

## ASTROLOGY AND ITS INFLUENCE UPON THE DEVELOPMENT OF ASTRONOMY\*

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In the history of the natural sciences certainly no other science occupies such an important and peculiar place as astronomy. This is, because it is the most ancient science. In those remote centuries of antiquity, when there was no trace of a systematic study of physics or chemistry, astronomy was already a highly developed discipline. To its great age the special importance of astronomy in the history of civilization is due. For the other sciences, history is confined almost entirely to the last three or four centuries; their development took place within the walls of universities and laboratories, far from the convulsions of social and political life. Their students were modern men, of our own kind, for whom the pursuing of scientific researches was a special profession, directed by the same accepted tradition as our own work.

With astronomy matters are different. Its history accompanies the development of mankind from its first beginnings. It goes back to ages in which social life had a structure quite different from that in modern times, in which society, state and church, religion, law and science were one unbroken unity, and in which human thinking and being was different from nowadays. Our predecessors were Babylonian priests and magicians, Greek philosophers, Arabian princes, mediaeval monks, Renaissance noblemen before they turned into modern university professors. For them the science of the stars stood not apart from their other opinions but was intimately interwoven with their philosophical and religious conception of life. In the 16th century the contest about astronomical truth was part of a struggle between world conceptions, and was deeply connected with the social struggles of that time. In this strife astronomy cleared the way for the freedom of scientific research generally.

If we now turn to the first beginnings of astronomy, which were coincident with the first beginnings of civilization, the question

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naturally arises,—what was its origin? What was the reason that these primitive people turned their eyes to the stars and began to observe them regularly? Was it admiration of the beauty of the heavens, was it the dawning impulse of study to find out the cause of the phenomena? No, it was the hard necessity of life that induced them to look at the sky, the practical needs connected with their labour and intercourse with other people. Two necessities chiefly imposed the study of astronomy upon them. The first was the need of orientation, when for purposes of commerce they had to travel through the trackless deserts or over the dangerous seas. The Arabs, when they travelled in their caravans through the burning sands, looked at the stars to keep their direction. The Polynesian sailors from the Australian islands in the Pacific used the rising and setting points of special stars as their compass and they had navigation schools where knowledge of these stars was taught. The Phoenicians and the Greeks, when crossing the Mediterranean sea, had the stars as their guides; in the *Odyssey* the goddess Kalypso tells Odysseus to keep the Bear always on his left hand when steering home. In this way such people became acquainted with many stars and constellations and their most common phenomena.

To this was added, as a second need, the necessity of time reckoning. Agriculture everywhere is bound to a period of a year, because sowing and harvesting always return at the same season or date of the year. These dates were determined in remote antiquity by the appearance or disappearance of certain stars. The most famous instance is the morning rising of Sirius, which for the ancient Egyptians announced the beginning of the Nile floods. In the old Greek poem of Hesiod the business of the whole year is connected with the stars; with the heliacal rising of Arcturus the grapes have to be picked, and when Orion and the Pleiades are setting in the morning the plough has to be put into use. With all the primitive tribes we find their agriculture, their hunting and fishing regulated by phenomena of the stars. In the course of the higher development of ancient society, with the rise and growth of cities and large empires, the need of chronology becomes more intense. For commercial life in the towns the hour of the day is needed; in Athens and other Greek towns it was found by shadow-

casting poles and gnomons. But also the days have to be counted and longer periods have to be measured. This was only possible by making use of the periods of the celestial bodies; and the moon especially presents itself for this purpose. With all peoples of antiquity, the Indians, Babylonians, Jews, Greeks, we find the moon calendar used; the period of the moon, the regular sequence of the first appearance of the fine crescent moon in the evening sky, its growth to first quarter, to full moon, at the same time coming up later and filling the whole night, then the decrease to last quarter till its disappearance after the last thin crescent before sunrise was seen,—this regular cycle of the moon's phases in the period of  $29\frac{1}{2}$  days was everywhere the first basis of chronology. "For regulating the time the moon has been created,"—this opinion we find written in many sacred books. Our month is a distorted tradition of the original lunar month, which always began with the appearance of the new moon crescent in the evening sky. Even to-day may we see in Mohamedan countries the priests in their high minarets watching the sky, in order to observe the moment this horn will first appear and to call out then the beginning of the new month. This important rôle of the moon in primitive societies was the origin of the moon worship.

With the establishment of this moon cycle, however, the calendar was not satisfactorily fixed, and it has further developed in different ways with different peoples. For us, who never have to care for time reckoning because we have our calendars made ready by the astronomers, years, and, if necessary, centuries in advance, we can hardly imagine what an important and difficult matter was the exact regulation of the calendar in ancient times and what a number of observations were necessary. It was a subject of continuous attention and concern for the priesthood, which had to take care of it; but just for this reason also, it added to their power. Perhaps one asks why such an exactitude was necessary, some days earlier or later would do no harm in those primitive societies. But we should not forget that in those times the people, the tribe, the state was at the same time a political and a spiritual and religious unity. Important events of society, the great agricultural performances, the beginning of the ploughing, the sowing or the harvesting were

great popular festivals and at the same time chief religious ceremonies, where offerings were presented to the gods. But as religious ceremonies they had to follow a strict ritual proceeding, the gods had to be served not carelessly but at the exact moment and in the exact prescribed way. The calendar was the chronological regulation of worship. Thus the moon calendar had to adapt itself to the economical life of the people, which was governed by the yearly cycle of seasons. There arose the practical problem of adapting the moon period of  $29\frac{1}{2}$  days to the solar year of 365 days. This chief problem of ancient chronology has been a mighty impulse to the study of astronomy, because it necessitated continual observation of the sky.

Twelve lunar months of  $29\frac{1}{2}$  days each, making a total of 354 days, fall 11 days short of the solar year. In the next year the beginning of each month occurs 11 days earlier, and in three years 33 days will be lost. To fix the same month to the same season always there is no other means than after two or sometimes three years to intercalate an additional month, number 13, by repeating the last month of the year. This was first done empirically. When in ancient Palestine the end of the twelfth month (in March) was approaching, the rabbis went out to the field to see whether the grain would be ripe and fit for the sickle within two weeks. For in the middle of the first spring month Nisan at full moon it would be Pascha, when an offering of the first crop was to be made. If now it was so early in the year that the grain would not be ripe, the month would be doubled and the beginning of the year postponed. In the same way the adaptation of the lunar months to the seasons of the solar year has originally taken place in other countries. Afterwards, as a result of centuries of practice, a regular rule founded upon better knowledge of the periods of the sun and moon was substituted for this irregular empirical proceeding. The highest development was reached in the 19-year period in which 12 ordinary and 7 enlarged years of 13 months were interchanged in a determinate way. This was reached in ancient Greece through the golden number of Meton, as well as in the old Babylonian and in the existing Jewish calendar.

So we find the science of astronomy in its first beginnings grow-

ing out of the necessities of practical life. But we know that not everything in society depends on practical usefulness. Where society develops to higher forms, where, by commerce or by the fertility of the soil an abundance of goods is produced above immediate needs, where a dominating or a wealthy class takes the direction of the more complicated social structure, there has grown up a more refined culture and more differentiated spiritual need, which themselves become new incentives to study and research. The history of astronomy presents an example of this. These beginnings of science, as a basis of travel and chronology, may be compared to a vigorous useful plant, firmly rooted in the soil of practical necessity. But now from it there blossoms, like a beautiful flower of luxury and fancy, astrology, the doctrine of the intimate connection between the course of the stars and the fate of mankind, which during dozens of centuries was the mightiest motive power of science and which exalted astronomy from a practical knowledge to the rank of a sublime doctrine.

Out of the primeval civilization of Babylon it was born, a mixture of primitive superstition and high mental aspiration. All primitive peoples believe in omens and sorcery, in prophesying and exorcisms. In the first stage of religion they saw the world around them full of spirits, good and evil ones, on whose sentiments and interposition the success of their work depended. So they tried to win their good will, or at least to know their intentions. Among other omens now and then, also, celestial phenomena—e.g., eclipses or shooting stars—were considered as indications of the future. But only in Babylon arose a firm and intimate connection between divination and the firmament.

Here, in the fertile plains of the Euphrates and the Tigris, already in pre-Babylonian times, large centralized empires arose, chiefly from the necessity of a general regulation of watercourse and water supply; besides, the military power of the princes' organized priesthood stood as the chief spiritual power. Their task of serving the gods included the fixing of dates for general ceremonies, the regulation of the calendar,—consequently the observation of the celestial phenomena.

When watching, in their wonderfully clear climate, the appear-

ance of the new moon in the evening sky or its rising and setting, for the exact times of the full moon sacrificial rites, their attention would be drawn to the constellations, regularly changing each month, and especially to those bright stars, the planets, wandering in quite irregular trails among the other stars, as travellers over a landscape. What was their meaning? The meaning of the sun's and moon's motion was obvious; one provided the change of seasons, the other regulated the time. Then these other luminaries must also have a meaning; they had to indicate the other regulations which the gods made for mankind on earth. Each of them was identified with one of the chief gods of their Pantheon. In this way in the mind of these priest-astronomers the conception arose of a world unity, where the phenomena of the sky were the prototype of the happenings on earth. They saw the seven light-gods, while quietly describing their irregular tracts through the stars, spinning the threads of destiny for the peoples and empires on earth. Now the attentive observations of the celestial phenomena became still more necessary than for the practical aim of the calendar; it was now a holy service of the gods, it was reading their messages to their servants, the priests, the kings and the other men.

In the large collection of clay tablets covered with cuneiform inscriptions which were dug up from the ruins of the library of Assurbanipal at Niniveh and which now are preserved at the British Museum and have been partly deciphered, we have an important source of information about these things. Here we may see how, among other omens, from the flying of birds, the barking of dogs, the livers of the victims, the appearance of the clouds, also the omens from the moon and the stars take an especially important place. Continually the astrologers from the chief cities are sending their reports to the king on what they have seen and what is the meaning of it. To show the character of these observations and explanations I cite some of them from the collection, published by Thompson.

"When the star of Marduk (here Mercury) appears in the beginning of the year the crops will grow well. Mercury appeared in the month of Nisan. The planet approached the star Li (Aldebaran); this means the king of Akkad will die. The star of Marduk was seen in the Bull, as far back as the Pleiades it returned; during a month it was visible; rain, showers and floods will occur."



“When there is a ring around the moon and Spica is in it, the king of Akkad will have a long life. The moon was surrounded by a river; great floods and cloudbursts will come; Spica is within the ring around the moon.”

“Mars was in the region of Bel near the feet of Perseus; on the 26th of Airu I saw it high in the sky; to the king my lord I send the explanation. Mars approaches the Pleiades means: in Amurru is war; one kills another.”

“This night the moon was surrounded by a ring, Jupiter and the Scorpion were within. If Jupiter is within a moon-fence the king of Akkad will be besieged. When the Scorpion is within a moon-fence the lions will murder and the traffic of the land will be inhibited.”

We will, of course, not insist on these explanations; they were partly taken from the appearance, such as the comparison of a moon-halo with a besieged city or with a streaming river; partly from traditions of former events. The interesting fact is that astrology, in order to find a correlation with the irregular unexpectedness of events on earth, had to turn to these celestial bodies which show most irregularities in their appearance, not to the sun and the stars, but to the moon and the planets. So a regular and assiduous observation of the planets, which were of no use for calendar or travel, was secured; and this has been the foundation of the later development of astronomical science.

Of course a long time elapsed before this took place. During many centuries the priest-astrologers observed the planets, noted their motions in their reports, without thinking of deriving periods out of these observations. Moreover, this was not possible, as long as they did not have a regular and continuous counting of the years. But when such a counting was introduced, say 800 B.C., then soon a knowledge of the periods of the planets developed. Then they found the hidden regularities in what at first seemed quite irregular, and at last they reached a state of knowledge where they were able to predict the course of the moon and the planets with great precision. This perfection was reached nearly 400 or 300 B.C., in a time when Babylon was one of the capitals of the Persian empire.

By a thorough study of the clay tablets dug up from different sites Epping and Kugler have discovered the high precision of the modes of computation and numerical data which were used by the Babylonian astronomers during the following centuries in predicting the celestial phenomena. It must be remarked, however, that this high perfection of Babylonian astronomy was only numerical. Just because these astronomers were priests, bound to religious tradition, they have not conceived another world system than what is given by the ordinary every day appearance. Only after they handed on their knowledge to the Greeks did it become the basis of new cosmological systems.

Greek astronomy, before it came into contact with the Orient, had developed its chronology and a general knowledge of the chief stars. Because no mighty priesthood grew up in this land of separate independent townships and islands, religious tradition had not a paramount influence and philosophical speculations of laymen, travellers, merchants and landowners occupied themselves with the structure of the world. They surprise us by the boldness of their abstract conception and at the same time by the poverty of their observational facts. In these speculations, which found their climax in the grand world system developed by Aristotle, astrological believings find no place. This picture changes when, with the conquest of the Persian empire by Alexander, East and West came into contact. Babylonian collections of observations were sent to Greece, instruments such as had been used already at Babylon were introduced in Alexandria and other Hellenistic capitals in order to observe the stars. The periods found by Babylonian astronomers were now used by Hipparchus to build up his system of planetary epicycles. What had been mere numbers in Babylon, in the hands of the Greek astronomers became the elements and dimensions of geometrical orbits of the planets. By the combination of oriental richness of experimental facts and the Greek genius of abstract thought the golden age of ancient science was brought about.

Along with oriental science astrology now enters into the mind of the western peoples. Theophrastus, a pupil of Aristotle, wrote a work "On the Signs," in which he explains Chaldaean astrology, the stoics propagated its doctrine and in the Roman world it was



accepted by nearly every man of learning and culture. But here it assumed an entirely different character from what it had been in Babylon. In the old despotic empires of the Orient the stars of Marduk, of Ishtar and of the other great gods foretold the fate of states and princes, the happenings of importance for the whole country such as floods, harvest and war, but they did not take notice of the fate of the single ordinary men. In the citizens of Rome and Greece, however, a strong individualism had grown up, that did not ask after predictions on harvest and on politics but wanted to know the future of themselves. Horoscopy, the derivation of a person's fate from the position of the planets at his birth, now became the most important practice of astrology. In Babylon astrology had been a religious truth, so that nobody asked reasons. In the Roman empire the primitive religious beliefs had given way to a critical and sceptical state of mind; here each creed and each theory was discussed and so astrology had to be founded on logic and experience.

You smile at the idea that astrology should be founded on reasons from experience because from the standpoint of modern science we see it only as a superstition. If, however, we proceed from the general state of knowledge in those times we will see that it could bring forward for its support some facts of experience; it simply deduced too far reaching consequences from these facts—but so often did modern science. Let us look at the relations between the course of the heavenly bodies and the happenings on earth. First take the sun. For us the yearly alternation between heat and cold is an obvious effect of the changing height of the sun. But in the more southern countries the yearly period is not chiefly a change of temperature but an alternation of a wet and a dry season. When the complicated geophysical origin of these climatic peculiarities was not known the regular return of the rainy season was obviously connected with the presence of the sun in certain signs of the zodiac, which just by this reason bear the names of Waterman and Fishes. It was observed that storms, or excessive heat, or rains each year coincided with the rising or setting of certain stars; was it illogical to see in those stars the causes of these phenomena? Just in the same way the aborigines in some parts of Australia consider not the

sun but the Pleiades as the cause of the summer heat; for the sun they say shines all the year, but the Pleiades are only present in summer time. We may know better by the totality of our science but we cannot pretend that this is bad reasoning. Then for these ancient peoples was added the knowledge of a monthly period in physiological functions of the body and the phenomenon of the tides, which both pointed to an influence of the moon on earthly life. All this could give a firm certainty already of an intimate connection of celestial and earthly phenomena. If now at the occurrence of an extraordinary event, say a pestilence, there happened to be a conjunction of some planets or stars, a relation between the two events imposed itself at once upon the mind. We may remark that from one coincidence they should not derive a rule and that more caution in generalising should have been used; but then we have to consider the deep-rooted conviction of a unity of the whole world, which was the case in all astrological inferences. At that time heaven and earth were not so far apart as nowadays and men and the universe were more comparable and equally valued. Let us hear arguments from the astrologers themselves; I quote here the following reasons which Ptolemy gives in his great astrological work:

"We have here at once a thesis which is entirely evident and does not need a lengthy argumentation; a force that proceeds from the eternal region of the ether, propagates to everything that surrounds the earth, and is subjected to continual variations. The first elements below the moon, the fire and the air, are disturbed by the movement of the surrounding ether; in their unrest they draw with them the lower things, the water, the earth as well as the plants and the animals that originate from them. The sun which with the sky surrounds all the terrestrial things imposes upon them its fixed and permanent order. . . . The moon which is next to the earth influences all the earthly world in an obvious way; most animate and inanimate beings follow its changes; the rivers increase and decrease with the moon; as she rises and goes down the seas are moved by opposite streams and plants and animals feel in some of their parts or totally the influence of the increase or the decrease of the moon. Furthermore, the course of the stars is an omen to numerous phenomena in the air, such as heat, cold or wind. The relative situations of the stars are a cause of many variations, for by their combination the celestial bodies mix up their effects. The force of the sun surpasses, after the structure of the world, the other stars, but still they can add to or subtract from what it does. The moon shows this most obviously in its different phases; for the other stars, we cannot verify this so often and in such a clear way."

I suppose many are astonished to hear that this is said by Ptolemy, the most famous astronomer of antiquity. That is because modern writers are in the habit of speaking of old astrology as a regrettable aberration of the human mind, and of trying to wash the famous astronomers of history clean from the stain of having believed this superstition. You see that nothing could be more false than this standpoint. In our text-books only that part of ancient astronomy is reproduced which coincides with the beginnings of our modern science. But in reality the ancient science of the stars was in the first place astrology, the doctrine of the influence of the heavenly bodies upon earth and mankind. By this reason it was highly estimated by the princes in Egypt, the nobles and the emperors in Rome, who certainly would have had not the least interest in an abstract astronomy in our sense of the word and would not have favoured and endowed it. The methods of computing the planetary motions, the conjunctions, the eclipses, *i.e.* astronomy in our sense, was only a technical implement for this higher aim. The epicycle theory, this admirable ancient theory of the planetary motions, was only a geometrical means for practical computations. It was not meant as an image of the world-construction; for nowhere in Ptolemy's "Almagest" do we find the dimensions of these orbits given. An often repeated sentence of a famous philosopher, Posidonius, says, that the physicist has to make out, upon physical principles, what are the real motions in the world, the astronomer does not care what body moves and what body is at rest, and every theory is acceptable to him that represents the phenomena. This sentence is wholly unintelligible, if we do not take into account that the astronomer wanted only the relative and apparent motions for his higher purpose, their influence upon the earth.

The judgment of astrology as a regrettable aberration is wrong in a double sense. We cannot regret a belief that has been the chief means of raising the science of astronomy to the height it reached already in those ancient times. And though it has been superseded by the later development of science and proved to be an erroneous theory, it cannot be judged for this reason an aberration of the human mind, just as some other erroneous theories, such as the vortex theory of Descartes, Newton's emission theory of light, the

philogiston theory, or the theory of heat matter were not aberrations of the human mind. The way of science goes through error to truth, or more rightly, each former phase of science is error compared with later truth. Each cosmological theory in olden times was necessarily geocentric, considered the earth and mankind as centre and aim of the world. In this conception astrology was the expression of the belief that the universe was one unity, in which every part depended upon the others. If we place ourselves a moment into the ideas of those times then what more sublime aim could there be imagined than to investigate and to discover the most intimate connection between men and the world, between the course of the stars and happenings on the earth? And if we succeeded in discovering it, what science could have a greater practical importance for men?

From this standpoint we will not be astonished to find most of the great astronomers of antiquity also believing in astrology. The great astronomical work of Ptolemy, the "Almagest," is only a part of his whole treatise; the other part, the "Tetrabiblion," from which our citation was quoted, deals only with astrology, and it was in the next fourteen centuries studied with the same ardour as the "Almagest." The same holds for the astronomers of the middle age, the Arabian as well as the European, from Albattani until Regiomontanus; all of them while studying the science of antiquity occupied themselves with astrology. And all this time astronomy depended on astrology. It was the belief in the influence of the stars upon the earth and the hope to know the future that induced the Califs and the Sultans in the Orient to erect observatories, to pay astronomers and to have translated the ancient astronomical works. By this general interest in astrology the study of the difficult geometrical theories of the planetary motions was kept awake and even towards the end of the middle ages led to the perfection of trigonometrical methods. In Europe the Catholic church condemned astrology as opposed to its theology; she had adapted the world system of Aristotle to its doctrine and in this system astrology was not admitted. This did not prevent the learned monks and laymen from studying the works on astrology as well as other heathen literature, and to believe more or less in its truth. And at the dawn of the new age, astronomy received a fresh impetus, as a repetition on a

higher plane of its first history; the calendar was in disorder, so that fresh inquiries about sun and moon were necessary, and by the discovery of America and the Indies navigation of the oceans wanted the help of an astronomy of higher precision. And now astrology too once more rises up into a brilliant flame, before it is extinguished.

Probably social conditions strongly contributed to awaken in the 16th century an intense interest and belief in astrology. Out of the middle ages a new society, with new conditions and new antagonisms, arose. The discovery of new continents gave a fresh impulse to human energy and opened wide horizons of adventure; but the inflowing stream of gold raised all prices and improverished the mass of the peoples. While the human mind awakened from mediaeval sleep and enjoyed the new knowledge the desperate peasants rose into revolts that were crushed in streams of blood. The art and science of the Renaissance, the finest blossom of culture, grew up at the courts and in the homes of princes and rich citizens, while at the same time barbarous bands of mercenaries went ravaging and murdering through the lands of the highest civilization, such as Italy and Holland. The princes fought against the nobility, the nobility against the citizens, the peasants against the nobility and the princes, the citizens against one another,—a wild pell mell of dynastic, religious and civil wars, of which nobody could see the goal and outcome. Bewildered, men stood in the midst of this world of cruel struggle; and no less cruel was the world of fantasy that grew up in their mind. Never the belief in devils and witches rested so heavily upon their brains as in this time; on every side man felt himself surrounded and threatened by terrible powers. Certainly these same superstitions had been present in the middle ages; but then the powerful authority of the Catholic church had given comfort and certainty to the oppressed minds. Now, however, this authority was broken, and a new mode of thinking and feeling with the same security had not yet arisen. This state of mental derangement was a fertile soil for all kinds of belief and superstition.

It is no wonder that in such a time of transition the most highly cultivated minds turned to astrology. The fate of man apparently was subjected to cruel chance. But here was an outlook to a fixed



order. Here perhaps the torturing uncertainty about the future could be destroyed by linking the wavering destiny of men to the calculable course of the eternal stars.

You all know that modern astronomy was founded upon the long series of observations by Tycho Brahe. And what was it that induced him to make these observations? It was his belief in astrology.

Tycho Brahe, a Danish nobleman, belonged to that group of searching minds, so numerous in the 16th century, who, driven by a keen desire of understanding the secrets of the world, occupied themselves with every kind of science, with alchemy, with anatomy and with astronomy. We have a document in which he revealed his ideas on these matters, a public lecture given by him in 1574 at the University of Copenhagen, now reprinted in the edition of Tycho's complete works. Its title is significant already; "*De Disciplinis Mathematicis*,"—On the Mathematical Sciences—and it is almost entirely devoted to astrology. Astrology was for him just as generally at that time, the real mathematical science, the chief science for which mathematical methods were used. In order to show you, in addition to the Babylonian and the ancient aspect of this doctrine, also its 16th century character, I may cite some parts of it:\*

"Whoever denies the forces and the influence of the stars undervalues firstly the divine wisdom and providence and contradicts moreover the most evident practice. For what could be thought more foolish about God than that He should have created this large and wonderful scenery of the skies and so many brilliant stars to no use or purpose—while even man makes his least work always with some aim. That we may measure our years and months and days by the sky as by a perpetual and indefatigable clock does not sufficiently explain the use and purpose of the celestial machine; for this

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\*In *Popular Astronomy* of June-July, 1929, a translation is given of the first part of this lecture by R. H. Coon; the translator says about it "While not possessing scientific value it has a genuine interest as it expresses the reflections of so distinguished a scientist." It is clear, however, that the omission of the second part of the lecture, treating on astrology, must give an entirely wrong impression of the real mode of thinking and of the reflections of Tycho. If there is any interest for us to get a right conception of the personality of Tycho a translation of the remainder of that lecture would be very desirable.



measuring of time depends only on the big lights, sun and moon and on the daily rotation. For what purpose, then, serve these five remaining, in different orbits revolving planets? . . . . . May we suppose that God has made such a wonderful work for no aim and use? . . . If thus the celestial bodies are placed by God in such way as they stand in their signs, they must have of necessity a meaning, especially for mankind, for whom everything chiefly has been created . . . . But not less those, who speak in such a way, violate clear evidence which it does not suit for educated people with sane senses to contradict. Who did not perceive that the difference in quality between the four seasons proceeds from the rising and the decreasing of the sun and its course through the twelve parts of the zodiac? We see too, that with the waxing of the moon everything cognate to her nature—such as the brains in the living beings, the marrow in the bones and the trees, the flesh in the shells and many things more—increases also, while it diminishes when the moon wanes. In the same way the flux and reflux of the wide ocean is affixed as with a chain to the moon's motion, so that immediately with the rising of the moon the sea also begins to rise. . . . These and kindred phenomena are known even to uneducated people. Then sailors and peasants by repeated observation have perceived that from the yearly appearance and disappearance of certain stars they can predict occasional storms. The scholars, however, who are trained in abstract science have deduced that the configurations of the planets with one another or with sun, moon and stars have an influence too. They have observed that the condition of the air in the seasons of different years are changed by them in a different way. So it has been perceived that conjunctions of Mars and Venus in certain parts of the sky raise showers and sometimes thunderstorms. . . . That important conjunctions of the big planets cause large changes in these lower parts of the world has been shown often by experience. So in 1563, when a conjunction of Jupiter and Saturn took place in the first part of the Lion, near to the nebulous stars of the Cancer, which Ptolemy calls the smoky and pestilent ones, did not then the heavy pestilence which made perish in Europe numerous people, show the influence of the stars by an undeniable fact?"

Then, after treating the opinions of those opposed to astrology, Tycho proceeds:

"But we, on the other hand, hold that the sky not only operates on the atmosphere but also directly upon man himself. Because man is made out of the elements he is subjected to the same laws as the matter of which he consists. Since, furthermore, the air which we inhale and by which we are fed not less than by food and drink, in different ways is affected by the sky, as has been shown above, it is unavoidable that we also are affected by it in different ways. And then I leave apart, what must be clear for every mind, that man by some hidden cause lives and is fed by the sky in a still higher

degree than by air, water and other low elements, and acquires an incredible affinity to the related stars; so that not wrongly ancient philosophers, among them after Pliny's testimony also Hipparchus, have said that our spirit is a part of heaven itself."

All this may not be very convincing to us because, for the real facts of experience as the yearly variations and the tides, we have other explanations founded upon the wider and more developed science, but it shows how strongly rooted in its author was the conviction of the truth of astrology. He was also practically engaged in it; when a prince or princess of Denmark was born, he calculated for the king's use their horoscopes after the common rules. But he was not all too confident in them himself; he often points out the uncertainty of the predictions, because he was convinced that the science of the connection between heavenly and earthly happenings was still in its imperfect beginnings. It was his aim to advance it and to discover the real details of these connections. The condition necessary to it was an exact knowledge of the events in the heavens, the motions of the planets. He had observed that the time of conjunction just mentioned, between Jupiter and Saturn, was given many days in error by the then existing planetary tables. Obviously they were not exactly right and the reason was that the elements, the numerical data of the circular movements, from which the tables had been computed, rested themselves only on a few observations, especially made for the purpose of ascertaining either the period, or the inclination, or the eccentricity of the orbit. Tycho was the first to realise that to find the real motions of the planets it was necessary to observe them continuously, one year after another as often as possible, so he resolved to devote his life to this task. From the king he obtained the small island Hveen as a feudal tenure, and the means of building an observatory and constructing instruments of the highest precision possible. With these he made during 16 years, 1580 to 1596, an extensive series of observations of the sun, the moon, the stars, the planets, the comets, with an accuracy hitherto unknown and only once again reached with instruments without telescope. After his departure to Bohemia, in 1596, the observations were still pursued, until his death in 1600. Then the discussion and computation of the orbits of the planets from

these observations was the task of his assistant, Kepler. The further history is generally known; how Kepler first attacked the problem of Mars, how he started from the same hypothesis as was always used till then, of eccentric circular orbits for the planets, and only substituted his sector law instead of the older explanations of the variable velocities. But there still remained some small differences between Tycho's observation and the computation from these orbits, so small indeed that formerly they would have been entirely disregarded, only 8 minutes of arc, but regularly recurring and too large for the high accuracy of Tycho's work. After years of troubles and trials he found at last the explanation that the orbits were not circles but ellipses. And so were found the laws of the planetary motions, the stepping stone for the rapid progress of astronomy in the next century, leading to the discovery of the laws of gravitation by Newton.

Thus we see that twice in the history of science up to the beginning of the 17th century there have been collected large series of observations of the planets; once in Babylon from the 8th century B.C. onward, and the second time in the 16th century by Tycho Brahe. And in both cases they supplied the foundation for a great progress of science, first the discovery of the planetary periods and the system of epicycles, building up the construction of ancient astronomy; the second the discovery of Kepler's laws and Newton's gravitation, the basis of modern astronomy. And both times it was the belief in astrology that gave the observers the patience and the high-minded endurance to pursue their work consistently through all these years and centuries.

After it had rendered this supreme service to science astrology went down. With the acceptance of the new world system of Copernicus, its basis,—the anthropocentric conception of the world,—was taken away. And at the same time in the 17th century political and social conditions settled into a new fixed order and so the mystical needs, that gave her strength in the former century, disappeared. Some of its doctrines were still fostered in this century; Kepler with his rich fantasy seems not to have given it up entirely; in the narrative of an English clergyman, Horrocks, on the first observation of a transit of Venus across the sun, he men-

tions the rainy weather caused by a conjunction of planets; and in the popular belief of the moon's influence on the weather we see still in our time its remnants. In the 17th century the princes still had their astrologers at their courts, but they were already partly considered as impostors. Astrology did not at once disappear, but its practice and theory are now only possible as a superstition, outside of science and beneath it. The astronomers now see new and other larger aims before them. The principle of which it once was the expression, the conception of the unity of the whole world, had now to take a new form; to find not the connection of universe and man—for man is now only a small and accidental attribute to one small planet—but to find the laws of the universe itself. On this new path astronomy has gone upward during the following centuries.