him." In the Christian New Testament, in John 1:1-5, we have an echo of the beginning of the book of Genesis: "In the beginning was the Word, and the Word was with God, and the Word was God. 2. The same was in the beginning with God. 3. All things were made by him; and without him was not any thing made that was made. 4. In him was life; and the life was the light of men. 5. And the light shineth in darkness; and the darkness comprehended it not." Again, in 8:12 of the book of John, we have: "Then spake Jesus again unto them, saying, I am the light of the world; he that followeth me shall not walk in darkness, but shall have the light of life.". John 9:5 says: "As long as I am in the world, I am the light of the world.". John 12:46 has: "I am come a light into

the world, that whosoever believeth in me should not abide in darkness." Most pointed of all are the words of 1 John 1:5: "This then is the message which we have heard of him, and declare unto you, that God is light, and in him is no darkness at all." Finally, Revelation 22:5 has: "And there shall be no night there; and they need no candle, neither light of the sun; for the Lord God giveth them light; and they shall reign for ever and ever."

Another influence on Grossteste's theory of emanation, directly or indirectly by way of Arab writers, was the work of Plotinus (204-270 A.D.), commonly regarded as the founder of the intellectual movement called Neoplatonism. For example, in the fifth of his six *Enneads*, written in 250 A.D., Plotinus says (section 2): "How life was purveyed to the universe of things and to the separate beings in it may be thus conceived: ... As the rays of the sun throwing their brilliance upon a lowering cloud make it gleam all gold, so the soul entering the material expanse of the heavens has given life, has given immortality: what was abject it has lifted up; and the heavenly system, moved now in endless motion by the soul that leads it in wisdom, has become a living and a blessed thing; the soul domiciled within, it takes worth where, before the soul, it was stark body -- clay and water -- or, rather, the blankness of Matter, the absence of Being, and, as an author says, 'the execration of the Gods.' The Soul's nature and power will be brought out more clearly, more brilliantly, if we consider next how it envelops the heavenly system and guides all to its purposes: for it has bestowed itself upon all that huge expanse so that every interval, small and great alike, all has been ensouled. The material body is made up of parts, each holding its own place, some in mutual opposition and others variously independent; the soul is in no such condition; it is not whittled down so that life tells of a part of the soul and springs where some such separate portion impinges; each separate life lives by tyhe soul entire, omnipresent in the likeness of the engendering father, entire in unity and entire in diffused variety. By the power of the soul the manifold and diverse heavenly system is a unit: through soul this universe is a God: and the sun is a God because it is ensouled; so too the stars: and whatsoever we ourselves may be, it is all in virtue of soul; for 'dead is viler than dung.' " (*The Six Enneads*, translated by Stephen Mackenna and B. S. Page, 1956)

Again, in section 6 of the fifth Ennead, Plotinus writes: " ... from such a unity as we have declared The One to be, how does anything at all come into substantial existence, any multiplicity, dyad, or number? Why has the Primal not remained self-gathered so that there be none of this profusion of the manifold which we observe in existence and yet are compelled to trace to that absolute unity? ... Everything moving has necessarily an object towards which it advances' but since the Supreme can have no such object, we may not ascribe motion to it: anything that comes into being after it can be produced only as a consequence of its unfailing self-intention; and, of course, we dare not talk of generation in time, dealing as we are with eternal Beings: where we speak of origin in such reference, it is in the sense, merely, of cause and subordination: origin from the Supreme must not be taken to imply any movement in it: that would make the Being resulting from the movement not a second principle but a third: the Movement would be the second hypostasis. Given this immobility in the Supreme, it can neither have yielded assent nor uttered decree nor stirred in any way towards the existence of a secondary.

What happened then? What are we to conceive as rising in the neighborhood of that immobiliity? It must be a circumradiation -- produced from the Supreme but from the Supreme unaltering -- and may be compared to the brilliant light encircling the sun and ceaselessly generated from that unchanging substance. All existences, as long as they retain their character, produce -- about themselves, from their essence, in virtue of the power which must be in them -- some necessary, outward-faving hypostasis continuously attach to them and representing in image the engendering archetypes: thus fire gives out its heat; snow is cold not merely to itself; fragrant substances are a notable instance; for, as long as they last, something is diffused from them and perceived wherever they are present. Again, all that is fully achieved engenders: therefore the eternally achieed engenders eternally an eternal being." (loc. cit.).

In his book *Roger Bacon's Philosophy of Nature* (1983, p. xxxix), David Lindberg notes that Augustine may be regarded as having developed a synthesis of Christianity and Neoplatonism in which light was a central element. Since Augustine was a major source for Grosseteste's thought, we may take it that Plotinus and other Neoplatonists had a major influence on Grosseteste.

A famous follower of Robert Grosseteste was Roger Bacon (c 1214-1294). Of him, David Lindberg says that "Grosseteste's influence is every where evident in his works." (loc. cit., p. liv). One among several works in which Bacon considers theories of radiation is his *De multiplicatione specierum (On the multiplication of species)*, written, Lindberg says, no later than about the mid 1270s. As to the significance of the title, Lindberg says (p. liv-lvi): "Before examining Bacon's physics of light, we must briefly consider the term 'species', by which he denotes the effect of an agent. The primitive meaning of the term ... was that of aspect, form, or exterior appearance. During the Middle Ages various shifts and refinements occurred. As early as Augustine, we see the term used for psychological purposes, to denote the image or likeness of a perceived object in the senses and the intellect -- the agent by which a thing is perceived. Augustine argues in *De trinitate* [xi.9, translated by McKenna, quoted by Lindberg] that a corporeal object gives rise to an incorporeal likeness, a species, in both the external and internal senses: 'In this arrangement, therefore, when we begin with the species of the body, and finally arrive at the species which is formed in the gaze of thought, four species are found; they are born, as it were, step by step, one from the other: the second from the first, the third from the second, and the fourth from the third. For the species of the body, which is perceived, produces the species which arises in the sense of the percipient; this latter gives rise to the species in the memory; finally, the species in the memory produces the species which arises in the gaze of thought. The species, too, of the man is known to us in ourselves, and is likewise presented to the senses of the body from without in other men: to the eyes when it is seen; to the ears when it is heard; to the touch when it is held and touched; it also has its own image in our mind, incorporeal it is true, but yet similar to the body.' But with Grosseteste and Bacon, there is a significant broadening of the term's meaning. No longer does 'species' apply merely to the perceptual realm; now it denotes the likeness of any object, emanating from the object, whether or not a percipient being is present to receive it. Indeed, the term 'likeness' is no longer an adequate translation; the species is, of course, the similitude of the object from which it emanates,

but it is more than that; it is the force or power by which any object acts on its surroundings. In short, the term has been appropriated by Grosseteste and Bacon to denote al-Kindi's universal force, radiating from everything in the world toproduce effects. ... Bacon develops the idea much more extensively [than Grosseteste did] in the first chapter of his *De multiplicatione specierum*. 'Species', he says, 'is meant to designate the first effect of any naturally-acting thing.' This first effect has different names in different contexts [says Bacon]: 'It is called 'similitude' and 'image' with respect to the thing generating it, to which it imitates. It is called 'species' with respect to sense and intellect. ... It is called 'idol' [reflection?] with respect to mirrors. ... it is called 'phantasm' and 'simulacrum' in the apparitions of dreams. ... It is called 'form' by Alhazen. ... It is is called 'intention' by the multitude of naturalists because of the weakness of its being in comparison to that of the thing itself. ... It is called 'virtue' with respect to generation and corruption [as in saying that something has lost its virtue, or power]. ... It is called 'impression' because it resembles impressions. ... It is called 'passion' because the medium and sense, in receiving species, undergo a transmutation in their substance ... ['passion' in the sense of 'the state or capacity of being acted on by external agents or forces', Merriam-Webster online dictionary]. [A species then] is the first effect of an agent; for all judge that through species [all] other effects are produces.' [end quote from Bacon, as quoted by Lindberg]. Lindberg concludes (p. lvi) that "It is apparent that Bacon attributes all natural causation to the multiplication of species." We may say, I take it, that it won't be too anachronistic to say that by multiplication of species, Bacon meant different kinds of radiation, including effects of such radiation on things.

Note: The Arab (Iraqi) Alhazen (Ibn Al-Haytham) (c. 965-c. 1041 A.D.), mentioned above, wrote an influential treatise on on the nature of human vision known to medieval European philosophers such as Roger Bacon. Books I-III of this work (there were seven books) are available in an English translation by A. I. Sabra under the title *The Optics of Ibn Al-Haytham* (1989). There were seven books. Books I-III deal with problems of rectilinear vision, IV-VI with vision by reflection, and VII with refraction (Sabra, v. 2, p. lx). A notable feature of this work is Alhazen's theory that human vision involves combining the idea that visual perception can be accounted for in terms of 'forms' received in the eye, with earlier theories, espoused by Euclid, Galen and others. that the visible appearances of objects can be explained by means of 'visual rays' assumed to go forth from the eye. (v. 2, p. liv). Sabra observes (v. 2, p. lx) that "It is clear beyond doubt that I. H.'s [Ibn al-Haytham, Alhazen's] *Optics* took its starting point from the work nine hundred years earlier by Ptolemy. This was fortunate, for, as far as is known, Ptolemy's *Optics* was the most complete mathematical and experimental study of vision ever to have been produced before I. H.'s time, and by basing his own approach on it, I. H. was continuing the best approach to the subject that had been provided by Greek science."

Despite the fact that Ptolemy was interested in applying his optical theories to astronomical and astrological matters, the *Optics* of Alhazen contains little on relations between celestial and terrestrial influences. However, in his commentary, Sabra describes a work by Alhazen called *On the Light of the Stars*. Sabra says (v. 2, p. xli): "I. H. [Alhazen] sets out to refute the opinion of 'certain philosophers' ... who thought it

possible ... that the stars (viz. the fixed stars and the five planets) may derive their light from the sun, as is the case with the moon. Arguing mainly from the observation that those stars (unlike the moon) always exhibit the bright shape of a complete circle regardless of their positions in their orbits or in relation to the sun, and regardless of the location of the observer, he concludes that the stars emit light by virtue of a property inherent in their substance. The moon is thus unique among heavenly bodies in being the only one that shines with a light borrowed from another heavenly body." Also, Sabra observes (v. 2, p. lv) that "Nowhere in the *Optics* does I. H. expound a theory of the *nature* of light." Alhazen did write a short work called *Discourse on Light* in which he distinguishes between (1) inquiring about the essence or nature of light, including the nature of transparency and of rays of light, which belongs to natural science (natural philosophy, physics), and (2) concern with such things as the shapes of rays or the manner in which rays extend themselves in transparent bodies, said to belong to mathematical science (geometry) (p. li). In this connection, Sabra observes (p. lii) that Alhazen proposes in this work that "There are two classes of transparent body: one is identical with the heavenly sphere, and the other consists of a group of simple and composite sublunar bodies such as air, water, glass and crystal. The latter group, though capable of transmitting light, are endowed with a certain degree of opacity which allows some of the light to be fixed in them, and it is from this fixed light (rather than from the traversing light) that secondary light emanates in *all* directions. Can the same be said of the celestial Sphere? I. H. answers this question in the affirmative, maintaining with 'the mathematicians' that no perfectly transparent body exists, while agreeing with Aristotle that the Sphere is actually the most transparent body in existence." Of course, in the absence of a theory of gravity explaining how celestial bodies stay in their orbits, the existence of almost transparent spheres in which they are embedded served as explanation of their stability.

On the question of relationship between celestial and terrestrial influences in his *De multiplicatione specierum*, Bacon has this to say: "We must now consider the fifth principal [subject] concerning the influence of an agent on a recipient, and it consists of the requirements on the part of the recipient, about which there are three conclusions. The first concerns terrestrial things in relation to celestial. Now it is evident that lower things can be influenced by higher things, since they share the same matter, because things of the same genus have the same matter, as [Aristotle's] *Metaphysics*, book V, states. And therefore, although celestial and terrestrial things are not linked to the point where there is complete mutual generation and corruption between them, for this is denied in *De generatione* and elsewhere, nevertheless because they belong to the same genus they must share the same matter, as Aristotle says. ... Now the purpose of this conformity is that the more the parts of the universe are like one another, the greater are their well-being and utility. And therefore, although terrestrial things cannot resemble the heavens in their complete natures, they agree at least to the point [of being linked] through the reception of species. Moreover, the same conclusion follows necessarily from the generation and corruption of things, the principal cause of which is twofold: the motion of the sun and the obliquity of its circular path. But the sun does not exist in terrestrial bodies according to substance, and therefore it is in them according to virtue [virtually?]; and the same is true of other celestial bodies. And this is evident from

experience of light diffused through all terrestrial things from celestial bodies. Consequently, when it is objected that celestial nature in not generable or corruptible, and therefore that it will not be generated in elemental matter, we reply that this is true as regards complete being; however, as regards the being of species it is not unsuitable, but necessary [for celestial nature to be generated in elemental matter]. Second, it should be recognized that celestial bodies can receive species from other celestial bodies, as the moon and stars receive the virtue and species of the sun, so that the light of the coming to the surface of the moon or any star brings light into being there, by natural alteration, out of the potentiality of the matter. ... [Third] it should be understood that a species is produced in celestial bodies not only by other celestial bodies, but also by terrestrial things. And it is for this purpose that there is conformity and susceptibility to influence [between heavens and earth], as we said [above] concerning the action of celestial bodies on terrestrial; but there is no absolute necessity in so far as celestial bodies are considered in and of themselves, but in so far as they are parts of the universe, assimilated to the others by reception of species, and in so far as they function as media in sensation. For if the eye were situated in the lunar sphere, it could see many things placed in the elemental spheres; but it sees only by means of species [i.e., eyes also radiate in order to see]. And since the species of our eye is required for the act of sight ... when we see the stars the species of our eye must be generated in the heaven, just as in the elemental spheres [i.e., sublunar spheres, where one finds the four basic elements]. ... If it should be objected that since the heaven acts on terrestrial things and be acted upon by them through the generation of a species, therefore it must be a physical agent, the contrary of which is asserted in *Physics*, book iii, and *De generatione* and many other places, we reply that physical action is not involved in the reception of influence that occurs in the generation of a species, but [only] in that which occurs in the corruption of the essence of the recipient; and the latter is not found in the heavens. However, Avicenna says in *De anima*, book iii, that it is absurd to claim that the heavens are affected by our sight. But we reply that he himself, immediately before that, showed how he conceived this effect [on the heavens], speaking against those who supposed that air and the heaven were so affected and altered by sight as to become the instrument for perceiving the visible object and conveying or returning its species to sight, and that from sight there issues some corporeal substance extended through the medium to the visible object; and he does not speak against the heaven serving as a medium for sight, receiving the species of the eye and the visible object, for this is necessary." (translated by David Lindberg in *Roger Bacon's Philosophy of Nature*, 1983, p. 70-77).

So we see that Bacon viewed our sun as the source of the light of all the stars. We also see that he was committed to the view that our eyes see using radiation from themselves, by interaction of radiation from objects with radiation from our eyes, and that our looking at the stars has an effect on them. Of course today we can claim that our eyes radiate by virtue of the fact that they involve electromagnetic effects, although we might be loathe to claim that such radiation is of sufficient strength to affect the heavens.

2. Descartes' Vortex Hypothesis, Overthrown by Newton

Moving ahead several hundred years, I return once again to Johannes Kepler, whom I treated at some length in my work *The Marriage and Divorce of Astronomy and Astrology*. In 1601, Kepler published a work on astrology whose title, in English, is *On the More Certain Fundamentals of Astrology*. This has been translated into English by J. Bruce Brackenbridge and Mary Ann Rossi in *Proceedings of the American Philosophical Society* (v. 123, no. 2, April 27, 1979, p. 85-116). The translation is made from the edition published in the *Gesammelte Werke of Kepler* (18 v., 1938-1959, v. 4. p. 8-35). Kepler aims at a reformation of astrology, not at a refutation of all of the claims made by astrologers. The translators observe (p. 87-88): "In the best tradition of Ptolemy he [Kepler] seeks to protect its borders from those who, in [Otto] Neugebauer's words, would obliterate "the boundaries between rational science and loose speculation." Kepler's title *On the More Certain Fundamentals of Astrology* attests to this concern and illustrates his belief that such fundamentals exist. The modern astronomer associates astrology with magic and mysticism, while accepting astronomy as a science. Kepler, however, like Ptolemy, views astrology as the profane, utilitarian, and less exact facet of the same activity of which astronomy is the sacred, abstract, and exact since. Unlike the modern astronomer, it was natural for Kepler to take astrology seriously."

Kepler is concerned with physical causes of celestial influences on sublunary affairs. The translators say (p. 91): "There are three major sources of physical causes: the sun, the moon, and the planets. Light is the primary mechanism by which they exert their influence: reflected light humidifies and radiated light heats." Kepler begins with a wry comment (*Thesis 1*, p. 91): "It is commonly considered the duty of the mathematician to write annual prognostics. ... I shall begin with the principal prognostic that can be cited with the utmost safety: that this year there will be a rich harvest of prognostics, since, owing to increasing popular demand, more authors are adding daily to their number." In *Thesis 5* (p. 91), Kepler says: "The most general, most powerful, and most certain cause, which is known to everyone, is that of the approach and withdrawal of the sun." Kepler proceeds with an analysis of the way the sun operates in different seasons, with different degrees of heat. In *Thesis 15* (p. 92), Kepler says: "Another physical cause of predictions is the moon. For it has been proved by experience that all things uniformly moist swell with the waxing moon and subside with the waning moon. This one fact is the reason for most of the choices and predictions in domestic economy, agriculture, medicine, and shipping. The reason for this natural inclination has not yet been clearly recognized, according to physicists." Next, Kepler turns to the planets. In *Thesis 19* (p. 93), he says: "The third physical cause of predictions is the varied nature of the remaining planets, seen in the colors that they themselves give forth. And we shall be mistaken here if we distribute the four usual qualities to the planets. For cold and dryness are not positive dispositions but ones [that arise when] deprived of light and related life. For cold and dryness are greatest where there is an absence of all light, all life, and thus all heat. Since, therefore, nothing descends to us from heaven but the light of the stars, certainly cold and dryness will not come down by themselves."

Kepler says in *Thesis 21* (p. 93): "Now because we are discussing the forces that the stars exert on bodies below, we ought to consider whether anything descends to us from the stars. Not matter or body itself, for that is in our possession before-hand. Not

life itself originally, for all living things draw life from the movement of the soul which is within them. To be sure the stars do not generate life, but they help it. They serve, therefore, the function of an instrument. They provide us with two instrumental qualities to correspond with the number of natural faculties: 1) through the power of humidifying making possible the tractability of matter, and 2) through the power of heating making possible the fostering of life and movement. Both of these powers they possess and exercise through the benefit of light, which they have received and send down to us continuously. For the proper quality of light inasmuch as it is light is heating; but the proper quality of light insofar as it is reflected, is humidifying." We see then that Kepler is here following in the tradition of Robert Grosseteste and Roger Bacon, and their Neoplatonic and Biblical predecessors as to light being the agent of celestial influence on terrestrial matters.

This conclusion appears to differ from that of Stephen Mory Straker in his dissertation *Kepler's optics: a study in the development of seventeenth century natural philosophy* (Indiana, 1971). Straker says (p. 423), speaking of Kepler's explanation of the production of inverted images when light passes through a small aperture in a *camera obscura* in Kepler's *Paralipomena ad Vitellionem (Additions to Witelo)* (1604): "It was now becoming apparent that the especially active or virtuous rays spoken of by the medieval opticians do not exist. The 'vision' of light as a procreative paradigm of natural activity was replaced by the 'vision' of the passive threads of light, stretching rectilinearly through the space they serve to create. [Albrecht] Dürer [with his theory of perspective] and Kepler had created the foundations of the mechanization of light and vision." And also (p. 502): "What had been wrong with optics until his [Kepler's] day, he asserted unmistakably, is that it had been treating light as if light were an agent, with a will and a mind of its own, bu which it chooses the perpendicular path [for strongest effect] and by which it moves itself towards sphericity. Such an approach is wrongheaded. Light is not an agent; it is a patient. And its motions in refractions, in reflections, and in the 'affections' of vision are a result of material necessity, the mathematical laws of optics and the actions of external forces. Light does not bend itself in refractions. It is bent by the action of external forces."

In Kepler's work, there follows a mathematical study of how combinations of these effects in various degrees operate, and of differences between reflected and radiated light. In *Thesis 35* (p. 96), Kepler summarizes: "Those causes of future events that I have explained up to this point, even though they do indeed possess much of the divine, nevertheless all resemble the nature of matter more nearly than those which now will follow. For their method of operating consists in a certain flowing out of light continued as far as these sublunary bodies; although this flower out is without matter and time, nevertheless it is not without quantitative dimensions. For it is made in a straight line; it is attenuated with distance from a star; it increases or decreases with the face of the shining planet; it is impeded by the interference of an opaque body; and, on the other hand, given the visible presence of the star, it flows continuously." Next, Kepler considers what are known to astrologers as *aspects*, which involves calculating the influence of pairs of planets according to observed angles between them.

In *Thesis 38* (p. 97), Kepler speaks of the traditional aspects (conjunction, opposition, quadrature, trine, and sextile, viz. angles of 0, 180, 90, 120 and 60 degrees, respectively). To these, Kepler recommends adding three more aspects, which he calls quintile, biquintile, and sesquiquadrature (72, 36, and 135 degrees, respectively). These are introduced by Kepler in part because, as he says, their usefulness in prediction has been confirmed by experience, and in part because of their relationship to harmonies of music and ratios of musical intervals ('music of the spheres'), which Kepler in other works, especially his *Harmonice Mundi* (*Harmonies of the World*), associates with the arrangement and motions of planets in our solar system. Kepler says in *Thesis 44* (p. 98): "Even though the diverse natures of planets explained above vary the effect of aspects considerably, as at times the earth is affected by a geometric mingling of the opposites Saturn and Mars, and at other times of the similar planets Jupiter and Venus, in almost the same way that we observe purgatives effecting a movement of the humors in man's intestines, but especially rhubarb for the bile."

Besides the aspects or angles observed from our earth between two planets, Kepler recommends that ratios of the speeds of planets also be taken into consideration, although he says that this effect has not yet been confirmed by experience nor has a method of investigating them been constructed yet (*Thesis 48*, p. 99). One may wonder why the traditional five aspects were introduced by astrologers, and why some or all of the other angles between 0 and 360 degrees are not considered too. It seems likely that a major reason is that the angles involved play a fundamental role in Euclid's *Elements* of geometry. One would not expect Kepler to want to introduce additional angles without giving reasons for doing so based on geometry, which in fact he does. Kepler is noted for his devotion to the five regular solids (tetrahedron, cube, octahedron, dodecahedron, icosahedron), and their significance in connection with the structure and activities of our solar system. To these, he added some so-called semi-regular and star-shaped solids. In connection with aspects and ratios, Kepler makes a biting criticism of a number of traditional astrological practices.

In *Thesis 49*, Kepler says: "But nothing is more intolerable in this almost unique concern of certain astrologers than that they distribute with a certain infantile credulity twelve houses among seven planets beyond every sound and philosophical reason: they invent tyrannies and momentary vicissitudes of empires, as if in some assembly of people. From this [concern] every magical and astrological superstition has arisen." Finally in his work *On the More Certain Fundamentals of Astrology*, Kepler proceeds to give extended prognostications for the weather in each month of the year 1602 A.D., and predictions concerning eclipses, crops, illnesses, and certain political and military matters.

In his book *The Fire Within the Eye* (1997), David Park says (p.155, 156): "As to astrology: I have said it is hard to understand how anyone in those days [Kepler's time] with an a priori belief in the unity of Nature under a divine plan could fail to believe in some form of it. ... Kepler aimed at something new, a fusion of mathematics and physics and astronomy into one great body of knowledge. ... A work from 1601m called *On the More Certain Foundations of Astrology*, explains the science's principles in fifty-one

propositions, and then lists twenty-four more that predict the weather for the next year and a few of the consequences that would follow from it. Kepler has no use for zodiacal astrology. He ridicules the notion that a planet's influence changes abruptly at the instant it crosses the boundary between two arbitrarily defined areas of the sky. His astrology is lunar and planetary, but it is in some sense a physical theory."

Concerning aspects, Park says (p. 157): "How can geometry cause anything? It can't, but if you believe as Kepler did that everything that exists in the world is formed according to God's mathematical principles, it follows that a new soul also is formed that way, and forever afterwards it retains the form. Choose a pair of planets and imagine lines drawn from them to the Earth at the moment a child is born. Now study the angle between the two lines. If it is one of the angles that flow from simple and ancient geometry, then the planetary influence is strong and predictions can be made."

Park quotes (p. 158) from a letter written by Kepler to Galileo in April 1610 (translated by E. Rosen, 1965, in *Conversation with Galileo's Sidereal Messenger*): "How does the face of the sky affect a man at the moment of his birth? It affects the human being as long as he lives in no other way than the knots which the peasant haphazardly puts around a pumpkin. They do not make the pumpkin grow but decide its shape. So does the sky: it does not give the human being morals, happiness, children, fortune, and wife, but it shapes everything in which he is engaged." Park adds: "Rays shape a life but do not determine outcomes, for choices are ours to make, and how we make them determines our fate on the Last Day. However kings and prelates and judges may have used astrology in conducting their lives and affairs, they all understood this, and only unseasoned radicals ever adopted the extreme position that the stars, not we ourselves, are responsible for what we do." (p. 158-159)

Despite the fact that Galileo Galilei (1564-1632) was a pioneer in the use of telescopes in astronomy and made a number of important discoveries with it, he published nothing of interest on how it works. As to the nature of light, according to Park (loc. cit. p. 148) he made a suggestion that "light pertains to the world of atoms." Park adds that "It will be three centuries before that egg hatches". Park remarks (p. 155-156) that Galileo at the request of of the Grand Duchess Christina of Tuscany, cast a horoscope for the Duke of of Tuscany who was at the time approaching the age of sixty. Galileo predicted many more active years for the Duke, but the Duke died shortly afterwards. He thus wasn't as successful at astrological prediction as Kepler was. Of Kepler, Park says: "His first almanac foretold cold weather and an invasion by the Turks; both happened. Much later, in 1618, he predicted that the month of May would bring great upheavals. On the 23rd, delegates from a seething Protestant assembly in Prague marched up to the Hradeany Castle and threw two Catholic regents and their secretary out of a window, igniting a war that for thirty years devastated much of central Europe, and among the thousands of lives it crippled or destroyed were those of Kepler and his family." (Park, p. 156). These events are known to historians as "the defenestration of Prague", and the Thirty Years War.

Park refers to a very significant contribution made by Kepler to the study of the nature of light, although one which didn't take hold until quite a bit after Kepler's time. Park says, referring to Kepler's treatment of human vision (p. 162): "Why is it, he [Kepler] asks, that when we look at something in a mirror it seems to be located just as far behind the mirror as it actually is in front of it? To answer he develops a theory of visual perception that Galileo may have known about later, when he fought his own battles in this arena. The image that forms in our mind when we look at something is a subjective (Kepler says 'intentional') entity that the mind creates in response to the visual rays that enter our eyes. It is not something that travels along the rays; there are no *eidola* [images of what is seen carried by light to our eyes]. It is the mind that creates the images and locates it at a point determined by the convergence of rays from the two eyes. If the rays are reflected ..., the angles presented to the eyes are unchanged, and the mind locates the image behind the mirror where it would have located it if the rays had been straight."

That is, when looking in mirrors we receive images of objects even though there is no object radiating light where we see the images. One might think that this proposition is not related to the question of whether or not whatever astrological information there is may be transmitted to us by means of light, since our question has been whether or not light is the conveyer of such information and not the details of how that information is conveyed. However, Kepler's alternative, that certain kinds of images are created by our minds suggests that we seriously consider to what extent people might create astrological information in our own minds as a result of the reception of light from stars (including sun, moon and planets), or by some other means of communication from the stars. One can see here a start on a path leading through Immanuel Kant in the 18th century to studies of the nature of vision and visions and their relations to our brains and minds and to our consciousnesses and subsconsciousnesses from the 19th century up to the present time.

On the other hand, Stephen Mory Straker in his dissertation (1971, p. 479) is of the opinion that: "Kepler defined by his own works what should properly be called optics.. In his account of the means of vision, we recall, Kepler insisted that 'the laws of optics' and 'the equipment of the optician' proceed only as far as the opaque wall in the back of the eye [the retina]. Whatever goes beyond that barrier -- perception, cognition, understanding, seeing itself -- these things are not the business of the student of optics, not until, at any rate, they can be subsumed under optical laws, which laws, Kepler left no doubt, are mathematical. What cannot be subsumed under such laws remains 'occult' and hidden; of such things we know nothing. In responding to and redefining the purposes of the inherited science of optics, Kepler's *Additions to Witelo* [1604] is the last treatise in the medieval optical tradition. His *Dioptrice* [1611] stands squarely and firmly in the 17th century."

3. Traces of Astrology in Works of Descartes

An old saying had it that all roads led to Rome. It would be too much to say that all scientific roads lead to Isaac Newton. However, insofar as they pass through Newton, they often also have passed before through René Descartes. A considerable amount of what Newton did was in reaction and opposition to what Descartes did in the way of what we now call science. One can get a preliminary idea of a basic complaint had about the way Descartes did natural philosophy by considering the next-to-last paragraph of the conclusion, the General Scholium, of Newton's *Principia,* said by I. Bernard Cohen in his guide to and translation (with Anne Whitman and Julia Budenz) of this work, to be "probably the most discussed portion of all of Newton's writings." (*The Principia*, trans. Cohen, 1999, p. 275). Here Newton says: "Thus far I have explained the phenomena of the heavens and of our sea by the force of gravity, but I have not yet assigned a cause to gravity." (p. 943). Newton then gives some properties of gravity, and then says: "I have not as yet been able to deduce from phenomena the reason for these properties of gravity, and I do not "feign" hypotheses [*hypotheses non fingo*]. For whatever is not deduced from the phenomena must be called a hypothesis; and hypotheses, whether metaphysical or physical, or based on occult qualities, or mechanical, have no place in experimental philosophy. In this experimental philosophy, propositions are deduced from the phenomena and are made general by induction. The impenetrability, mobility, and impetus of bodies, and the laws of motion and the law of gravity have been found by this method. And it is enough that gravity really exists and acts according to the laws that we have set forth and is sufficient to explain all the motions of the heavenly bodies and of our sea." (p. 943). Newton appears to have begin work on his *Principia* in 1684, although he made some use of earlier work of his. The first edition was published in 1687. However, the General Scholium did not appear until a second revised edition was published in 1713. There was also a third edition in 1726, a year before Newton's death in 1627. (Cohen, loc. cit., p. 11, 274).

There is a work by Descartes called *Le Monde* (*The World*) which was written during the years 1629-1633, but not published until 1664 with the alternative title *Le Traité de la Lumière* (*Treatise on Light*), evidently because Descartes wished to avoid possible trouble with ecclesiastical authorities after he heard about the trouble Galileo got into with the Church. Here he says: "For a while, then, allow your thought to wander beyond this world to view another world -- a wholly new one which I shall bring into being before your mind in imaginary spaces. ... Now since we are taking the liberty of fashioning this matter as we fancy, let us attribute to it, if we may, a nature in which there is absolutely nothing that everyone cannot know as perfectly as possible." This translation from the French is the one made by Cottingham et al in their work of 1985 cited above, p. 90-91. In the original work this reads: "Permettez donc pour un peu de temps à votre pensée de sortir hors de ce Monde, pour en venir voir un autre tout nouveau, que je serai naître en sa presence dans les espaces imaginaires. ... Or puisque nous prenons la liberté de feindre cette matiere à notre fantaisie, attribuons lui, s'il vours plaît, un nature en laquelle il n'y ait rien du tout que chacun ne puisse connoître aussi parfaitement qu'il est possible." (*Oeuvres de Descartes*, v. 11, 1967, p. 31, 33, ed. Charles Adam and Paul Tannery; spelling modernized).

Cottingham et al have translated "de feindre" as "of fashioning". However, "feindre" in French means "to feign" or "to pretend" or even "to dissemble." It appears that "feindre" is etymologically descended from Latin "fingere" (first person present tense "fingo") which can mean "to form" or "to fashion", but which can also mean "to feign" or "to invent" or "to fabricate" (*Cassell's New Latin Dictionary*, D. P. Simpson, 1959, p. 248). The Littré dictionary gives: "Étymologiquement, feindre, c'est donner une forme comme l'artiste fait à la terre qu'il moule (...) du latin *fingere* (...) le sens propre de *fingere* est façonnner. Du sens de façonner on a passé à celui de feindre, c'est à dire façonner une apparence. (...)"; in the sense of *suppose*, *imagine*, the Littré gives this example from Descartes: "Il est nécessaire de feindre qu'il [Dieu] soit trompeur, si nous voulons révoquer en doute ces choses que nous concevons clairement". I will therefore suggest that what Newton had in mind, when he uttered his famous *hypotheses non fingo* slogan, could well have been a response to what Descartes says in favor of "feigning" in *Le Monde*, perhaps along with other passages from the writings of Descartes (see below).

I. Bernard Cohen, in his edition of Newton's *Principia* already mentioned, has a discussion of translations into English of this slogan. Cohen says (p. 275-276): "Newton obviously did not mean by this phrase that he never 'uses' or 'makes' hypotheses, since this statement could easily be belied: for example, by the presence of one 'hypothesis' in book 2 and two more in book 3. Alexandre Koyré suggested that by 'fingo' Newton probably intended 'I feign', in the sense of 'inventing a fiction', since the Latin version (1706) of the *Opticks* (1704) used the cognate 'confingere' for "feign'. ... Most English-speaking readers know this phrase in Andrew Motte's translation [of 1729] as 'I frame no hypotheses'. There is no way of telling what meaning Motte intended the verb 'frame' to have. Certainly one use of 'frame', in the context of theory, was 'to fabricate'.

In any event, in Newton's day and in Motte's, one of the senses of 'to frame' was decidedly pejorative, just as is the case today. In today's usage, however, the pejorative sense of 'to frame' has a very different signification from what it did in Newton's day, since for us the verb 'to frame' means 'to concoct false evidence against' (a person). In Samuel Johnson;s *Dictionary* (London, 1785), one of the definitions is 'To invent, fabricate, in a bad sense: as to *frame* a story or lie'. Johnson gives, as an example, a quotation from Francis Bacon, "Astronomers, to solve the phaenomena, *framed* to their conceit eccentrics and epicycles'. Surely, Motte was intelligent enough to recognize that for Newton 'fingo' was a derogatory word. Accordingly, Motte would surely have intended that his translation 'frame' would equally convey this sense to the reader."

One finds a little later in *Le Monde*, presumably to clarify what *he* means by "feindre": "Were I to put into this new world the least thing that is obscure, this obscurity might well conceal some hidden contradiction I had not perceived, and hence, without thinking, I might be supposing something impossible. Instead, since everything I propose here can be distinctly imagined, it is certain that even if there were nothing of this sort in the old world, God can nevertheless create it in a new one. For it is certain that he can create everything we can imagine." (Cottingham et al, loc. cit., p. 92). However, in the original French, "feindre" is not used here, but rather "imaginer" (Adam and Tannery,

loc. cit., p. 36). As to the use of the word "hypothesis" by Descartes, in the Third Part of Descartes' *Principles of Philosophy (Principia philosophiae*, 1644, *Les principes de la philosophie*, 1647), the title of §15 is: "The observed motions of the planets may be explained by various hypotheses" ("Eadem Planetarum apparentias per varias hypotheses posse explicare", "Qu'un peut user de diverses hypotheses pour expliquer les Phainomenes des Planetes"; the English is by Cottingham et al, p. 250, the Latin is from the version of 1644 in v. VIII-1 of the *Oeuvres,* p. 108, and the French is from the version of 1647 in v. IX-2 of the *Oeuvres*, p. 84-85).

There is another possible source of Newton's slogan about hypotheses. Descartes' most mature and extensive work on astronomy and cosmology was the *Principia Philosophiae (Principles of Philosophy)* which was written by Descartes in Latin and published in 1644. In 1647, a translation into French by the Abbé Claude Picot was published. This version has a preface by Descartes in which it is apparent that he endorses and approves of the French version, which differs in some respects from the Latin version. There are four parts to this long work. The first part is titled "The Principles of Human Knowledge", and would today customarily be classified as a philosophical rather than a scientific work. The second part is called "The Principles of Material Things", and is a kind of mixture of philosophical and scientific material according to today's terminology. For example, section 4 of part 2 is titled "The nature of body consists not in weight, hardness, colour, or the like, but simply in extension (trans. Cottingham et al, p.224). This view can be taken to be metaphysical rather than physical. Section 22 of part 2 is titled "Similarly, the earth and the heavens are composed of one and the same matter, and there cannot be a plurality of worlds." (idem, p. 232). This of course is flagrantly a view which casts doubt on the basis of any astrological theory which explains actions of the planets and stars on men and their affairs as being due to their constitution being different in some fundamental way from that of the earth. The first part of the title of section 22 is taken to be a fact based on physics astronomers and cosmologists today, and the second is a proposition discussed by current physical cosmologists, so is classifiable today as a matter of science rather than philosophy. There is also an analysis of the concepts of space and motion in part 2, an assertion (sections 20 and 34) that matter can be subdivided into an "indefinite" number of particles, and an analysis of what happens when two bodies -- in 1668 this last was shown by Christiaan Huygens to be defective. Descartes has explained earlier that he prefers to use "indefinite" in connection with the nature of the "extension of the world" rather than "infinite" (sections 26 and 27 of the first part of the work). In part, Descartes says, he wishes to reserve the term "infinite" for God.

This brings me closer to a second hypothesis (!) about sources of Newton's "hypotheses non fingo" proposition. The third part of the *Principia philosophiae* of Descartes is called "The Visible Universe", and is concerned with matters which today are considered to be astronomical and cosmological. In section 4 of this part (loc. cit., p. 249), Descartes says: "The principles which we have so far discovered are so vast and so fertile, that their consequences are far more numerous than the entire observed contents of the visible world; indeed, they are so numerous that we could never in a lifetime make a complete survey of them even in our thought. But I shall now put forward for scrutiny

a brief account of the principal phenomena of nature whose causes we must now examine. Our purpose is not to use these phenomena as the basis for proving anything, for we aim to deduce an account of effects from causes [by which Descartes seems to mean something very like what today are often called called axioms], not to deduce an account of causes from their effects. Here we see a contrast with Newton's program of deducing causes (or axioms) from phenomena or effects, as before. In section 43 of this part (p. 255), Descartes says: "If a cause allows all the phenomena to be clearly deduced from it, then it is virtually impossible that it should not be true. ... For this would imply that God had endowed us with such an imperfect nature that even the proper use of our powers of reasoning allowed us to go wrong." In the next section 44, Descartes says: "Nevertheless, I want the causes that I shall set out here to be regarded simply as hypotheses. ... And if it is thought that the hypothesis is false, I shall think I have achieved something sufficiently worthwhile if everything deduced from it agrees with our observations ...". The title of section 45 is "That I shall even assume here some [hypotheses] which it is certain are false." Now we can ask why did Descartes allow for the possibility that someone might want to think his hypothesis was false? The answer, of course, is well known: Descartes wished to avoid trouble with theological doctrines of the Church, as based on Holy Scriptures. This casts a rather strange light on Newton's slogan. One can consider that Newton was so faithful to an experimental approach to finding first principles, or axioms, that he wanted to make it clear how he differed from Descartes in this respect. On the other hand, I propose that it is possible that in addition to this, Newton may have wished to make the point that he was not going to propose hypotheses contrary to Scripture and ecclesiastical doctrine, but instead was only going to base his principles on experimental evidence, on what he saw, on what Descartes called "the visible world", of which Descartes said he was not going to use "to prove anything". In this connection, one can note that Descartes is offering here (and elsewhere) as support for his axiomatic approach the fact that one can't handle all possible observations in a lifetime, whereas if one takes the right axioms, which he believes he has found, one will be in a position to deduce all the observations one wants to, or has time for. For example, near the end of this work, in section 199 of part four (loc. cit., p. 285-286), Descartes says : "There is no phenomenon of nature which has been overlooked in this treatise. ... So the entire visible world, as far as it is simply visible or perceivable by the senses, contains nothing apart from the things I have given an account of here."

In Part III of the *Principia Philosophiae*, one sees that Descartes is trying to avoid trouble with ecclesiastical authorities over what in today's terms might be called a case of creationism versus science. Here it is a question of theories of cosmology rather than of theories of evolution. It is in this Part III that Descartes puts forth his theory of vortices (*tourbillons*) which are generated by rotating and revolving celestial objects, and which fill space, producing what came to be called a *plenum*. It was this theory that Newton was so concerned to overthrow in his own *Principia*, as being hydrodynamically untenable. Here, for example, Descartes has a theory of the formation of planets from fixed stars (*étoiles* -- when Descartes speaks of *astres* in the French version of this work, he means to include planets and comets as well as the fixed stars). In section 115, Descartes proposes "That sometimes an entire vortex, which has a star at its center may be destroyed", and says "It can also also happen that an entire vortex that contains some

such star is absorbed by the other surrounding vortices and that its star, snatched into one of these vortices, becomes a Planet or a Comet." (*Principles of Philosophy*, translated by Valentine Rodger Miller and Reese P. Miller, 1983, p.147). The title of section 146 is "Concerning the creation of all the Planets." Here Descartes speaks individually of each planet of our solar system known to him. (loc. cit. p. 171). Descartes begins Part IV of this work with the following: "Although, as I have already sufficiently warned, I do not wish it to be believed that the bodies of this visible world were ever created in the manner which was described above; I must however still retain the same hypothesis, in order to explain the things which are seen on the Earth. So that if, finally, as I hope to do, I clearly show that the causes of all natural things can be understood by means of that hypothesis, thhough by no other, it will thence be justly concluded that their nature is the same as if they had indeed been formed in such a way, (although the world was not formed in that way in the beginning, but was created directly by God)." The reason for the parentheses in this translation by Miller and Miller is that the last clause appears in the French translation of 1647 made by the Abbé Claude Picot, but not in the original version of 1644 written by Descartes. It is anyone's guess whether or not the clause was added by Descartes or Picot. It is true that Descartes wrote an approving preface to the French version, but it doesn't follow that he made all, or perhaps even any, of the additions or emendations in the French version. One may conjecture, for example, that Descartes was aware of this addition, made by Picot, but approved of it because of his desire to escape censure from ecclesiastical authorities. In connection with Newton's *hypotheses non fingo*, one may conjecture that perhaps Newton had in mind an implication that he, Newton, makes or pretends to make no *false* hypotheses, or hypotheses he declares to be false, in the manner of Descartes.

On Traces of Astrology in the Work of Descartes

In the 17th century the marriage of astronomy and astrology in Europe and its offspring began to run into the sort of trouble that led to their separation, and eventually to divorce. The works of Descartes were influential in this regard, although indirectly. Statements involving astrology are scarce in his writings. In the translations by Cottingham *et al* cited above, there are two passages concerning astrology. Rule 5 of his *Rules for the Direction of the Mind* (c. 1628, published 1684) reads: "The whole method consists entirely in the ordering and arranging of the objects on which we must concentrate our mind's eye if we are to discover some truth. We shall be following this method exactly if we first reduce complicated and obscure propositions step by step to simpler ones, and then, starting with the intuition of the simplest ones of all, try to ascend through the same steps to a knowledge of all the rest." Descartes then say that "This one Rule covers the most essential points in the whole of human endeavor. ..... But many people either do not reflect upon what the Rule prescribes, or ignore it altogether, or presume that they have no need of it. They frequently examine difficult problems in a very disorderly manner, behaving in my view as if they were trying to get from the bottom to the top of a building at one bound, spurning or failing to notice the stairs designed for that purpose. Astrologers all do likewise: they do not know the nature of

the heavens and do not even make any accurate observations of celestial motions, yet they expect to be able to delineate the effects of these motions. ..... "

A second reference to astrology comes from the *Discourse on the Method* (1637). After discussing his experiences with several branches of knowledge, he says: "Finally, as for the false sciences, I thought that I already knew their worth well enough not to be liable to be deceived by the promises of an alchemist or the predictions of an astrologer, the tricks of a magician or the frauds and boasts of those who profess to know more than they do." This opinion of astrology is in agreement with his later statement he decided to "reject as if absolutely false everything in which I could imagine the least doubt, in order to see if I was left believing anything that was entirely indubitable.". This attitude led him to his famous arguments based on the slogan "I think, therefore I exist.".

Given the prevalence of astrology in the 17th century, it is notable that there are only a few references to astrology in all of the five volumes of Descartes' correspondence edited by Tannery and Adam in the *Oeuvres* of Descartes, and these are disparaging. Nowhere is astrology or any any related matter mentioned in his most mature and comprehensive work on physical matters, the *Principles of Philosophy*. This is so despite the fact that Parts III and IV of the work are devoted to "The Visible Universe" and "The Earth", respectively. From the point of view of astronomers and cosmologists of today, many of his explanations of the relationships of celestial and terrestrial bodies will be considered to have been wrong. Nevertheless, the ways in which Descartes approaches these topics will be regarded by many cosmologists today as akin to their own methods in mathematics and theoretical physics, as compared with those based on observational and, when possible, experimental methods. Such a cosmologist, if he or she were relatively uninformed about the kind of astrological speculations about the heavens and the earth which were prevalent during the time of Descartes, might take it that there was an abrupt breakup of astronomy and astrology very soon after Descartes described his methods, and that Descartes started it all, perhaps along with Galileo. There would seem to be some truth in this statement, although the separation appears to me to have been more gradual, and to have taken more time than is sometimes indicated. It must be remembered that Kepler, who defended and applied certain astrological theories was approximately contemporaneous with Descartes, and that Newton still had some roots in older views of the relationship of the heavens and the earth, and that questions about the nature of light and gravity and other possible celestial influences on the earth were not settled by Descartes and Galileo. I discuss this in my work *The Marriage and Divorce of Astronomy and Astrology*, on this web site.

One can see rather vividly in a work by Claude Gadroys (1642-1678) a transition from what I have called the *marriage* of astronomy and astrology to a kind of *separation*, which eventually led to divorce in the course of the 17th century. This work is called *Discours sur les influences des astres, selon les principes de M. Descartes*. This is a work designed on the one hand to attack astrology as practiced by judicial astrologers who pretend to predict the future by observing stars, but on the other hand to claim for the stars (including and especially the sun, moon, and our planets) the implanting of *inclinations* in humans, at birth, due to influences radiated from the stars, influences

which are transmitted by way of the vortices (*tourbillons*) held by Descartes to fill space, surrounding each celestial body. A principal aim of his work is to make his theory about influences of stars conform to both the physics and the physiology of Descartes as best as he can. Also Gadroys wants to emphasize that humans are free to resist or comply with such inclinations, by acts of will, and to argue that it is not contrary to the authority of the Church or revelation to study influences of the stars. He says in his preface that "It is hard to imagine that these beautiful celestial bodies dwell uselessly; that they do not act on bodies here below; that they do not actuate and govern; and that they do not support all sublunary things."

Gadroys observes that judicial astrologers attribute too much to influences of the stars, while philosophers (*philosophes*) don't attribute enough. "Thus," he says, "it is necessary to look elsewhere for what we can't find there; and I believe that one can succeed in this no more advantageously than in following M. Descartes: The beauty of his principles shine in this matter to such a degree that that they reveal numerous things which people have up to now believed impossible. I have only undertaken this work with the aim of showing that one should believe in Influences; and and to prevent people either from falling into the superstitions of the Astrologers, or to submit themselves to the prejudices of the Philosophers." There are ten chapters in Gadroys' work. The first concerns the status of questions about Influences of the stars, and the 2nd through 4th are concerned with the *nature* of the stars, especially the planets. In Chapter 5, Gadroys explains how the *matter* which leaves the stars comes down here below, and also what conjunctions, oppositions and aspects of the planets are. In the 6th chapter, he presents proposals concerning effects attributable to the stars, in particular "the different temperatures of the air, and the different sicknesses which arrive in various seasons". He makes in Chapter 7 an argument in favor of how talismans affected by the planets may work successfully, and he says that "in the 8th [chapter] we consider how the celestial matter can cause some Inclinations in people". The 9th chapter treats the different effects of individual planets, and in the 10th he mounts an attack on judicial astrologers.

In Chapter 1, Gadroys agrees that heat and light from the fixed stars (*étoiles*, to be distinguished from *astres* which include the sun, moon and planets as well as the *étoiles),* and from the planets, are too weak to produce Influences on people. He says these have no more power in the vortex (*tourbillon*) of the earth, a kind of field of hydrodynamic type emanating from or produced by the earth, than a lighted candle has on the fruit of a fruit tree (presumably sufficiently distant from the fruit), or on that of a woman giving birth. But, he says, one should consider other possibilities as sources of Influences. He observes that certain *Philosophes* attribute Influences to some "hidden qualities," and goes on to argue that there are effects of stars which cannot be attributed to heat or light. He asks, rhetorically, "Can one explain the properties of the magnet without recourse to the stars (*astres*)? Can one give reasons for all the different temperatures of the air, which occur equally when the sun is elevated above or is lowered below our horizon? And can one find without these Influences the causes of certain contagious sicknesses which sometimes affect part of the earth, which spoil grains and fruits, which kill animals, and which depopulate provinces and kingdoms?"

Gadroys quotes St. Augustine to the effect that all things here below are governed by the celestial bodies, and *order* demands theat the inferior bodies such as the sublunary ones obey those which are in the middle, and those in the middle obey the celestial ones. Gadroys also quotes St. Thomas Aquinas as attributing the source of the power of magnets to the stars, and Hippocrates and Galen as being so convinced of Influences of stars on the "humors" of people that they asserted that in order to practice the art of medicine, one should have a special knowledge of the stars, and, says Gadroys, "we see that those who follow this advice today, practice medicine successfully." Gadroys quotes Pico della Miranda in his work devoted to an attack on astrologers as saying that celestial objects do indeed act on "the elements and on all of the sublunary world, and that without the help of the heavens, nothing would happen in the corporeal world." Pico, he says, was attacking only the superstitions of astrologers, and not the idea of Influences of the stars. Similarly, Gadroys quotes Pierre Gassendi as saying "We do not deny that God has given to the stars (*astres*) some powers, but one finds that the astrologers hardly know what they are."

In Chapter 5 of his work, Gadroys argues in favor of a "subtle matter" transmitted from the stars (*astres*) to the sublunar regions, being careful to adhere to principles laid down by Descartes in his *Principium philosophiae*. Much of Gadroys' argument depends on Descartes' theory of vortices which fill space and rotate with the objects to which they belong, and serve to generate attracting forces to the objects by way of centrifugal action. Gadroys says: "We have therefore found a celestial matter [presumably that which makes up the vortices], different from that which makes light, and it is this matter from which the Influences are made. Gadroys argues further, again using principles of Descartes, that "this matter is different in form (*figure*) from magnetic matter."

The title of Chapter 7 indicates its content: "In which one shows how celestial matter can be the cause of effects which one attributes to Talismans". Gadroys first gives examples from various ancient and more contemporary writers of the efficacy of talismans, and remarks that one may know that they work from personal experience. Then he proposes a theory of how talismans work by receiving "astral matter" into their pores.

The title of Chapter 8 is: "In which one explains how celestial matter can cause in people different Inclunations." Here Gadroys works with the extensive physiological theories put forth by Descartes in a number of his works. Gadroys says, for example: "Following this thought [of Descartes], can't we believe that the matter from different stars is capable of causing in us various movements, and consequently various Inclinations? Can't it be of such a nature that entering with blood into the heart, and exciting there more or less heat, it produces more of less of the spirits (*esprits*)." Here, I take it, by *esprits*, Gadroys means to refer to the *esprits animaux*, "animal spirits" proposed by Descartes to exist within us, and to be a basic constituent in life processes.

Gadroys argues against an unidentified author that such Influences don't preclude a free will, which however can be acted on by the stars. "The stars," says Gadroys, " do not act on the will either physically or directly; between an agent and a recipient (*patiant*

[sic]), as the *Philosophes* say, some *proportion* [quantitative interaction?] is necessary; the stars are material, the will is spiritual; between the material and the spiritual there is no *proportion*. But the stars act indirectly on the will: As they can excite in the body various movements, they can give birth in the will to different desires." Gadroys goes on to propose, in line with Descartes' physiological explanations, that the spiritual part of us must be mediated by our nerves and brains. For example, he says, "a serene air (*un air serain*)" acts on our soul to make one happy, while a "charged air" (*un air chargé*) makes one sad. This must be so, says Gadroys, if we are to adhere to principles laid down by Descartes. Gadroys gets further support for this point of view by quoting a confirming statement from the *Summa contra gentiles* of St. Thomas Aquinas. He further address the question of *when* the stars exert their Influences on a person, and concludes: " ... I believe that the time in which the stars produce in us our Inclinations is the time of our birth." When we advance in age, he ways, the stars can no longer produce in us new inclinations, even though we still receive such influences. Chapter 9 of his work is devoted to an exposition of different Inclinations caused by different planets, again done in conformity with Cartesian principles.

In Chapter 10, the last chapter of his book, Gadfroys mounts an attack on judicidal astrology. He says: "Adam and Seth, as reported by Joseph [presumably Flavius Josephus?], were the first to devote themselves to Astrology, and according to the same author, Abraham having fled to Egypt, learned it from the Egyptians. Since Adam had received directly from God, he therefore possessed it perfectly: but this science which was pure in the hands of our fathers, was soon corrupted in those of their children." This corruption, says, Gadfroys, is the reason the Church has found it necessary to condemn astrology. Gadfroys again emphasizes that his theory of celestial Influences in no way eliminates human free will. He says, "... it is necessary to assert that the stars acting on our bodies do not compel our wills; it is always in our power to consent to or to resist the movements which they excite in us. The union of thoughts with movements, although very close, is not indissoluble ... "

Gadfroys is adamant about the inability of judicial astrologers to predict the future: "We assert then that astrologers cannot make judgments with certainty about our particular actions: We assert that they do not know how to divine what our fate will be: and that because our life is in the hands of God, it is in vain that they pretend to determiner both the hour and the manner of our death. ... Thus it is a criminal deed to pretend to pierce the thick darkness of the future: our eyes are too weak, and time is too obscure a veil." Gadfroys concludes his work by saying that he has only approached the truth about Influences of the stars. "It is not necessary," he says, "to demand absolutely necessary propositions in all the sciences. There are some disciplines which are called sciences, and which do not have the certitude of geometry. One should distinguish among subjects; and it is a fault to demand for everything mathematical demonstrations. There are, says a great man [unnamed], different degrees of proof. There are those which show that something is certain, and others which show they are probable; and often from a number of probabilities one derives something certain which all reasonable minds should recognize. It is true that in the science of Influences, one has only conjectures; but since they harmonize so well, it seems that one ought not to reject them."

The reference to the dispensability of geometric certainties can be taken as an uncharacteristic criticism or rejection of the methods recommended by Descartes in his works on scientific methods. Nevertheless, one sees in this work by Gadfroys a process of separation of astronomy from astrology taken place, done largely according to principles laid down by Descartes, as interpreted by Gadfroys. This is the kind of separation which led to the divorce I discussed in my previous work, *The Marriage and Divorce of Astronomy and Astrology*.

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