Mss 374

Keppler

Johann Keppler it was who discovered the form of the planets' paths in coursing round the sun and the law of their varying speed. This achievement, by far the most ~~intricate~~ triumphant unravelment of facts ever performed, — cunninger that any deciphering of hieroglyphics or of cuneiform inscriptions — occupied its author's whole time from October 1600 to October 1604, and the greater part of four years more. That fairylike town Prague was the scene of these studies and there in April 1609 was published the immortal Commentaries on the Motions of the Star Planet Mars. To gain any idea of a scientific research, one must look with one's own eyes and brain at the things with which it deals. Now the year 1892 happens to be a good one for watching Mars, and if the will from his own naked-eye observations set down

upon a star-map (say upon the figures in the Century Dictionary) the course of the planet from the third week in March to the end of the year, as it traverses the constellations Sagittarius, Capricornus, and Aquarius, the true greatness of Keppler will begin to dawn upon him. For the telescope was only invented in the very year in which Keppler's book was published; so that he had before him only naked-eye observations, and saw only what anybody may see.

During the year 1892 Mars will describe a loop among the stars, moving first eastwardly, then gradually bending to the south, then to the west, then to the north, and last to the east again, so that on October 6 he will cross his previous path at the point where he was on June 10. This motion in a loop is characteristic of all the planets; and to account for it, the ancients very naturally supposed each to move round a circle

itself carried round another circle, within which, though not at its centre, the earth was immovably fixed. ~~But~~ They could not make the centre of the first circle move at a uniform rate round the circumference of the second; but took within the latter, at the same distance from its centre that the earth was, but on the opposite side, another fixed point, round which the centre of the first circle described equal angles in equal times. They found themselves further obliged to suppose that the first circle had a perpetual tilting, or reciprocating motion around an axis tangent to the second.

Copernicus, however, had shown that it was better to suppose earth and planets to move round a common centre very near the Sun, while still continuing to make them move on circles that were carried round on other circles and balanced back and forth.

Keppler was the scientific executor of the astronomer Tycho Brahe, who had measured as well as he could with the rude instruments of those days

the celestial latitude and longitude of Mars in ten alternate years. From the study of these observations together with and a few of his own of inferior value (for he was both near-sighted and awkward) and those by the ancient observer Ptolemy, Kepler found out and proved conclusively, that there are no such tiltings, or libration, as had been supposed but that all the motions of Mars take place in a plane having an excessively slow motion if any, and furthermore, what Copernicus had failed to discover, that the sun lies in this plane, and also that Mars does not move in one circle carried by another, but simply in an ellipse having the Sun at one of its foci*, and also that this ellipse itself turns round at a very slow rate, and also that ~~Mars in its revolution~~ round the line from the Sun to Mars describes in its motion equal elliptical sectors in equal times. Was it not wonderful to make out all this, and with perfect certainty too, from mere naked eye observations which anybody could nowadays improve upon with the commonest Gunsell

* The foci of an ellipse are two points within it such that if from them lines be drawn to any point on the ellipse those lines are equally inclined to the curve at that point and their sum is equal to the greatest diameter of the ellipse.

instruments?

The Keppler family had once been noble; but Johann's near ancestors were artisans of Nürenberg, coarse people, hard and shrewd, but not long-lived. His grandfather, was a bookbinder, had removed to Weil der Stadt near Stuttgart, where, owing to his reputation for sagacity, he had risen to be burgomaster, and where Johann was born. His father was a soldier and inn-keeper, his mother, a yellow blonde, little and spare, with a terrible tongue that was a curse to herself and to all that were near her; in later life narrowly escaped being burnt as a witch. Her husband abandoned her when Johann was 18 and his only brother 14 years old. Johann, who had been born prematurely, was physically puny and ailing all his life; yet was rather pleasing in appearance, and vivacious in his movements. Though not a precocious child, he was a clever lad, especially at mathematics, eager to learn, curious about all the ways of nature, and in short manifesting that gigantic power of right reasoning that distinguished him from other men. ~~He~~ It was

this reasoning, no doubt, that stimulated him even as a boy to his indomitable industry for which he is celebrated and which was all the more extraordinary that, not to speak of his delicate health, his was a nature to which all drudgery was uncommonly irksome. His success in his studies, together with his weak body, naturally pointed to his becoming a Lutheran minister, and to that end he was sent to the university of Tübingen as a stipendiary scholar. But when later astronomy seemed to offer a better opening, he turned from theology and devoted himself to the study of the stars under Professor Maestlin. In this he was governed, as in all the affairs of life, by careful calculation; for he assures us that of predilection for astronomy he had none.

In those days, by a "mathematicus", or "Sternseher", was meant understood a man that earned his living by making astrological predictions. Into this study Keppler

threw himself with energy, and was more or less 7
addicted to it all his life. He soon came to rate it
as nonsense and trickery, and therefore disliked to
practise it. Yet, said he, astrology has been the nurse
of astronomy. He meant that astronomy could only
be advanced by students wholly given up to it, and that
the world could hardly be persuaded to give people
a livelihood for doing only that. For astronomy seemed
to be of no practical use, and was in fact of none
except posterity; though by calling modern ma-
thematics and physics into being it has indirectly
been the source of all the conveniencies and inventions
of our time.

At 22, Keppler was appointed professor of
mathematics at Grätz in Styria, a hundred miles south
of Viennee. At 25, he succeeded in marrying a well-
~~to~~ wealthy young grass widow. Meantime, his
position in Grätz was becoming untenable on account
of his protestantism; for though so far from a bigot
that he was called a half-catholic and was finally read

out of the Lutheran church for his too easy opinions, yet he would not join the catholic church. He used so much policy that the jesuits took his part, and remained after the other protestant professors had most of the scholars had gone. But, at last, he was glad at 28 to accept the Great Tycho Brahe's invitation to become, under him, assistant astronomer to the Emperor Rudolph II. On Tycho's death in the following year, Keppler was made chief "mathematicus" with an additional allowance for preparing planetary tables from Tycho's observations. A strange appointment this, wherein power missed a rare opportunity of doing a stupid thing; but the explanation of it is that Keppler was designated by the dying Brahe for the task. Besides, Rudolph really had some knowledge of astronomy. These tables were computed in 26 years, and were published under the title of the Rudolphine Tables. During their preparation,

Keppler had many a tussle with the representatives of the noble house of Brahé, who as long as Tycho lived had frowned upon one who would demean himself with star-gazing, but who now insisted that ~~it should be~~ his theories should govern the new tables; for what Nature's truth might be, if they ever so much as reflected that there was such a thing, they neither knew nor cared. The last breath of the dying Tycho himself had been expended in imploring Keppler to follow his system; but then, that was before Keppler's great discoveries. At 37, he published his great work on the motions of Mars. About that time discord arose between Emperor Rudolph and his brethren. Prague in 1611 found itself the focus of the theatre of war. That year all Keppler's family were very ill. His favorite son died, and his wife followed. She left no will, so that the property was divided among her children

to the exclusion of the father. Meantime, Rudolph was forced to surrender Bohemia to his brother Matthew; and Keppler moved to Linz in Austria proper. After Rudolph's death, Matthew succeeding to the imperial throne continued his brother's bounty to Keppler. On 16:3, Keppler being 42 years old married after the maturest deliberation a poor girl 18 years younger than himself. At 46, he discovered his "third law," that the squares of the periodic times are proportional to the cubes of the mean distances, not a discovery involving any difficult reasoning, yet leading at once, had he only been able to see it, to the corollary that the planets are attracted to the sun inversely as the square of the distance. The same year began the Thirty Years' War. Then Emperor Matthew died and was succeeded by the bigoted Ferdinand II. Keppler's books were prohibited in some places for teaching that the sun does not move round the earth. There was little hope of further salary, even if he should not be proceeded against; and he received private intimations from the emperor that it would be well for him to renounce astronomy. Then came the invention of Logarithms, requiring the

planetary tables, now nearly ready, to be entirely reconstructed. In 1620, in the midst of his greatest difficulties, the learned James I warmly invited Keppler to go to England; but he would not accept the saccour, lest the tale should be told to the disgrace of his own country; and at last by prudent conduct he overcame his chief difficulties. In 1630, at the age of 59 while on a journey he died rather suddenly at Ratisbon of an infectious fever. He had had in all 12 children.

As the endowments of Keppler's intellect and heart seem to have been concentred upon one function, that of reasoning. In his great work on Mars, he has laid bare to us all the operations of his mind during the whole research; and what better sign of the perfection of this ratiocination could there be than that no better pathway could be found by which to lead another's thought to the same conclusion

them that his own had broken in the first instance. His admirable method of thinking consisted in forming in his mind a diagrammatic or outline representation of the entangled state of things before him, omitting all that was accidental, retaining all that was essential, observing suggestive relations between the parts of the diagram, and performing divers experiments upon it, or upon the natural objects, and noting the results.

The first quality required for this process, the first element of high reasoning power, is evidently imagination; and Keppler's fecund imagination strikes every reader. But "imagination" is an ocean-broad term, — almost meaningless, so many and so diverse are its species. What kind of an imagination is required to form a mental diagram of a complicated state of facts? Not that fact-imagination that "bodies forth the

forms of things unknown," but a docile imagination, quick to take Dame Nature's hints. The poet-imagination riots in ornaments and accessories; a Keppler's makes the clothing and the flesh drop off, and the apparition of the naked skeleton of truth to stand revealed before him. Accordingly, we are not surprized to find that Keppler looked upon life with an eye of sadness, without tears, yet without illusions.

No man was ever more coolly sensible of his own faults and weaknesses, as well as of his own superior powers. In coming to an understanding with Bouhé, he recommends himself as follows: "in observing I am under the disadvantage of nearsightedness, and am awkward in handling instruments; while in transacting business, my own or others, I am betray an impertinent and choleric nature; nor can I bear to sit long at work,

without getting up and moving about, nor to pass my regular hours for meals, even when I am not downright ill." There is no looking at himself through soft violet glass here.

He never was able to put aside a puzzle until he had completely resolved it. Early in his studies of Mars he obtained a theory which so accurately represented its Heliocentric Longitudes, that he ever after called it his "vicarious theory," inasmuch as it obviated the necessity of resorting to the observations. It saved the appearances as far as Heliocentric Longitudes went; and that would have satisfied many an astronomer. But Keppler could not be satisfied, since the theory did not agree with the latitudes nor geocentric longitudes; and by far the greater part of this labor came after he had obtained this vicarious hypothesis.

Keppler was forever trying experiments with his figures. No bad luck, not dozens of negative results,

which other men rather failures, could discourage him from trying again. Yet it would be a great mistake to suppose that he was addicted to wasting time on wild-cat theories, or what Darwin used to call nonsense-experiments. Each step was made deliberately, and for sound reasons; and few of Kepler's "failures" failed to throw some light on the problems he had in hand.

When the slightest clue presented itself, Kepler's promptitude to seize upon it was amazing. The last and most essential step of his great discovery was made according to his own account by accident. Namely, it was due to his remarking that two numbers which seemed to have no connection with one another were nearly equal, one 429, the other 432. Kepler does not remark that an ordinary man's attention would not have been struck by this near equality, or if it had, would never have divined its meaning. Significance.

There is one moral quality without which a reasoner cannot escape fallacies, and that is a sturdy honesty of purpose. For the lack of that, we every day see creatures in the guise of men losing fortune, health, and happiness too, deluded by their own sophisms. But Kepler, while not altogether devoid of astuteness and diplomacy, could hardly bring himself to aid his fellowmen to dupe themselves with astrological predictions; and this certainly was the nearest approach to duplicity that he ever made. It had its effect, no doubt, in blinding him to the fanciful character of some of his speculations; — another instance of the inevitable intellectual retribution which follows upon guile.

Johann Keppler it was who discovered the form of the paths of the planets in their course round the Sun and the laws of their velocities in these paths. This achievement, by far the most difficult unravelment of facts ever done, — greater than Mendeléef's Law, greater than the deciphering of ~~the~~ any hieroglyphics or cuneiform inscriptions, — occupied the whole time of its author, in beautiful Town of Prague, from October 1600 to October 1604, and a great part of his time for four years more. The great book which explained it De Motibus Stellae Martis was published in April 1609. If the reader cares to procure Heis's Star Atlas and, with the aid of an opera glass to set down night after night during a suitable year, say 1892, ~~for two years~~ the positions of the planet Mars among the stars, he will find that it moves

generally in an eastwardly direction, but with one turn backwards, or retrogression, so as to describe a ~~long~~ loop. Thus in the third week of March before sunrise Mars may be seen in the south east in the bow of Sagittarius. He will traverse ~~that constellation~~ from the rump of that figure and be found June 10 behind the shoulder of Capricornus. On July 6, he will be stationary ~~under the tail~~ in the flipper of Capricornus. Then, he will go back in a southerly course (coming in to opposition on Sept 4 August 3) till it gets where the leg of Capricornus reaches beyond the ~~body~~ chest. Here it will turn east again, and on October 6 will be just about where it was on June 10; and before the end of the year it will rapidly traverse the ~~breast~~ first fingers of Capricornus and the whole breadth of Aquarius about the loins ~~rising~~, when it will be lost in the beams of the setting sun. To account for this sort of motion, the ancients supposed each planet to move

round a circle itself ~~which~~ carried round another ~~line~~ which it was inclined, and perpetually tilting backward and forwards. Copernicus showed that it was better to suppose the earth and planets all to move round the Sun; but he continued to suppose they moved in circles carried in or ~~by~~ the circles and having a tilting or balancing ~~motion~~. Now, remember that ~~the~~ telescopes had not yet been invented; Keppler had before him ~~nothing~~ but naked eye observations; such as anybody could make now with a sextant and a star-catalogue; he saw only what anybody can see by the study of ~~twelve~~ ten years observations and yet ~~what did he make of~~ he found and conclusively proved of Tycho Brahe ~~and~~ that all the motions of Mars take place in one plane, that it describes ~~a circle~~ not a circle or a circle nor any curve but an ellipse, that the Sun is in ~~the~~ one focus of this ellipse, and that Mars in its ~~motions~~ revolution round the Sun describes equal triangular ~~spaces~~ areas in equal times. Was it not wonderful, to make out

all this, and that with complete certainty, from mere naked eye observations?

The Keppler's had once been noble; but Johann's near ancestors were artisans of Nuremberg; ~~his grandfather was a bookbinder, his father a soldier. They were~~ coarse people but hard and shrewd. His grandfather was a bookbinder, his father a soldier. His mother was a ~~terrible creature~~, little, spare, blond, with a most terrible very tongue, who after Johann grew up came near being burnt for a witch. His father ran away and left her with her two boys in destitute circumstances. He himself was a delicate, always ailing, if not scrofulous, little fellow; very near sighted, but very lively. He was not a precocious child, nor had he as a Youth any bent for astronomy. But he was bright, very clever at mathematics, very curious about nature, and much given to beginning things that and finishing. He did not finish. As a man he had the temperament of a student, irascible and almost ill-tempered. But he was singularly conscious

of his own defects, and looked upon all the affairs of life with a cool, unbiassed eye. He married twice, first, at 25, a rich widow; then at 42, a poor girl. He had 6 sons and 6 daughters. His health was never strong; he had to be very careful about his diet. Though a hard worker, he was not at all fond of drudgery. He died at 59 ~~of an obscene~~ rather suddenly of an obscene disease.

Keppler's style of writing is admirable; and carries conviction to the mind of the reader by detailing the whole train of reasoning of the author. Occasionally it is enlivened by personal poetical quotations or Lemmas by similes. In his book on the New Star in Ophiuchus (Chapter xxvii) discussing the Epicurean opinion that the world is due to the fortuitous concourse of atoms, he says: "Yesterday when fatigued with writing and my soul reduced to ponder by thinking of those atoms I was called to supper and my wife brought me a salad. So, said I, if throughout the ~~air~~ air there had been flying from eternity, a lot of

pewter platters, leaves of lettuce, grains of salt, drops of water, vinegar, and oil, (ants of eggs, it should at last happen by chance that that would make a salad. Yes, said my wife, but not as nice a one as this." In his work Harmonice Mundi, where he announces his celebrated third Law of planetary motion (Book V, praemium) he says: "It is a toss-up whether I write this book to be read by contemporaries or posterity; and it makes no difference; it can well wait its reader for a hundred years, if God himself has for six thousand years stood awaiting an understanding contemplator." I confess I do not like this passage. The rule of three it suggests is quite out of place; and besides, it implies that Kepler thought he had said the last word about the planetary system, thus betraying an enormous misunderstanding of his function in the development of science.

Johann was born), his father was a soldier. His mother was a little, spare, blond, with a terrible tongue, a curse to herself and all who were near her, who after Johann grew up came very near being burnt for a witch. His father ran away and left her with her two boys destitute. Johann was a delicate little man, always ailing, very near sighted, lively and witty. He was not a precocious child; nor had he in his youth any bent for astronomy. He was clever, however, especially at mathematics, extremely curious about all natural things, and fond of his books; so that his mother managed to send him to the University. When he was young, he was much given to beginning studies which he was not able to carry out; older, he had the temper common among students, irascible and almost ugly. But he was always singularly conscious of his own defects, and looked upon the affairs of

life with a cool, unbiassed eye. He married twice; first, at 25, a well-to-do widow; then, at 42, a poor girl. He had six sons and six daughters. He died at 59 rather suddenly of an obscure disease.

principle in his representation were as follows.
1°, he represented the ~~planetary~~ deferents by
the circles circumscribing the ~~true~~ ellipses,
thus giving it a breadth too great in the
case of the Mars, most elliptical of the superior
planets, by one half of one ~~per cent~~ Per cent. 2°, instead
of supposing the moving radius AD to describe
equal areas in equal times, he drew a
line from D, the ~~point~~ attachment of the epicycle to ~~cen-~~
~~tre~~ the deferent, to B, ~~the which was~~ called the centre of the equant, being
the empty focus of the ellipse, and he
supposed this line BD to turn equably,
so as to describe equal angles in equal
times. This made a quite observable
error, but only in the case of Mars.
3°, he not only made the epicycle circu-
lar but he placed its centre upon
the deferent. 4°, he made the planet to
~~move round~~ revolve in its epicycle in
~~such a manner~~ ~~at a uniform~~ so as to describe

The former phenomenon was accounted for by supposing that at two opposite seasons the epicycle was at a greater distance from the earth than at the seasons three months from these, and to produce this motion a complicated mechanism was introduced. Namely, the centre of the equant remaining fixed, the centre of the deferent itself revolved uniformly about a centre, ~~for~~ ~~in a Line~~ as shown in Figure 3. ~~with the~~ But this hypothesis greatly falsified the relative distances from the earth, and inasmuch as the plane of the orbit of Mercury is inclined more than 7° to the ecliptic, it thus threw the latitudes into confusion, so that to bring them nearly right the deferent was supposed to oscillate about an axis in its plane while the ~~eccentric~~ epicycle had two independent oscillations about different axes, and even so the theory remained unsatisfactory.