MEDICINE AND MATHEMATICS IN THE SIXTEENTH CENTURY

By DAVID EUGENE SMITH, LL.D.

NEW YORK CITY

NO one who gives serious attention either to the history of medicine or to the history of mathematics can fail to be struck by the number of physicians who have excelled in mathematics and astronomy, and by the number of mathematicians who have been skilled in the healing art. The cases are so numerous as to surprise even those who would naturally be familiar with the connection between the two sciences, and they are by no means confined to any single race or to any particular period. To enter into an exhaustive study of the matter would be impossible within the limits of a paper of this character, such a study of the Arab civilization alone being enough to fill a printed volume.[1] All that can be attempted under the present circumstances is to consider some of the causes of the phenomenon and to speak of its development in the century of its greatest prominence, namely, the period from 1500 to 1600.

When we seek for the cause of any occurrence whatever, as of some disease or of some event in the domain of astronomy or history, we always find that it is by no means unique. Various contributing influences enter into the situation, and so it is with the close relationship between the medical and mathematical sciences.

One of the most potent causes in this case was the general belief, both in ancient times and in the Middle Ages, in the influence of the stars upon human life. Astrology therefore became the handmaid of medicine and was looked upon by the intellectual world as part of the equipment of the man who aspired to highest rank in the medical profession. Great stimulus was given to this idea through a translation of a passage in Hippocrates in which the master speaks of τι θεῖον in disease, a term which the early translators rendered by *cœleste* instead of *divinum* and which was thus thought to refer to the influence of the heavenly bodies.[2] Moreover, there was much to encourage the belief because of the manifest curative powers of the sun, of the influence of the moon upon human emotions, and of the force of tradition derived from the religious beliefs of the ancients in the power of the stars. To our somewhat more scientific minds a little of this belief seems warranted; but we of the present fail to comprehend the further belief in horoscopes or to recognize that the best scientific minds of a few centuries ago failed as completely to take our own point of view. That a man like Caspar Bartholinus (1585–1629), father of the mathematico-medical scholar Erasmus Bartholinus (1625–1698) and professor of medicine at the University of Copenhagen, should have seriously advocated the claims of astrology [3] only three centuries ago seems to us quite beyond reason, but such cases were by no

[1] For example, in Wüstenfeld's list of 300 Arabian physicians ("Geschichte der arabischen Aerzte und Naturforscher," Göttingen, 1840) there are the names of 38 prominent mathematicians, while many of the others were doubtless interested in the subjects of astronomy or mathematics. In Suter's list of 528 Arabian mathematicians ("Die Mathematiker und Astronomer der Araber und ihre Werke," in *Abhandlungen zur Geschichte der math. Wiss.*, Leipzig, 1900), at least 85 are known to have been physicians.

[2] E. Withington in Little's "Roger Bacon Essays," Oxford, 1914, page 343.

[3] "Astrologia, seu, de stellarum naturâ," Wittenburg (?), 1612, and his "De astrologia," Rostochii, 1616.

means rare at that time or even up to the close of the eighteenth century.

To this belief in the power of the stars is partly due the development of the Greek-Alexandrian sect of iatromathematicians,[4] a sect that has its origin in the superstitions of the ancients long before the period of Hermes Trismegistos.[5] The beliefs of these iatromathematicians, relating chiefly to the application of astrology in the domain of medicine, have been clearly set forth by Sudhoff, particularly as they showed themselves in the fifteenth and sixteenth centuries.[6] These beliefs are to be found in the writings of some of the best scholars of earlier times, such as the Rabbi ben Esra of Browning's poem, who asserts that a lunar eclipse at the beginning of an illness has a baneful influence, that a solar eclipse prolongs the period of sickness, and that a conjunction of planets or of the sun and moon is a very dangerous sign. Another such writer was the Arab scholar Alcabitius (fl. c. 965),[7] whose work on astrology was translated by Johannes Hispalensis and commented upon by Johannes de Saxonia.[8]

Still another example, and this from the thirteenth century, is seen in the case of Roger Bacon.[9] This remarkable man touched all branches of science then known, and in particular he wrote upon medicine as set forth by the school of Galen and by the Arab writer Avicenna.[10] Just as he antagonized the mathematicians of the day, so he asserted that contemporary medicine abounded in error. He stated it to be his belief that the *antiqui* had a sort of primitive medical revelation which endured through the periods of Chaldean, Greek, and Arab ascendency, although dimmed by the errors and defects of the *Latini rustici*.

Once the belief is established that astrology has value in the equipment of the physician, it is evident that a certain degree of proficiency in mathematics will be looked upon as necessary in his education. He must know something of angle measure, must be able to use astronomical tables, and must be fairly well equipped as a computer. This explains in part the relation of mathematics to medicine in that period in which printing first made learning really popular, namely, the sixteenth century.

There was also another potent influence leading to the development of the iatromathematicians, namely, the universal ancient belief in number mysticism, a belief which had not died out in the seventeenth century and which is not unknown even to-day. *Deus imparibus numeris gaudet* is a phrase as old as the period of the Pythagoreans, and even to-day the belief that "there is luck in odd numbers" is very general. The recognition of the influence of the number seven in medical literature, until recently almost universal, a recognition due in large part to a work long attributed to Hippocrates himself but probably spurious, is an illustration of this belief. The superstitions relating to numbers like three

[4] Ἰατρομαθηματικοί

[5] See his Ἰατρομαθηματικὰ in Patricius, "Nova de Universis Philosophia" (1593). On his general beliefs in the subject, see "Die Lehren des Hermes Trismegistos" by Josef Kroll in the *Beiträge zur Geschichte der Philosophie des Mittelalters*, Bd. XII. Heft 2–4, Münster i. W., 1914, pp. 206 seq. and 367 seq.

[6] "Jatromathematiker, vornehmlich im 15. und 16. Jahrhund.," in the *Abhandlungen zur Geschichte der Medizin*, Breslau, 1902, Bd. II. The term has also been applied to those interested in the general use of mathematics in medicine.

[7] 'Abdel 'azîz ibn 'Otmân ibn 'Alî, Abû'l-Ṣaqr, el-Qabîsî. The transliteration of Arabic names follows the Suter list.

[8] This commentary was printed in Venice in 1485 and again in 1521.

[9] A. G. Little, "Roger Bacon Essays," Oxford, 1914. See the article by the present writer, on "The Place of Roger Bacon in the History of Mathematics," page 153, and the one by E. Withington, "Roger Bacon and Medicine," page 337, from each of which extracts have been freely made.

[10] El-Ḥosein ibn Abdallâh ibn Ḥosein ibn 'Alî, Abû 'Alî, el-Ṣeich el-Ra'îs, Ibn Sînâ (980-1037).

and seven, with their squares, have all the appearance of being transmitted from the East, possibly through Pythagoras himself; but at any rate they were powerful enough to interest the medical profession for many generations in the mysticism of number.

This number mysticism naturally led to the use of amulets such as the Thibetans and others of the East wear to-day, — plates on which magic squares, the mystic trigrams of the Chinese, and the signs of the zodiac are engraved. These are closely related to various instruments of divination in which number played a leading part. This subject is so extensive as to permit only of brief mention at this time, and a single illustration will serve to show its importance.[11] Tradition relates that the astrologer Petosiris dedicated to King Nechepso, of the seventh century B.C., a sphere of wondrous power.[12] To foretell the outcome of the sickness of a patient it was only necessary to add the numbers corresponding to the Greek letters of the name of the disease, to add to this sum the number corresponding to the day of the month on which the invalid took to his bed, to divide the result by 29 (approximately the number of days in the lunar month), to note the remainder, and then to consult the magic sphere. This sphere was divided into six cells, the upper three being the cells of life and the lower three those of death. Whether the patient would live or die was determined by the group of cells in which the remainder was found, and whether the recovery would be speedy or slow was determined by the particular cell in the group.[13] It will at once be seen that there is a connection between this superstition and that of gematria, the theory of finding the attributes of a person from the numerical value of his name obtained by adding the numerical values of the letters, a subject too extensive to admit of discussion at this time.

A fourth reason why the medical class in the Middle Ages was led to a study of mathematics is found in the imagined need for the compounding of drugs in such proportions as to bring out their *dynamidiæ*. This need led the physician to the study of alligation, as the alchemist and the mint master were also led, and it is, of course, even more potent in carrying out the scientific work of to-day. It was very likely this influence that led a man like Arnaldo de Villanova (1235–c.1313), or Arnaldo Bachuone, to study mathematics. Teaching medicine in Barcelona and Paris, physician to Frederick of Sicily, a prominent practitioner in Rome, Bologna, and other great centers, known chiefly for his writings on alchemy, Arnaldo was the type of man who would naturally be led to imagine a close connection between medicine and number, and between alchemy and astrology. So whether the aspiring physician, when Salerno began to encounter serious rivalry, went to Padua, which leaned to the astrological doctrines of Pietro di Abano (c. 1250–1316),[14] or to Montpellier, which favored the alchemy of Arnaldo, he was sure to come in contact with some form of mathematics.

A fifth influence to be noted, even though this is not the place to discuss it historically, is that of the study of optics, especially on the part of the physician who specialized in the treatment of the eye. Upon this topic there is a large literature, beginning promi-

[11] For further discussion, see Wickersheimer, "Figures Medico-Astrologiques des IXe, Xe, et XIe Siècles," in *Janus*, 1914, Vol. XIX, pp. 157–177.

[12] This sphere seems, however, not to be older than the second century B.C. For discussion, see Sudhoff, *loc. cit.*

[13] See also "Nechepsonis et Petosiridis fragmenta magica," in *Philologus*, Suppl. VI (1891–1893), pp. 382–383.

[14] Also known as Petrus Aponensis, professor of Medicine at Padua. His "Astrolabium planum" was published at Venice in 1502, his "Geomantia" at Venice in 1556, and his "Opera artis" (on alchemy) at Paris in 1567. Sudhoff gives the dates 1253–1319 (?).

nently with the Arab scholars and spreading thence to the West, particularly in the thirteenth century, one of the most remarkable periods in the world's intellectual progress.

A sixth reason why physicians were so commonly led to the study of mathematics is to be found in the general belief in the influence of comets upon human health. This is quite independent of the belief in astrology, and it proved to be so strong as to attract the attention of a considerable number of physicians in the sixteenth century, and to lead them to a sufficient study of mathematics to make use of armillary spheres and astrolabes for locating the comets in the heavens. An example of this is found in the case of Fernández Raxo y Gómez (d. 1695), a graduate in medicine at Valencia, physician to Philip II, and the author of a well-known work on the influence of comets.[15]

It is especially appropriate in this connection to mention one more influence leading the physician to the study of mathematics, since this makes the mystic number seven, and so I refer to the fact that medicine was a very natural gateway to mathematics in the early universities. A young scholar was offered four great possibilities in the mediæval period, namely, theology, philosophy, law, and medicine. Of course he might follow out his mental bent without taking any of these paths, but these were the enticing ones. If his taste was for science in any of its branches, the path of medicine was the natural one to follow, since, as we have seen, medicine had as auxiliary sciences astronomy (which was mathematics par excellence in those days) and alchemy, and made not a little use of physics. Scientific training, therefore, found its path of least resistance through medicine.

[15] "De Cometis, et prodigiosis eorum portentis libri quatuor," Madrid, 1578. A Spanish bibliographer remarks that "era más bien filósofo que astronomo."

An illustration of this general combination of all the sciences under the guidance of medicine is seen in one of the sumptuous volumes that came from the Aldine press at the opening of the sixteenth century, written by Georgius Valla, the elaborate title beginning: "Georgii Vallæ Placentini viri clariss. de expetendis, et fvgiendis rebvs opvs, in qvo hæc continentvr." Valla was born at Piacenza in 1430 and died at Venice in 1499. He lectured on physics and medicine at Pavia and also at Venice, and translated various writings of the Greeks, both medical and mathematical. His *magnum opus*, above mentioned, treated of Boethian arithmetic and music, of Euclidean geometry, of medicine and optics, of astrology and the astrolabe, of rhetoric, poetry, and law, and of most of the other great branches of human knowledge. Much of the work is devoted to medicine. Thus he has "De Physiologia libri .iiii. . . . De Medicina libri .vii. . . . De Corporis commodis, & incommodis libri .iii. quorum primus totus de anima, Secūdus de corpore, Tertius uero de urinis ex Hippocrate, ac Paulo ægineta, déq; Galeni quæstionibus in Hippocratem." Like all such works, this was merely a compendium, but it established Valla's reputation as a physician of great scientific learning, and it serves to illustrate the point in question.

There is much more to say if one desires to enter fully into the relations between mathematics and medicine. The story is one of interesting mysticism, of the Greek, Roman, and mediæval symbols of drugs and numbers, of tetragrams, of exorcisms, of skryers, and of all that borderland between the region of superstition and that of science. The story is therefore a long one, and lest it might prove unprofitable it is better to leave it untouched and to mention a few of the great names in the fields of medicine and mathematics in the sixteenth century.

This century has been selected because

it combines the seven influences above mentioned more completely than was the case before the year 1500 or has been since the year 1600. Before the sixteenth century printing had not been sufficiently developed to make it possible to freely disseminate thought, while after the close of that century superstition began to give way more rapidly than ever before to scientific inquiry.

Before considering the list of sixteenth century mathematico - medical scholars, many of whom were slavish followers of tradition, one name should be mentioned as standing in a class by itself. No list of medico-mathematical writers would be complete without reference to this remarkable genius who was neither a medical man nor a mathematical professor, but who knew more of anatomy and of mathematics than most of his contemporaries who were working in these fields. The works of Leonardo da Vinci (1452–1519) in mechanics, in astronomy, in the study of the infinitely great and the infinitely small, and his familiarity with the writings of the scholars who had made mathematical physics, all show the same remarkable acumen that he revealed in connection with the study of the heart and the circulation of the blood. Had Leonardo not been one of the world's greatest artists he would have been known as one of the world's greatest anatomists; had not the other phases of his genius overshadowed his work in mathematical physics, he would have been known as one of the world's greatest scholars in this important field. The contributions of Dr. Arnold C. Klebs to our knowledge of his work on the circulation of the blood were a revelation to most of us who thought that we knew something of Leonardo's scientific attainments, while even a brief consideration of his fragmentary work in mathematics will convince anyone of his real ability in this field as well.

I now propose to mention a few of the other leading names among those whose tastes led to the study of mathematics as well as medicine, and to speak very briefly of their labors. After that it will be quite enough to enumerate, for purposes of reference, the names of others who, in that century, cultivated more or less impartially the two sciences under discussion.

It usually happens that a really great man attains his dominant position in one line, his other lines of interest being so completely overshadowed as to be forgotten. Of course there are exceptions to this rule, as in the cases of Descartes, Pascal, Leibnitz, and particularly Leonardo da Vinci; but in general it is a law that is almost axiomatic. For this reason few in the medical profession will recall the fact that Galileo (1564–1642) was at least a novice in their guild. This, however, is the case, for his father withdrew him from the monastery of Vallombrosa, where he had decided to take orders, and sent him to Pisa to study medicine. His observation of the swinging lamp led not only to his study of the law of the pendulum but to his use of this device for measuring the frequency of the pulse.[16] His tastes, however, were toward applied mathematics, and so he secured his father's consent to give up the study of medicine and to endeavor to make a name for himself in his chosen field.[17]

As in the case of Galileo, so with Copernicus (1473–1543); it is not generally recalled that he was a physician, as also Canon of the Cathedral at Frauenburg in East Prussia. His mathematical and astronomical studies under Peurbach, Regiomontanus, Domenico Maria, and Brudzewski led him to devote his energies to the mathematical side of astronomy with an intelligence that made for the success which the world has long since recognized.

[16] Paolo Frisi, "Elogio del Galileo," Milano, 1778, p. 14.

[17] "Le Opere di Galileo," Firenze, 1856, tomo xv, p. 334.

Of all those who achieved a reputation in the fields of mathematics and medicine in the sixteenth century, none was more notorious, to say the least, than Girolamo Cardano [18] who was born at Pavia in 1501. He was the illegitimate son of a jurist, Facio Cardano, a man who had also taken a degree in medicine, had given some attention to mathematics, and had edited Archbishop Peckham's "Perspectiva Communis," and of a mother who had a reputation that was none too good. Students of heredity may find here a fertile field for speculation, for Girolamo certainly combined in his nature some of the highest and some of the lowest elements. He was at once an astrologer (not a great reproach at that time, however) and a serious student of philosophy; a gambler and a first-class algebraist; defender and father of a murderer and at the same time a physicist of high ability; a liar and at the same time a physician of repute; an inmate of a poorhouse and a professor in the University of Bologna; a victim of blind superstition and rector of the College of Physicians at Milan; a heretic who ventured to publish the horoscope of Christ and a recipient of a pension from the Pope. While only twenty-one years of age he taught mathematics at Pavia; at the age of twenty-five he took his degree in medicine at Padua, practicing for seven years at Sacco. In 1534 he became professor of mathematics at Milan, at the same time practicing and teaching medicine. He died in Rome in 1576.

Cardano's greatest mathematical work is the "Ars Magna" (1545), a work in which the solution of the cubic equation first appeared in print, although apparently secured under the pledge of secrecy from Tartaglia. He wrote, however, numerous other works on mathematics, physics, philosophy, and astronomy, and a number of "oposcoli" on medicine, published and unpublished. Among the medical writings given by him in his own list, are the following: "Delle cause, dei segni e dei luoghi delle malattie," "Picciola terapeutica," "Degli abusi dei medici," "Delle orine, libro quattro," and "Sulla medicina di Galeno," but a careful modern edition of his works has not appeared, and a systematic search for his unpublished manuscripts has probably not been made. Among his works was also a commentary on the anatomy of Mundinus.

Cardano's own opinion of a medical career is familiar to all who have looked into the history of medicine, but it may be interesting for others to read. He says, in his garrulous autobiography: "If I had money to earn, I could earn it as a doctor, and in no other way. But that calling of all others (except the glory that attends it) is completely servile (tota servilis est), full of toil, and (to confess the truth) unworthy of a high-spirited man (ingenuo viro indigna), so that I do not at all marvel that the art used to be peculiar to slaves." [19]

The most popular writer on arithmetic in the Latin language in the sixteenth century was Gemma Regnier or Rainer (1508–1555). Having been born at Dockum, in East Friesland, he was known as the Frisian, or commonly as Gemma Frisius. He was only thirty-two years old when his "Arithmeticæ Practicæ Methodus Facilis" was published at Antwerp (1540), and so favorably did this work strike the popular taste that it went through at least fifty-nine editions in the sixteenth century, not to speak of many later ones. He also wrote on astronomy and geometry, acquiring a high reputation as an author if not as a mathematician. Soon after publishing his arithmetic he took the degree of doctor of medicine and then gave up his mathematical studies. While nothing was published upon medicine under his name during his lifetime, there is, in a work printed at Frank-

[18] Jerome Cardan, Hieronymus Cardanus.

[19] Morley, "Jerome Cardan," II, 283; "Opera," I, 131.

fort in 1592, a "Consilia quædam de arthritide" attributed to him.

Among French physicians of the sixteenth century there stood out prominently one whom his admirers called the modern Galen, Jean Fernel (1497–1558), who received his doctorate from the Faculté of Paris in 1530. Four years after receiving his degree he became a professor in Paris, and soon rose to a position of leadership in the medical profession. His "Universa Medicina" (1567) went through more than thirty editions. In the field of mathematics he published two works, "De proportionibus" (1528) and also two in the field of astronomy, the "Monalosphœrium" and the "Cosmotheoria." His work in geodesy was also noteworthy, his computation of the length of a degree of the meridian being 56,746 toises, although it is really 57,024 toises, — a good approximation for the time.

Of the English scholars who cultivated both mathematics and medicine in the sixteenth century, Robert Recorde was the most prominent. Born at Tenby, Pembroke, c. 1510, he studied at Oxford and Cambridge, and received his degree in medicine at the latter university in 1545. He taught mathematics at Oxford and very likely at Cambridge, became royal physician, and wrote on medicine as well as mathematics. It was in the latter field, however, that he attained his chief prominence. His arithmetic, "The Ground of Artes," appeared between 1540 and 1542 and went through at least thirty editions, being the most popular work that appeared in England upon the subject in the first two centuries of printing. He wrote also "The Castle of Knowledge" (1551), a work on astronomy; "The Whetstone of Witte" (1557), a work chiefly on algebra, and the one in which the present sign of equality (=) first appeared in print; and "The Pathway to Knowledge" (1551), a work on geometry, written, like the others mentioned, in catechism form.

His medical work, "The Urinal of Physic," appeared in 1548 and went through several editions, being as popular in medical circles as were his mathematical works in the field of general education.

His end was not what one would have expected for a man who had been permitted to dedicate one of his works to "Princesse Marie," over his signature of "Robert Recorde Physicion;" who had administered to the medical needs of Edward VI and of Mary Tudor, and who had written the most popular mathematical books that England had known. He was imprisoned for debt in Southwark Prison, and died there, probably soon after June 28, 1558, the date of his will.

Among the physicians whose mathematical attainments were much above the average to be found in those who devoted themselves wholly to the exact science, there should be mentioned Ludovico Lilio (1510–1576) who was one of the astronomers called by Gregory XIII to consider the change of the calendar. It was substantially his suggestion for reform that was adopted. Unfortunately he died six years before the new calendar was put into general use, and so he did not live to see the fruition of his labors in this important field.

In Belgium, contemporary with Galileo, there lived the well-known Adriaen van Roomen (1561–1615) who divided his time rather impartially between medicine and mathematics. He lectured on both subjects at Louvain and upon mathematics in Würzburg, where he was physician to the bishop, and he was at one time mathematician to the king in Poland. He is best known in mathematics for his computation of the value of π to sixteen decimals,[20] but he wrote also upon other geometric subjects.[21]

[20] In his "Ideæ mathematicæ pars prima," Antverpiæ, 1593.

[21] In "Archimedis circuli dimensionum expositio et analysis," Wirceburgi, 1597; "Mathesis polemica," Francofurti, 1605; "Canon triangulorum sphæricorum," Moguntiæ, 1609.

Interested in the same line of mathematical study was his contemporary Adriaen Metius (1571–1635), or Adriaen Adriaenszoon, who was a professor of mathematics and medicine in the university at Franeker, but whose writings were all in the line of mathematics and astronomy. He also is well known for his approximation to the value of π.[22]

Among those of less importance in the combined fields of medicine and mathematics in the sixteenth century was Jacques Peletier (1517–1582). He was a man of some ability in mathematics,[23] but he was too ready with his pen, and this in too many lines of work, to attain a high standing. Interested in law, a voluminous writer in general literature, principal of the Collège de Bayeux, physician at Bordeaux, Poitiers, and Lyons, teacher of arithmetic at Annecy, author of various textbooks on mathematics—including algebra, geometry, and arithmetic—it will be seen that he had little time for serious work in any of his various fields of activity.

Perhaps the most all-round dilettante of the sixteenth century to come within our field is Henricus Cornelius Agrippa (1486–1535). He posed as physician, lawyer, soldier, philosopher, astrologer, and alchemist in various centers of learning, including Cologne, Pavia, Freiburg, Brussels, Bonn, and Grenoble. His "De Incertitudine & Vanitate Scientiarum" went through various editions [24] and shows at least a superficial knowledge of substantially every science, mathematics ranking equally with medicine in his general condemnation.[25]

Such were a few of those who added to mathematical knowledge, who were held in high esteem as healers of the body, or who made some name in literary productions which touched upon both of the sciences. It will, however, be more helpful to those who care to study the intimate connection between mathematics and medicine if a list of some of the others who helped to establish this connection is made accessible to them, and such a list, necessarily much abridged, is given as a supplement to this fragmentary sketch.

Although it has been said above that the sixteenth century was *par excellence* the century of the iatromathematicians, it must not be thought that later centuries failed to find this same intimate relationship between the two sciences. Thus in the century following we find the great Boerhaave (1668–1738), whose reputation as one of the greatest physicians of his time obscured what would otherwise have been an enviable reputation in the field of applied mathematics. So his contemporaries Eisenschmid (1656–1712) and Guglielmini (1655–1710) represent the union of the two subjects, since it was the "Diatribe de figura telluris elliptico-sphæroide (1691)" of the former that gave rise to the dispute as to the elongation of the earth, and the latter was a recognized authority on mathematics as applied to hydraulics. These facts are apt to be forgotten both by the historian of mathematics and by the recorder of medical progress, just as when we see the beautiful colonnade of the Louvre, we forget that Claude Perrault (1613–1688) was not merely an architect but was also a physician and a mathematician. Not many, too, recall the fact that the famous Johann (I) Bernoulli (1667–1748), one of the two broth-

[22] His works include "Doctrinæ sphæricæ libri V," Francofurti, 1591, and Franeker, 1598; "Geometrices per usum circini nova praxis," Amstelodami, 1623; "Opera arithmetica et geometrica," Lugduni Batavorum, 1625.

[23] Among his works are "L'Algèbre, départie en deux livres," Lyon, 1554; "L'Arithmétique, départie en quatre livres," *ib.*, 1554; "Demonstrationum in Euclidis elementa geometrica libri sex," Lugduni, 1557.

[24] A copy in the writer's library has the double date, Lugduni Batavorum, 1643 and 1644.

[25] His "De occulta Philosophia libri III" appeared at Cologne in 1510 and again in 1533.

ers who founded the celebrated family of mathematicians bearing his name, held a degree in medicine. His dissertation "De effervescentia et fermentatione" (Basileæ, 1690) gave little suggestion that he would become one of the greatest leaders in spreading the knowledge of the new mathematical discipline of the calculus throughout continental Europe; yet such was the case, and his productions in mathematics were of highest scientific value.

Thus it has been through all the centuries, particularly from the ninth to the twentieth, that mathematics and medicine have found much in common, although the two periods in which this has been the most noticeable are the era of the Arab ascendency and that of the sixteenth century, to the latter of which this brief summary chiefly refers.

A PARTIAL LIST OF THOSE WHO, IN THE SIXTEENTH CENTURY, WERE DISTINGUISHED IN MATHEMATICS AND IN MEDICINE [26]

BERNARD ABATIA (1540–c.1590), physician, mathematician, astronomer, jurist, and linguist.

ALESSANDRO ACHILLINI (1463–1512 or 1518) was professor of medicine and of philosophy in Bologna and in Padua. His "Opera Omnia" (Venetiis, 1508) contains numerous contributions to medicine, and he wrote also on astronomy and physics, subjects so closely connected with mathematics as to show the trend of his interests.

JOHANN ACRONIUS, or ATROCIANUS (1520-1564), not only practiced medicine at Basle but was also professor of mathematics and of logic in the university of that city. His writings were in the line of mathematical astronomy. His skill as a physician could not save him from death as a result of the plague.

ADRIAEN ADRIAENSZOON. See the article.

AGRIPPA. See the article.

JUAN AGUILERA, who flourished in Salamanca in the middle of the sixteenth century, was well known as a mathematician, physician, philosopher, and theologian.[27]

JUAN ALEMÁN practiced medicine in Spain in the second half of the sixteenth century and wrote on astronomy and astrology.[28]

JUAN ALMENAR, born in Valencia in the latter part of the fifteenth century, took his degree in medicine and is described as "el primer español que escribió sobre el mal venéro" (1502). He was much interested in astrology, however, "en la cual llegó á adquirir gran fama," and he seems to have written a work on astronomy which was never printed.

JOHANN ASVERUS AMPSING (c. 1559 – 1642), one of the chief authorities on the iatromathematics in the seventeenth century, a native of the province of Upper Yssel. He was a physician of prominence and wrote a dissertation on iatromathematics.[29]

MELCHIOR AYRER (1520–1579), a physician of Nürnberg, well known in his day as a chemist and mathematician, was skillful in the making of mathematical instruments.

BERNARDINO BALDINI (1515–1600), professor of medicine in Pavia and of mathematics in Milan. His writings were chiefly on astronomy and physics.

PIERRE BEAUSARD (d. 1577), a physician of Louvain, and in later life a professor of mathematics in the university. While not

[26] The list is arranged alphabetically either by the family name or by the name by which the person is commonly known. It includes the names of many prominent medico-mathematicians who were living between 1500 and 1600, but the reader is referred to Sudhoff's list for a considerable number of minor names.

[27] His "Canones astrolabii universalis" appeared in its second edition at Salamanca in 1554.

[28] The first edition of his work appeared at Barcelona in 1580, under the title "Lunari ó repertori del temps compost per lo molt abil astrolec Joan Alemany."

[29] "Diss. iatromathica in qua de medicineæ et astronomiæ præstantia indissolubili cõjugio disseritur," Rostochii, 1629.

an original genius, he is known for two works of some merit.[30]

Isaac Beeckman (1570–1637), a physician, director of the Latin school at Dordrecht, wrote "Mathematico-physicarum meditationum," Traject. ad Rhen., 1644.

Lattanzio Benacci (1499–1572), physician and professor of astronomy in Bologna, and an astrologer of some repute.

Michael Beuther (1522–1587), doctor of law and also of medicine, professor of poetry and also of mathematics in Greifswald, and finally professor of history at Strasburg. He contributed slightly to the literature of the circle and the calendar.

Heinrich Brucæus (c. 1531–1593), was professor of mathematics in Rome, and afterwards practicing physician as well as professor of medicine and of mathematics in the University of Rostock. He wrote numerous medical works and at least two books on mathematical astronomy.

Olaus Engelberti Bure, or Buræus (1578–1655), was a physician at the court of Gustavus Adolphus, but he was also much interested in mathematics and was one of the pioneers in mechanical computation.[31]

Baldassare Capra (d. 1626) was a practicing physician at Milan, but his interests were rather in mathematical astronomy.[32] He was a bitter antagonist of Galileo.[33]

Facio Cardano (1444–1524), professor of medicine and jurisprudence in Milan, edited Bishop Peckham's "Perspectiva communis." He was the father of Cardano the algebraist.

Girolamo Cardano. See the article.

Johann Chesnecopherus (1581–1635), professor of medicine and anatomy at Upsala, gave much attention to astronomy and physics, and incidentally to mathematics.[34]

Federigo Commandino (1509–1575), a physician, became mathematician to Duke Guido Ubaldi of Urbino and to Cardinal Ranuccio in Rome, but his greatest contributions were in his editions of the mathematical works of Ptolemy, Archimedes, Apollonius, Aristarchus, Euclid, Pappus, and Heron. These were published in Venice, Rome, Bologna, Pisa, and Urbino between 1558 and 1592. His edition of Euclid is particularly well known.

Copernicus. See the article.

Juan Baptista Cursa, born in Valencia in the second half of the sixteenth century, a doctor of medicine, wrote one work on mathematical astronomy.[35]

Joachim Curtius (1585–1742), a practicing physician in Hamburg, edited Tycho Brahe's "Oratio de disciplinis mathematicis" (Hamb., 1621) and wrote "De certitudine matheseos et astronomiæ" (*ib.*, 1616).

Cyriaque de Mangin (c. 1570–1642), a Paris physician, published his "Problemata duo nobilissima, quorum nec analysin geometricam videntur tenuisse J. Regiomontanus et P. Nonius," etc., in Paris in 1616.

Federigo Delfino (1477–1547), a physician in Venice, became professor of astronomy in the University of Padua, his native town. His mathematical work is seen in his "Annotationes in Tabulas Alphonsinas."

Joseph Solomon Delmedigo (1591–1655), a native of Candia, a graduate of Padua, a student under Galileo, a cabalist in Constantinople, physician to Prince Rad-

[30] "Annuli astronomici instrumenti . . . usus," Antverpiæ, 1553; "Arithmetices praxis" Lovanii, 1573.

[31] "Arithmetica instrumentalis Abacus ab eo ipse inventus," Helmst., 1609.

[32] "Considerazione astronomica sopra la nuova stella del 1604," Padova, 1605; "Tyrocinia astronomica," *ib.*, 1606; "De usu et fabrica circini cujusdam proportionis," *ib.*, 1607.

[33] So we have Galileo's "Difese contra alle calumnie e imposture de Baldassare Capra," Venezia, 1607.

[34] E.g., in his "De stellis," and his "De eclipsi solis et lunæ," Upsala, 1624.

[35] "Discvrso mathematico sobre la natvraleza y significacion de los cometas . . . de 1618; Compuesto por el doctor Iuan Baptista Cursa, Filosopho y Medico Valenciano," Valencia, 1619.

ziwill at Vilna, a Rabbi at Hamburg, a physician in Amsterdam, and a prolific writer on medicine and mathematics.[36]

JOHANN DRYANDER, or EICHMANN (1500–1560), was professor of medicine and mathematics at the University of Marburg (1535). He wrote several works on mathematical astronomy.

THADDÄUS DUNUS, or TADDEO DUNO (1523–1613), was a Zürich physician, born in Locarno, but he is known only for his two rather obscure mathematical works.[37]

LORENZ EICHSTADT (1596–1660), professor of medicine and mathematics in the Gymnasium at Danzig, published several works on mathematical astronomy.

SAMUEL EISENMENGER, known also as Siderokrates (1534–1585), a practicing physician, was professor of mathematics at the University of Tübingen.[38]

PAUL FABRICIUS (1529 or 1519–1588), a physician of high standing, a professor in the University of Vienna, was known chiefly for his mathematical tables for use in astronomy.[39]

JEAN FERNEL. See the article.

AUGER FERRIER (1513–1588), physician to Catharine de Medici, queen of Henri II of France, was quite as much interested in mathematics and astrology as in medicine.[40]

FIENUS, or FYENS (1567–1631), professor of medicine at Louvain, writer upon medical matters, was also known as an astronomer.[41]

THOMAS FINKE, or FINCK (1561–1656), was court physician to the Duke of Schleswig-Holstein, and afterward professor of medicine (1591), of mathematics (1602), and of rhetoric in the University of Copenhagen. His mathematical work also led him into the field of astronomy.[42]

JACOB FLACH (1537–1611) was professor of medicine and of mathematics at the University of Jena, but he seems to have contributed nothing to the literature of either science.

ERASMUS FLOCK (1514–1568), a physician of Nürnberg, was for a short time (1543–1545) professor of philosophy and mathematics in the University of Wittenberg. Among his other activities he edited Ptolemy's "Almagest" (Norimb., 1550).

SIMON FORMAN (1552–1611), a physician and an astrologer in London and the author of various works on alchemy, magic, and astrology.

GERONIMO or GIROLAMO FRACASTORO (1483–1553), a physician in Verona, was afterwards Papal physician. He wrote on medicine, but also was interested in the mathematics of optics and seems to have had some idea of the telescope.[43]

JEAN FRANCO (c. 1550–1610), a physician of Brussels, wrote an ephemeris of astrological character, in Flemish, and this was published at Antwerp in 1594.

LORENZ FRIES (c. 1485–1531), a prominent iatromathematician, author of the "*Spiegel der Arznei*" (1518) and of a work on the astrolabe. He remarks that "medi-

[36] For example, the "Refuath Tealah" (Healing medicine); "Or Shibat Ha-yamim" (the Light of the Seven Days) including some discussion of optics; "Bosmat Bat Schelomoh" (Bosmat, daughter of Solomon), on mathematics and related subjects; and "Elim" (Amsterdam, 1629), a work containing answers to various scientific questions propounded by Zerakh ben Nathan and seventy mathematical paradoxes.

[37] "Arithmetices, practices methodus," Basileæ, 1546; "De nonis, idibus et calendis," *ib.*, 1546.

[38] "De usu partium cœli in commendationem astronomiæ," Argentorati, 1567.

[39] "Tabulæ astronomicæ," Vienna, 1558.

[40] "De diebus decretoriis secundum Pythagoricam doctrinam et astronomicam observationem," Lugduni Batavorum, 1541.

[41] "De cometa anni 1618," Antv., 1619.

[42] "De constitutione philosophiæ mathematicæ," Hafniæ, 1591; "Geometriæ rotundi libri XIV," Basileæ, 1583; "De hypothesibus astronomicis," etc., Hafniæ, 1593, etc.

[43] This is in his "Homocentricorum seu de stellis, liber unus," Venet., 1538.

cus sine astrorum cognitione perfectus esse non potest."

GALILEO. See the article.

GEMMA FRISIUS. See the article.

CORNELIS GEMMA FRISIUS (1535–1577), son of the better known Gemma Rainer (Gemma Frisius), was professor of medicine and also of astronomy at Louvain. His "De arte cyclognomica tomi III, philosophiam Hippocratis, Galeni, Platonis et Aristotelis in unam methodi speciem referentes" (Antv., 1569) is well known, and he also wrote two astronomical works.

SIMON GRYNÆUS the Younger (1539–1582) was professor of medicine and of mathematics at Heidelberg. His father published the first Greek edition of Ptolemy's "Almagest" (Basil., 1538), and was a friend of Luther and Melanchthon. Simon the Younger wrote a work on astronomy,[44] published in Basle in 1580.

ISAAK HABRECHT (d. 1633) was a doctor of philosophy and of medicine. In his later years he became an assistant in mathematics in the University of Strasburg. He published various works of an astronomical nature.

THADDÄUS HAGEK (1525 – 1600), also known as Hajek, or Hagecius ab Hayck, and as Thaddæus Nemicus, was for a long time professor of mathematics in the Carolinum at Prague, but later was physician to Maximilian II and to Rudolph II. He wrote several works on geometry and astronomy.[45]

MUḤAMMED IBN IBRÂHÎM IBN JÛSUF, RAḌÎ ED-DÎN ABÛ 'ABDALLÂH (d. 1563), known as Ibn el-Ḥanbalî, a native of Aleppo, a man well versed in medicine, law, and mathematics, wrote various works on geometry and arithmetic.

JOHANN HARTMANN (1568–1631) was professor of mathematics in the University of Marburg (1592) and later took his degree there in medicine (1606), then becoming professor of chemistry (of "Chymiatrie"). He was physician at the court of the Kurfürst of Hesse.[46]

SIXTUS AB HEMMINGA (1533–1581) was a physician and mathematician of some prominence in Belgium. He studied in Gröningen, Cöln, Louvain, and Paris.[47]

GEORG HENISCH (1549–1618), of Hungarian birth, was a physician and afterwards taught logic and mathematics at Augsburg. He wrote numerous works on mathematics,[48] philology, and medicine.

DAVID HERLICIUS (1557–1636), also known as Herlick and Herlitz, a physician, was professor of mathematics in the University of Greifswald from 1585 to 1598. He wrote upwards of fifty works, chiefly on astronomy.

JOACHIM JUNG (1587–1657), professor of mathematics at Giessen (1609–1614), of medicine at Padua (1618), of mathematics at Rostock (1624–1625), of medicine at Helmstädt (a few months), and again of mathematics at Rostock, alternated as few men do between his two favorite sciences. His writings cover a wide range, including mathematics,[49] astronomy, physics, and botany.

LILIO. See the article.

JOHANN MARCUS MARCI DE KRONLAND (1595–1667), for more than forty years professor of medicine at Prag, physician to Emperor Ferdinand III, wrote quite as much,

[44] "De cometis dissertationes novæ."

[45] Among them, "Oratio de laudibus geometriæ," Pragæ, 1557; "Apodoxis physica et mathematica de cometis tum in genere, tum imprimis de eo, qui 1580 . . . affulsit," Görlicii, 1581.

[46] His sole printed work on mathematics was his "Disputatio elementorum geometricorum," Cassel, 1600, but he wrote on medicine and chemistry.

[47] He wrote "Astrologiæ ratione, et experientia refutatæ liber," Antverpiæ, 1583.

[48] "De numeratione multiplici, vetere et recenti," Aug. Vind., 1605; "Arithmetica perfecta et demonstrata," *ib.*, 1605; "Commentarius in sphæram Procli," *ib.*, 1609; and others.

[49] "Geometria empirica," Rostochii, 1627, with later editions; "Disputatio de Stœcheosi geometrica," Hamb., 1634.

in a somewhat heterodoxical fashion, on mathematics as on medicine.[50]

PHILIPS VAN LANSBERG (1561–1652), a physician and priest at Antwerp and elsewhere, devoted his energies chiefly to mathematics[51] and astronomy. His "Opera omnia" appeared at Middelburg in 1663.

WILHELM LAUREMBERG (1547–1612) was professor of mathematics and medicine at Rostock and wrote on both sciences.[52]

PETER LAUREMBERG (1585–1639), son of Wilhelm, was even more versatile than his father, for he studied medicine in Leyden, was professor of philosophy in Montauban, of medicine in Montpellier, of physics and mathematics in Hamburg, and of poetry at Rostock. He wrote on astronomy, mathematics, physics, and various other disciplines, and his influence was what would be expected from one who scattered his energies so recklessly.

JOHANN WILHELM LAUREMBERG (1590–1658), a younger brother of Peter, divided his interests almost as disastrously. He received his doctor's degree in medicine at Rheims in 1616, was professor of poetry and mathematics at Rostock (1618) and of mathematics in the Ritteracademie at Soroe (1623). His writings were chiefly if not wholly mathematical, but not of a high character.[53]

HEINRICH LAVATER (1560–1623), a physician, was professor of physics and mathematics in Zurich, the city of his birth. His writings were chiefly on physics and astronomy and were of no particular merit.

LEONARDO DA VINCI. See the article.

ADAM LONICERUS, or LONITZER (1528–1586), was professor of mathematics at Nürnberg in 1553 and the following year he received his doctor's degree in medicine at Mainz. He wrote on botany, medicine, and mathematics.[54]

MANGIN. See Cyriaque de Mangin.

SIMON MARIUS, or MAYER (1570–1624), studied astronomy under Tycho Brahe and Kepler and then took a course in medicine at Padua. His contributions were all in the line of mathematics, including astronomy.[55]

MAYER. See Marius.

METIUS. See the article.

CHRISTOPH MEURER (1558–1616), a member of the medical faculty and professor of mathematics at the University of Leipzig.[56]

JACOB MILICH (1501–1559), or Milichius, professor of medicine in the University of Wittenberg, also taught mathematics there. His commentary on Pliny contains more or less of astronomy.

BURCKHARD MITHOB (1504–1565) was professor of mathematics and of medicine in the University of Marburg.[57]

ANTOINE MIZAULD (c. 1520–1578), a practicing physician in Paris, wrote a number of works on mathematical astronomy.

HENRY DE MONANTHEUIL, or MONANTHOLIUS (1536–1606), professor of medicine (1574) and later (1585) of mathematics in the Collège royal of France, at Paris. He was a

[50] For example, "De proportione motus," Pragæ, 1639, "De proportione motus figurarum rectilinearum et circuli quadratura ex motu," *ib.*, 1648; "De longitudine s. differentia inter duos meridianos; una cum motu vero lunæ inveniendo ad tempus datæ observationis," *ib.*, 1650; "Labyrinthus in quo via ad circuli quadraturam pluribus modis exhibetur," *ib.*, 1654.

[51] "Triangulorum geometriæ, libri quatuor" Lugduni Batav., 1591 and Amstelod., 1631; "Cyclometriæ novæ libri duo," Middelb., 1616–1628.

[52] Among other works he wrote a "Breviarium geometricum et geodæticum."

[53] "Logarithmus," Lugduni Batav., 1628; "Lusus et recreationes ex fundamentis arithmeticis," Havn., 1634; "Arithmetica et algebra," Soroe, 1643; "Instrumentum proportionum," *etc.* Rostochii.

[54] "Arithmetices brevis introductio," Francof., 1551.

[55] Among his works were "Die ersten sex Bücher elementorum Euclidis," Nürnberg, 1610; "Hypotheses de systemate mundi," 1596.

[56] He wrote "Analysis arithmeticæ et geometriæ tabulis succinctis," Lipsiæ, 1607, and edited the arithmetic of Psellus and the optics and catoptrics of Euclid.

[57] He wrote "Annuli cum sphærici, tum mathematici usus et structura," Marp., 1536; "Stereometria," Francof., 1544.

pupil of Ramus's. He wrote various works on mathematics and iatromathematics.[58]

Jean Baptiste Morin (1583–1656), physician to the Bishop of Boulogne and other notables, became professor of mathematics at the Collège royal in Paris in 1630. He was a voluminous writer, his interests including geology, astronomy, theology, astronomy, and mathematics.[59]

Joannes Morisotus, a physician of about the middle of the sixteenth century, wrote among other works four books on arithmetic.[60]

Jacob Müller (1594–1637) was professor of mathematics (1618) and of medicine (1620) in the University of Giessen, and later of both mathematics and medicine at Marburg. He wrote chiefly on mathematics.[61]

Müller. See also Mulerius.

Nicolaus Mulerius (1564–1630), also known as Mulierius, Muliers, and Müller, a Dutch physician, was professor of mathematics at the University of Gröningen (1614–1621). He wrote a number of works on mathematical astronomy.

Pieter Mulerius (1599–1647), son of the preceding, was a physician and became professor of physics and botany at Gröningen (1629). He wrote on mathematical astronomy, continuing the Ephemeris begun by his father.

Michael Neander (1529–1581) was professor of mathematics and Greek (1551) in the University of Jena, and later (1560) professor of medicine.[62]

Nemicus. See Hagek.

Gerard de Neufville (d. 1648), professor of mathematics and physics (1611) in the Gymnasium at Bremen, and later (1624) of medicine, wrote on mathematics,[63] astronomy, and physics.

Augustinus Niphus (1473–1546), a physician and astrologer in Suessa, Calabria, published in 1504, in Venice, an astrological work in which he endeavored to combine the observations of the physician with those of the astronomer.

Antonio Núñez de Zamora, a native of Salamanca or Zamora, born in the second half of the sixteenth century, lectured at the University in that city on medicine, mathematics, and astrology.[64]

Pedro Núñez Salaciense (1492–1577) studied medicine in Lisbon, but gave his attention thereafter entirely to mathematics. He became one of the leading Portuguese mathematicians of the sixteenth century, writing several treatises of considerable merit.[65]

Hermann Obermeyer (1588–1655), a Basle physician, became professor of mathematics in the University of Basle in 1630. His writings were astrological and astronomical and were of no value.

Peletier. See the article.

Kaspar Peucer (1525–1602) was professor of mathematics (1554) and then (1560) of medicine in the University of Wittenberg. His position as son-in-law of Melanchthon probably gave him more standing than would otherwise have been his.

[58] "Oratio pro mathematicis artibus," Parisiis, 1574; "Ludus iatromathematicus," *ib.*, 1597; "De puncto, primo geometriæ principio," Lugduni Bat., 1600, *etc.*

[59] "Trigonometriæ canonicæ libri tres," Parisiis, 1633.

[60] Heilbronner, "Historia Matheseos Universæ," Lipsiæ, 1742, p. 789, quoting Vossius.

[61] "Compendium geometricum," Gissæ, 1620; "Praxis geometriæ universalis," *ib.*, 1621; "Arithmetices compendium," Lipsiæ, 1631.

[62] His "Synopsis mensurarum et ponderum ponderationisque mensurabilium secundum Romanos, Athenienses," etc., was published at Basle in 1555. He also wrote "Elementa sphæricæ doctrinæ," *ib.*, 1561.

[63] "Arithmetica theoretica et practica," Bremæ, 1624.

[64] He published two works, the first being "Prognostico del eclipse del sol que se hizo en año de 1600," Salamanca, 1600.

[65] Among them, "Libro de algebra en Arithmetica y Geometria," Amberes, 1564–1567; "Tratado de sphera," Lisboa, 1537.

He was also physician at one of the small courts. He wrote various works on medicine and mathematical astronomy.[66]

JUAN MARTÍN POBLACIÓN, a native of Valencia, took high rank as a physician and astrologer in the sixteenth century. He wrote two works on the astrolabe, one of which exists only in manuscript.[67]

CRISTÓBAL PONCE DE LEÓN (d. 1598) was professor of medicine and also of mathematics in Alcalá.[68]

RAINER OR RAINIER. See Gemma Frisius in the article.

RECORDE. See the article.

REGNIER. See Gemma Frisius in the article.

AMBROSIUS RHODIUS (1577–1633), professor of mathematics in the University of Wittenberg (1608) and author of various works on optics, astronomy, and geometry,[69] gave also much attention to medicine. There seems to have been another of the same name, a contemporary, who was also interested in medicine and mathematics.

GIOVANNI ANTONIO ROFFENI (d. 1643), a doctor of medicine, became professor of mathematics in Bologna, but his works were astronomical and astrological only.[70]

ADRIAEN VAN ROOMEN. See the article.

PETER RYFF (1552–1629) was a practicing physician in Basle and became professor of mathematics (1586) in the university. He wrote several works on mathematics.[71]

FRANCISCO SÁNCHEZ (1550–1623), born at Tuy in the diocese of Braga, a Spanish physician, lived for some time in Montpellier where he was engaged in the practice of his profession, finally settling in Tolosa. He wrote one work on mathematics [72] and one on astronomy. He should not be confused with the great humanist of the same name, who was born at Brozas in 1523.

GIUSEPPE SCALA (1556–1585), a Sicilian physician, composed a set of astronomical tables which was published four years after his death.[73]

VICTORIN SCHÖNFELD (1525 – 1591) received the degree of doctor of medicine at Marburg in 1557, became professor of mathematics in the same university in 1557, and in 1566 became professor of medicine. He wrote on medicine, mathematics, and astrology.[74]

JACOB SCHÖNHEINZ, one of the earliest iatromathematicians of Germany, and the earliest in the sixteenth century, published his "Apologia astrologiæ," at Nürnberg, in 1502.

JOHANN SCHRÖTER (1513–1593), a Viennese practitioner, physician to the Imperial and Saxon courts, wrote various mathematical works.[75]

MIGUEL SERVETO (c. 1511–1553), one of

[66] Among the latter, "Elementa doctrinæ de circulis cœlestibus et primo motu," Viteb., 1551, with various editions; "De dimensione terræ et geometrice numerandis locorum particularium intervallis ex doctrina triangulorum sphæricorum," *ib.*, 1554, with later editions.

[67] The published work was entitled "De vsv astrolabi," and appeared in Paris in 1526 and 1527, later editions in 1546, 1547, 1550, 1553, 1554, and 1556. The unpublished manuscript is a "Tratado y uso del astrolabio" and is in the Biblioteca Nacional at Madrid.

[68] He wrote "Libro de la ciencia natural del cielo," Alcalá, 1598.

[69] "Euclidis elementorum libri XIII," Viteb., 1609, 1634.

[70] "Contra cæcam cujusdam Martini Horckii," Bononiæ, 1611; "De laudibus veræ astrologiæ," *ib.*, 1614.

[71] Among them, "Questiones geometricæ in Euclidis elementa," Francof., 1600; "Compendium arithmeticæ Vrstisii," Oxoniæ, 1626; "Elementa sphæræ mundi," *ib.*, 1627.

[72] "Objectiones & erotemata super Geometricas Euclides demonstrationes ad Christopherum Clavium."

[73] "Ephemerides ex tabulis Magini," Venetiis, 1589.

[74] Among his works are a treatise on epilepsy (Marburg, 1577) and the "Prognosticon astrologicum," which appeared for various years.

[75] Among them, "De arte numerandi."

the best educated young men of Spain in the sixteenth century, well trained in Latin, Greek, Hebrew, philosophy, theology, mathematics, and medicine, fell under the ban of the authorities because of his opinions and was executed in his forty-fourth year. He wrote on geography and astrology.[76]

Olaus Martin Sten (1598–1650) was professor of astronomy, physics, and medicine at the University of Upsala.

Georg Tanstetter von Thannau (1482–1535) was physician to the Emperor Maximilian I, and became professor of astronomy in the University of Vienna. He edited Peurbach's "Tabulæ eclipsium," Regimontanus's "Tabulæ primi mobilis," Proclus's "Libellum de sphæra," and the works of Albertus Magnus, Vienna 1523.

Jerónimo Torella, a physician to Ferdinand the Catholic, to Juana of Naples, and to other dignitaries in the sixteenth century, was much interested in astrology and wrote two works on the subject.

Bartolomé del Valle, a doctor of medicine in Salamanca, wrote two treatises on astrology, published in 1619.

Vespasieno Jerónimo de Vargas y Heredia, a physician and mathematician, published a "Tratado de cometas" in Granada in 1619.

Victoriano Zaragozana (1545–1602), a Spanish physician, was much interested in the mathematics of astronomy, and wrote several works on the subject, all printed at Zaragoza, 1583–1599.

[76] "Apologetica disceptatio pro astrologia."

STRUCTURE FOLLOWS FUNCTION

Thus man is the most intelligent of all animals, thus the hands are proper instruments for an intelligent being, since man is not wiser than the animals because he has hands (as Anaxagoras maintains), but as the judicious Aristotle asserts, he has hands precisely because he is the wisest. It is not by means of his hands, in fact, but through his reason that man learned the arts: the hands are an instrument like the lyre to the musician, like the tongs to a blacksmith. . . If we examine newly-born creatures that strive to act before the parts of the body are fully formed, it becomes clear that it is not the parts of the body which excite the soul to be cowardly, courageous or wise. For example, I have often seen a calf try to gore before its horns had developed, a chicken try to spur although its feet were soft, and a little pig trying to defend itself with its snout, although it had no tusks; even a little dog trying to bite without teeth; for every animal has in himself, without any previous instruction, an instinctive feeling of the faculties and functions of his body. . . It is not through instruction, I opine, that the eagle soars, the duck swims and the snake glides into a hole, for as Hippocrates says: Animal natures are untaught. Whence it seems to me, for the rest, that animals practice certain arts more by instinct than through reason.

Galen De usu partium, 1, 3.