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DE STATICIS EXPERIMENTIS OF NICOLAUS CUSANUS*

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ABOUT five hundred years ago the world was entering into a period of rebirth after its long lethargy of the Middle Ages. It was a period of beginning mental unrest and experimentalism, both partly ruled by the spirit of adventure. Men were breaking away from narrow, analytical medievalism to synthesize and build up a broad outlook on life. They were no longer satisfied to live a monastic life and spend their years scanning a single manuscript as dependent thinkers. Independence of thought, with its self-conscious freedom, became the watchword of the Renaissance.

We are all familiar with the great figures of both the Renaissance and the Reformation after the year 1500. Fifty years before this date, however, certain men, some of them thinking a century in advance of their time, were laying the foundation stones on which the Renaissance was to be established. One of them, little known in the annals of medical history, was almost the first to break away from the narrowness of the Middle Ages and become a student commanding all the then known sciences. Such a man was Nicolaus Cusanus. Only one figure of importance to science appears before his time in the Middle Ages, Roger Bacon, who, at the beginning of the thirteenth century, proclaimed that man, by the use of nature, could do all things. Cusanus, with his wider knowledge, two hundred years later, restated the same thought and, in order to prove his assertion, became one of the first scientific experimentalists.

He was born in the little village of Cues on the Moselle, half way between Trier and Coblenz, in the year 1401. The family name was Krebs or Khrypffs (Cryftz) and his father, Johann Krebs, is described as a sailor or fisherman, perhaps of some means. He died in 1450, just after his famous son had become a cardinal. The boy's mother, Catharina Römers, died in 1427. Little is known of the family. The original meaning of the name is, of course, a crab, and may have been derived from the family occupation, as fishermen. Krebs is still a common name in the Moselle district. The house of Nicholas' birth is standing today in a state of excellent preservation. Over the door has been erected a tablet containing the brief

* Read at a meeting of the Boston Medical History Club, October, 20, 1921.

facts in regard to his life, and a reproduction of the seal of the Cardinal showing a crab in the center. During the post-armistice period American troops occupied this house, Cues being within the area of the American Army of Occupation.

Nothing is known of the early childhood of Cusanus, except that there has grown up a story of very doubtful authenticity about his having fled from his father, because of ill treatment, to Count Ulrich of Manderscheid, in the neighbouring village. We know definitely, however, that the boy was sent at an early age, by Count Ulrich, to the famous school at Deventer, Holland. Deventer is about a hundred and fifty miles north of Cues, a long journey for those times, partly down the Rhine from Coblenz, past well-known religious centers such as Cologne and Düsseldorf, and then on foot or mule over the Holland hills to the great school of the Brothers of Common Life. The good Count must have seen great possibilities in this lad in his teens to send him on such a long and arduous journey five hundred years ago. Little did the youthful Nicholas Krebs realize, as he traversed this wonderful country for the first time, that he, thirty-five years later, would be a great Cardinal and papal legate over all the land as far as his eye could reach. We must think of this lad of the fifteenth century, however, as clear-eyed and thoughtful, observing nature at every hand, much as did John Hunter, the great experimentalist of the eighteenth century, in his boyhood days.

On reaching Deventer, Cusanus found a school well established and filled with ardent students. It was founded by Gerhard Groot, "Magnus," a striking personality of the late fourteenth century, and a papal legate to Holland. Born in 1340, he took his M. A. degree at the University of Paris in 1358. He then became a teacher of theology and philosophy at Cologne; later was canon of Utrecht and Aix-la-Chapelle. This remarkable man traveled throughout Holland, wearing old clothes, preaching penance and reform to thousands, with stupendous results. Many disciples gathered around him. He refused every dignity offered him by the state and church. His disciples are well remembered as copiers of manuscripts before the days of printing, many of which he distributed during his travels. By such means, knowledge was passed on from hand to hand. Groot founded the famous Brothers of Common Life, an order unique in that the members of it took no vows and worked for their bread between the times of their ministrations and teachings at the school at Deventer. Both of these principles were unheard of before Groot's time.

Another School at Zwolle near Deventer was founded by Zele, one of the pupils of Groot. Both of these schools were very important religious, educational influences in the fifteenth century, and boys streamed to them from all countries to receive their first teachings. It is not unusual, therefore, that Count Ulrich sent this young fisherman's son from Cues to Deventer. Cusanus received here his first inspirations of a moral and intellectual nature, but we know nothing definite of his studies except as they influenced, in a general way, his later life. He must have been profoundly impressed by his contact with the ardent, simple disciples of Groot, who was such an outstanding figure in history. In his will, as a tribute to this school, he left money enough to build a residence at Deventer for "twenty poor clerical students." This legacy was maintained for some years as the *Bursa Cusana* at the school. Ever humble, even in the greatness of his mature life, Cusanus was a firm believer in the principle of democracy of opportunity for rich and poor alike. He had been a "poor clerical student" and knew something of their struggles.

Except for the above facts, nothing more is known of Nicholas' early life or early education. We know, however, that in 1416 he went to the University of Heidelberg. He matriculated under the following signature, *Nicolaus Cancer de Coesze, cler(icus) Trever(ensis) dioc(esis)*.

The journey north to Deventer was the first important event in his life; the second came when he was seventeen years of age, and turned in a southerly direction to an even more famous school, this time, the University of Padua, nearly five hundred miles from his home. Count Ulrich must have had great faith in his youthful protégé! Padua, in 1417, already ancient and famed as a university, was beginning to emerge from its medievalism to take its part later in the growing Renaissance, under the influence of Montanus, Benedictus, Vesalius, Fallopius, Casserius and many others. Cusanus remained in Padua six years, until 1423, when he was graduated as a Doctor in Canon Law (*decretorum doctor*). He studied Latin, Greek, Hebrew, and later, Arabic. We know that one of his teachers was Guiliano Cesarini, later president of the Council of Basle. Here in the University, Krebs formed a friendship that lasted to the end of his days. This young man, three years his senior, was Paolo dal Pozzo Toscanelli, taking courses in mathematics, philosophy and medicine while Nicholas Krebs took law and mathematics. Toscanelli was graduated as a physician in 1424, a profession that his father had followed in Florence before him. So ardent a student of medicine was he that his friends called him *Paolo Fisico.* After graduating he went at once to Florence where he lived for the rest of his life. We know little of him as a practitioner, except that he was called to the deathbed of his lifelong friend, Cusanus, in 1464, but his fame was world-wide at the time as a learned man, and his judgment was sought on all abstruse questions of theoretical mathematics by both Regiomontanus and Cusanus. One of the works of Cusanus, "De transmutationibis geometricis," is dedicated to him, *ad Paulum magistri dominici Physicum Florentinum.* He was a careful astronomer, an observer of orbits and comets, especially Halley's comet in 1456. His work in cosmography is, of course, well-known to you. It is very probable that Columbus consulted with him about the passage to India and perhaps carried his maps on the famous voyage to America.

For the next two years we lose sight of Nicholas except for one reference not very clearly made in the literature. It is said that he practiced law after receiving his degree and lost a law suit at Mainz; as the result of this he decided to enter the church. This story, it has been pointed out, is rather unlikely in view of what we know later of Nicholas' life. At all events, he entered the church and, therefore, in 1425 went to the University of Cologne to study divinity. He was there fostered by the Archbishop of Trier, his native town of Cues being part of the archbishopric of Trier. It is said that the next year Nicholas became secretary to Cardinal Orsini, the papal legate for Germany, but the reference is doubtful. By 1428, he had finished his education at Cologne and had become a curate at Coblenz and other German cities and lastly in Belgium at Liège. This was probably a period of training in minor church matters, but he must have advanced rapidly, for three years later, in 1431, he began his public career at the Council of Basle.

To understand his work at the Council it will be necessary to review briefly the history of the papacy during the preceding years. Some fifty years before 1430 there had been a schism in the Catholic Church. At the Conclave after the death of Gregory XI, Urban VI, a Neapolitan, was elected (1378), but there was a distinct protest from the populace because a Roman had not received the nomination. Order was finally restored but the disturbed French cardinals succeeded in splitting the conference and retired for the second time, to Avignon in France with Clement VII as their pope. Therefore there were two popes for a time. This unfortunate situation continued for some years until 1409, when the Council of Pisa gathered without special authority. This body renounced both of these ruling popes and elected a third pope, Alexander V. The situation, therefore, left a three-headed papacy, and a schism within a schism.

This continued until 1414, when another Council was called by Sigismund, King of the Romans and later Emperor of Germany, which met at Constance. At this famous gathering the reformer Huss appeared, the doctrines of Wyclif were denounced, the books of Huss were burned and he with them. The Council did not succeed in disentangling the situation in regard to the popes but did elect Martin v in 1417, in place of the former pope elected at Pisa. Soon after this meeting at Constance, the news of the death of Huss penetrated into his native city, Prague, and a riot ensued by the Hussites. Two schools were formed, the Hussite opposing the Catholic. The storm soon abated, but by 1419 Protestantism was strongly in vogue. Thus, at this period in the church history, there were two great movements afoot, the beginning of Protestantism and the organization within the church, typified by the Councils of Pisa and Constance. In Germany, both Church and State were in an extremely bad condition; the bishops and abbots had begun to take an active part in the government and had become rulers and lords rather than shepherds. One son of each family usually sought the Church because of the easy life and the many benefices obtained. The number of monasteries controlled was enormous, thus increasing greatly the persons dependent, in large part, for support upon the working classes.

Into this complexed situation came Dr. Nicholas Krebs, a man in his early thirties, unknown except to a few, such as Count Ulrich of Manderschied, and his old professor at Padua, Cesarini, now president of the Council. The Council met first at Basle from 1431 to 1437, and later at Ferrara. The object was to settle many matters and was definitely hostile to the existing state of the papacy. Many members wanted a complete overthrow of all existing institutions, but some of the more thoughtful delegates were more conservative. Krebs was thoroughly embued with the necessity for reform but did not wish to become so radical as to overthrow all existing institutions. At this time he wrote his famous treatise "On Catholic Unity," *De Concordantia Catholica,* in which he placed the authority of councils, such as the Council of Basle, above that of the pope. After the council had met, however, for some years, he saw that all councils were fallible and later acknowledged his error in judgment. He then took the stand that the pope should be supreme and for this decision was honored by the then existing Pope, Eugenius iv. Other matters taken up at this famous Council of Basle interested Nicholas. He defended the cause of his old friend, Count Ulrich, in a minor matter, but the cause was lost. He suggested, perhaps the most important point at the Council, the reform of the Julian calender. In his "Reparatio Calenarii," (1436) he outlined a method, leading up directly to the work of Lilus and the Gregorian calendar of 1582. Cusanus and a French Cardinal who preceded him, Pierre D'Ailly (1350–1420) are important figures in the founding of the modern calendar.

As a result of the definite statement of allegiance to the Pope, made by Cusanus, he was sent to Constantinople by Eugenius iv, in 1437, where he remained two months. He gained, in this short time, many friends for the Pope. He also was interested in discovering Greek manuscripts and returned from the East with a number of them, chiefly mathematical, the translation of which into Latin he supervised.

Greek manuscripts were of great interest at the time. They had appeared in Europe after the great Crusades of the eleventh century when a few were brought back and deposited in the monasteries when monasticism ruled supreme over Europe and all monasteries had libraries. The monks were the great hoarders of learning, many of them "bookish men." Their time was partly spent in copying manuscripts and the arts of calligraphy, illumination and binding. In England it will be remembered that many of these manuscripts were destroyed by Henry viii. The largest collections of manuscripts in Europe were in the monasteries in Switzerland, at St. Gall, at the southern end of Lake Constance, and on the island of Reichenau. In France perhaps the most famous collection was at Cluny, and in Bavaria, at the Abbey of Tegernsee. By 1447 the schism of the Church had disappeared and Nicholas v was the pope at Rome. He was essentially a student and books were his great passion. It will be remembered that a few years before that time, about 1439, Gutenberg was building his presses at Mainz.

The real revival of the Greek letters is due in part to Petrarch, 1304–1374. He was born at Avignon and lived there just before the time of the residence of the popes. He did not begin the study of Greek until he was forty years old, but from then on spent most of his time studying the language and stimulating search for manuscripts. His great friend and fellow-student was Boccaccio, 1313–1375, who was also interested in classical studies. Petrarch formed one of the first modern scholars' libraries. Under his direction scholars traveled all over Italy and into Germany and Spain, collecting manuscripts from the monasteries, many of which are now deposited in the Bibliothèque Nationale in Paris. He inspired many to master the Greek language and to search for manuscripts throughout Europe. It is not surprising then, that nearly one hundred years later when Nicholas, keenly alive to all movements of his period, went to Constantinople, he was on the lookout for Greek manuscripts.

Nicolaus Cusanus
(1401–1464)

Other libraries of importance were begun at or about this time. The Vatican Library was founded by Pope Nicholas v in 1453. Cosimo de' Medici had begun the Medicean Collection a little earlier, to be followed by Poggio Bracciolini, who escaped from Constantinople with his precious freight in the first years of the fifteenth century. Not the least of these is the library of Cusanus himself, founded in the hospital built by him in his native village of Cues about 1450.

On his return, Cusanus reported to the Pope in 1438 at Ferrara and he was created a papal legate to various cities in Germany. During the next nine years he spent his time traveling throughout Germany and France. We hear of him at Mainz, Frankfort, Nuremberg and at the court of Charles vii of France. He rallied the various organizations of the Church to the support of Eugenius iv with such success that he was called "the Hercules of the Eugenians." As a result of this effort he was offered the red hat of a cardinal by Eugenius iv but refused at that time to take it. This was largely because the reign of Eugenius as a pope was nearly over, and the next year, 1447, Nicholas v was elected pope. Two years later, in 1449, Krebs was made

Cardinal-priest of S. Petri ad Vincula. He was appointed to the diocese of Brixen in 1450. His appointment, however, was opposed by Sigismund, Duke of Austria and Count of the Tyrol. The opposition was so strong that Nicholas could not take the appointment until 1452. In the meantime, he again went to Germany as a papal legate and also to the Netherlands. For two years he traveled throughout the country visiting many places and all the important monasteries and hospitals. He reformed and corrected many parishes. It is said of him that he rode a mule from place to place. A story is told of his reaching Halle on the 6th of June, 1451, where he was met by a multitude of the cheering populace. A large company had filled the streets before the Rathaus to do him honor, but with characteristic modesty and humility, he escaped the crowd and withdrew to an embrasure of a window where he had a long talk with Busch, a reformer of the time. He later made Busch his assistant in Germany in visiting the monasteries. His trip ended at Cologne in 1452. It was said that everywhere he went he was considered "an angel of light and peace."

For the next eight years he remained at his post at Brixen where he had great difficulty with Sigismund. At the end of this period the trouble had not been settled and Nicholas was imprisoned by Sigismund who extorted from him a treaty unfavorable to the bishopric. He then escaped and went back to Rome where he laid the case before the then ruling Pope, Pius II. Little protection, however, was offered Nicholas by this weak ruler. It was not until 1464, the year of the death of Cusanus, that the Emperor of Germany, Frederick III, finally forced Sigismund to submit to the Church. Cusanus never recovered from the ill treatment received at the hands of Sigismund. He was sent on another mission by the Pope but died on the way, at Todi, in Italy, on August 11, 1464, in the presence of his old schoolmate of Padua, Toscanelli, by this time a renowned physician, and another friend of his school days, Bishop Johannes Andreae. His body was buried at the church of S. Petri ad Vincula at Rome but the heart was removed and taken to his hospital at Cues.

Such is a brief description of the life of Nicholas Krebs, known in history as Nicolaus Cusanus. It was a life full of travel, adventure and reforming activities. In his fifty years of active life, he must have had few moments of relaxation and quiet. We constantly hear of him going or coming, reforming both the Church and the State. He seems to have been almost indefatigable, for he traveled year in and year out, much of the time on a donkey, from one end of Germany to the other, everywhere restoring order, improving the intellectual outlook of the clergy and providing instruction for the people. He thoroughly appreciated the value of pictures for teaching purposes and he had illustrations made of the Ten Commandments, the Apostles' Creed and the Lord's Prayer, with text appended for use in the village churches.

It is said of him that he "ever remained simple in speech, manner and dress, was mindful of his humble origin and loved humanity." He distinguished himself while a student at Padua and later in almost every branch of science, but "he had no other ambition than to be the lowliest instrument in building up the House of the Lord." He was a believer in no half measures and early in his career he said, "a mortal sickness has afflicted the whole realm and death will inevitably follow if a stringent remedy be not applied." Cusanus carefully and conscientiously practiced all that he preached and lived a blameless life. He was always a student in spite of his almost superhuman activities, a man of faith and charity, possessing a mind capable of grasping all the then known human sciences, yet despising no detail as too elementary or trifling to occupy him.

Some time before his death Cusanus founded a hospital or almshouse in his native village of Cues, for thirty-three poor persons, the number being that of the years of the earthly life of Christ. To this institution he left his valuable library, his scientific instruments and most of his worldy possessions. In addition to the founding of the hospital at Cues and the *Bursa Cusana* at Deventer, he left two hundred and sixty ducats for the infirmary, S. Maria dell' Anima, at Rome. His will is in the library of this hospital. The building was begun about 1450 and since that date few changes have been made in its structure. It stands close to the river with the village grouped around it, a fine example of early Renaissance architecture. During the War, the thirty-three poor men retired to the village and the building was used as a German hospital until after the Armistice when American troops occupied the area and used it as a Field Hospital.

By the will of Cusanus the hospital is really a poorhouse, the stipulations for entrance being that only men can enter; they must be good, poor, over fifty years of age and not sick. The men are chosen from the district by the Burgomaster of Cues and his assistants. Each man has a good room and is comfortably housed. Arrangements are made for his family to be looked out for outside the hospital. Only within the last nine years have women been allowed in the building. Now (1919) there are six sisters and six domestics; the sisters belong to the Order of the Poor Handmaidens of Jesus Christ. The Rector of the Hospital is curator of the Library and Museum.

The library is an integral part of the hospital, occupying a small room on the second floor. The approach is through dark corridors of stone and up a winding pair of stairs, dark, forbidding and steep, a true medieval passage to a monastic-like treasure room. The opening of a heavy door, unlocked with difficulty, discloses a neat room lined with bookshelves and dimly lighted with leaded windows. Ancient tomes and many bound manuscripts fill the shelves with some of the finest of them in a glass cabinet along one wall. All are well marked and catalogued, thanks to the untiring efforts of Professor Marx of Trier, who spent many hours going over each item, carefully describing the binding, paper, illuminations, notes, etc. All his results are now published in a splendid catalogue *raisonné*.

Library in the Hospital at Cues

Great treasures are at hand in fifteenth century manuscripts besides many of the originals of the works of Cusanus, filled with superb astronomical drawings and beautiful illuminations. In the few minutes given to me, I could only turn some of the pages with admiration for the founder of such a wonderful collection of books, many of them so beautifully preserved for over four hundred years. Such a library is a fitting monument to a great figure in history.

The Library contains over three hundred manuscripts, about eighty-five incunabula and some fifty books published between 1500 and 1550. The subjects are mainly theological, although medicine and astronomy are well represented. Many of the manuscripts are beautifully bound in vellum or written on parchment heavily embellished with illuminated letters. Scattered throughout are notes in the Cardinal's hand, especially in the books on astronomy, and many of them contain numerous illustrations and diagrams dealing with astronomical and mathematical problems.

All of the works of Cusanus are found in the Library, most of them in manuscript form, although printed editions have been added later. One volume, in the hand of Rector Erckelentz (about 1488) is a complete copy of many of the manuscripts, and was probably used as the basis of the first printed edition. This was printed in Strasburg by Martin Flach in 1488–90. Seven copies of this edition are now in American libraries and another, now in the library of the late Sir William Osler, will soon be added to them. A second edition, which I have not seen, said to be almost identical with the first, was published in 1502. Another edition was printed in 1514 in Paris; still another, by Henri Petri at Basle, 1565.

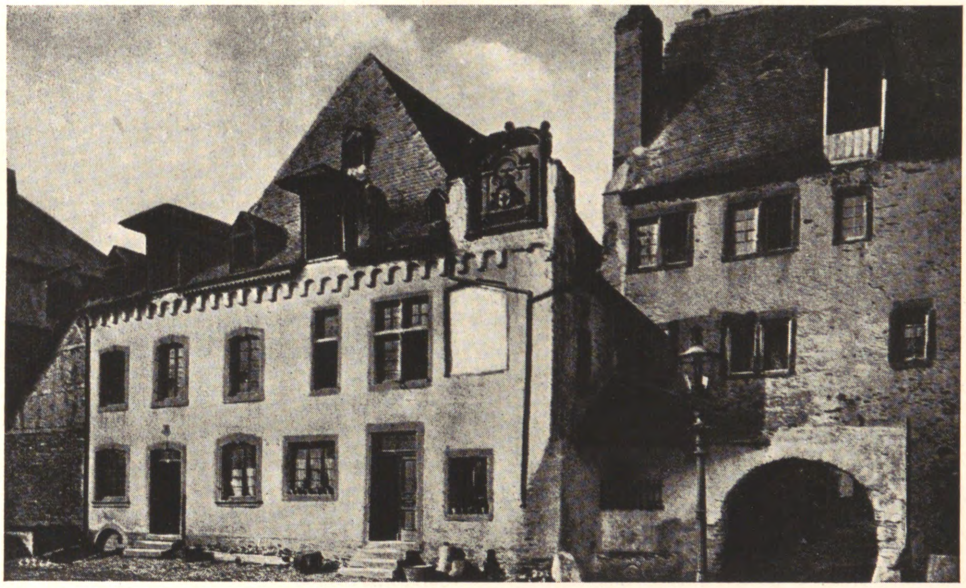
The writings of Cusanus have been conveniently divided under four general headings: juridical, philosophical, theological and scientific. In the first group, juridical, are found "De Concordantia Catholica" and other papers written for the Council of Basle (1432–35). His philosophical works were mostly written after he was forty. "De Docta Ignorantia" (1439–40) is the best known. It centers on a definition of finite and infinite, and demands a system of philosophy tending to unify all experiences, but more especially religious experiences. His main theme is that "all human knowledge is mere conjecture and that man's wisdom is to recognize his ignorance." Other philosophical works along similar lines are "De Conjecturis" and "Compendium," the latter, more especially, attacking the methods of Aristotle.

The theological papers are many, and can only be alluded to here. They are said to be dogmatic and mystic. The scientific papers interest us more. There are about twelve of them, all short. The "Reparatio Calendarii" (1436), written for the Council of Basle, has been mentioned. Other papers deal with astronomy, partly the result of careful observations with a few instruments, and partly speculation. Another paper, "Quadratura Circuli" deals with the old problem of squaring the circle, the attempted solution of which by Cusanus was opposed by Regiomontanus and criticized by Toscanelli.

In other works, partly scientific, one finds many suggestions, especially on astronomy, antedating the works of Copernicus (1473–1543). Cusanus states, in "De Docta Ignorantia," that the earth is not the center of the universe and that it is not devoid of motion. He even goes so far as to note that the earth moves not only on its axis, but as the stars in the heavens. "I have long considered that this earth cannot be fixed, but moves as do the other stars," and again, "to my mind the earth revolves upon its axis once in a day and night." The full development of the heliocentric theory came nearly a century later when Copernicus completed his "De Orbium Coelestium Revolutionibus" in 1530, not daring to publish it, however, until 1543 because of its revolutionary character, or perhaps more truthfully, as Walsh remarks, "because his astronomical opinions were constantly progressing; and with the patience of true genius, he was not satisfied with anything less than the perfect expression of truth as he saw it." The notes of Cusanus passed unnoticed in 1450 and those of Copernicus were not accepted in 1545. Even as late as 1600, Giordano Bruno, an exponent of the views of Copernicus, died a martyr at the stake in Rome in defence of the Copernican theory. Copernicus, like Cusanus, was a product of the school of medicine at Padua. He practiced medicine throughout his life with skill.

In mathematics and physics Cusanus was much in advance of his age. He wrote extensively on geometry and arithmetic, partly in a philosophical vein. Cantor, in his "History of Mathematics," gives some twenty pages to him. Cusanus preceded Regiomontanus (1436–76), sometimes known as Johann Müller, who wrote the first book on trigonometry ("De Triangulis, Nuremberg, 1533) and completed Purbach's great work on the astronomy of Ptolemy. Regiomontanus was the outstanding figure of his time. He equipped the first European observatory, making the instruments himses his fundamental ideas on the use of the balance in medicine and science.

Mitchell says, in his delightful essay on the "Early History of Instrumental Precision in Medicine," "the history of the balance in medicine is yet to be told." Cusanus' use of it forms an important chapter in its history. His work leads directly to Sanctorius and his metabolic studies with the steelyard chair and to Van Helmont's gravimetric analysis of urine.



The House in Cues, Germany, in which Nicolaus Cusanus was Born

self, and had a printing press as early as 1474. It is said that he was greatly influenced by the work of Cusanus. He died at the early age of forty, twelve years after Cusanus.

In one short paper by Cusanus, "De Staticis Experimentis," are found many of his interesting contributions to science. It was written and published as the fourth part of a series of papers called "Idiotae libri quatuor," in the form of a dialogue between *Idiota*, or an ignorant man, and *Orator*. These four papers were published separately as "Idiota" (1476).[1] In "The Experiments on Statics," Cusanus expresses his fundamental ideas on the use of the balance in medicine and science.

Cusanus first suggests that the balance might be used to establish more accurate judgments in regard to the qualities of water, blood, urine, herbs, etc., although he wisely remarks that "nothing in this world can reach absolute precision." Many mysteries, he says, can be truly solved by the differences of their weight. For instance, the weight of equal amounts of water from springs might be compared, and he quotes Vitruvius, the famous Roman architect and engineer, on the value of choosing the site for a house near lighter and sharper water rather than one located near heavy and earthy water, probably referring to the bad

[1]An English edition has been called to my attention by Dr. E. C. Streeter: "The Idiot in Four Books. The first and second of Wisdome. The third of the Minde. The fourth of statick Experiments, or experiments of the Ballance. By the famous and learned C. Cusanus, London, printed for William Leak, 1650." A copy is in the library of the University of Pennsylvania, Philadelphia.

effects of living near stagnant waters and perhaps suggesting the effects of malaria. The disease was common in Rome and the drainage of a swamp land was a plan of recognized value. A single manuscript of Vitruvius was found by Poggio Bracciolini while attending the council of Constance, at the monastery of St. Gall during the early life of Cusanus and it is not unlikely that he knew of it and perceived its value. We know that later in the Renaissance after the death of Cusanus the work of Vitruvius, "De Architectura," was the chief authority on the subject.

Perhaps more important than the weighing of water from different springs is the suggestion to weigh water from the same spring at intervals of time and thus note changes in its quality. It requires only a slight change of method to compare the weights of the sediments, a procedure now in vogue.

Cusanus also speculates, on less firm ground, in regard to the value of comparing the weights of equal volumes of the blood or urine of "a healthy man and of a weak one, of a young man and of an old, of a German and an African," thoughts which in part now find their place in the problems of modern blood chemistry. He also suggests that the difference noted in the blood and urine above would be an indication for the amount of treatment (herbs) to be given. Only very recently has the amount of blood sugar or the amount of protein in the cerebrospinal fluid been used as indicatory of the amount and character of diet to be given in diabetes, or the grams of arsenic to be administered in neuro-syphilis.

In suggesting the balance as a quantitative measure for metals, he first noted the difference between a weight in air and in water, *i.e.*, the specific gravity. He would use this to determine quality of metals much as we use it today, but he slyly remarks that such a method "would be of very great value in ascertaining how far the works of sophistical chemistry fall short of reality." A practical mind groping in the darkness of alchemy!

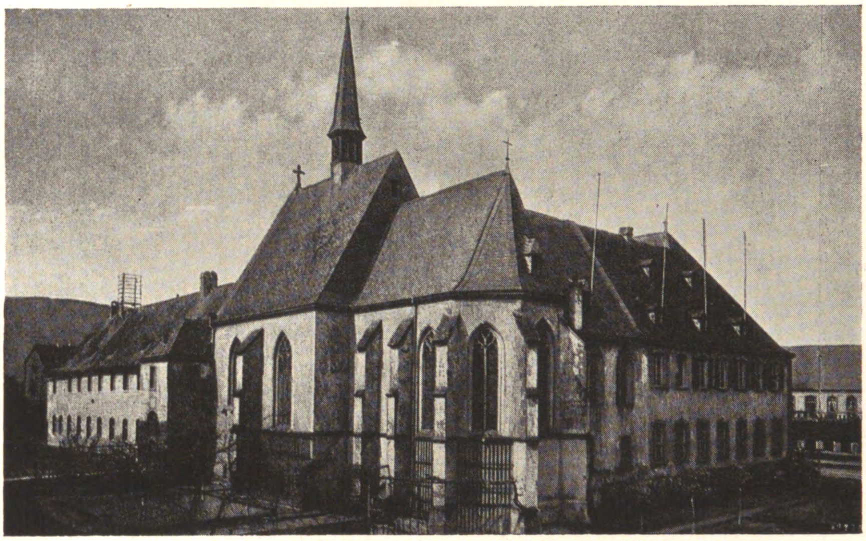
Among other points, Cusanus calls attention to the property of quicksilver clinging to other metals, the basis of making of mirrors, although today, of course, the silver is deposited by an electrical method. Also, he would measure the "pull" of a magnet by the use of the balance and, perhaps more important, he would compare the weight of an object with the weight of its ashes, thus estimating the loss of weight due to combustion. The absorption of water by seeds and the conversion of snow into water by heat are noted. In fact, so many points are brought out that he questions the possibility of recording all the facts even in a very large book. He remarks that "experimental science demands extensive treatises, for in proportion as they have been more numerous so much the more infallibly can the knowledge concerning experiments, which they bring to notice, be arrived at."

Another experiment is suggested, to record the humidity of the air by weighing an absorbable substance such as wool in dry air and moist air, and also, conversely, to test the drying power of the sun, both experiments being of great practical value to the agriculturist. Still other experiments test the speed of ships, and indicate his knowledge of both relative and absolute motion. The experiments relative to astronomy are fundamental but cannot be given here. Many of them are based on time as measured by the water clock, or clepsydra, which measured the time intervals by the flow of a definite amount of water. The Nuremberg eggs, the first watches, the invention of Peter Henlein, did not appear until the middle of the sixteenth century. Clocks only existed in the towers of cathedrals and public buildings; the water clock, in the time of Cusanus, was the only time measurer in the home.

Cusanus also suggested the use of the water clock to take the pulse, or rather, to weigh the water fallen from the clock during the time of one hundred pulse beats of a healthy man and during the time of an equal number of pulsations in a weak man. This method he would apply to men of various ages and with different diseases. The same method was used in relation to respiration, especially in fevers.

"The Experiments on Statics," therefore, is full of suggestions far in advance of its time. Some are, of course, only restatements of ideas expressed by others before the Middle Ages. Much of his work fell on deaf ears. Many years were to pass, even centuries, before the worth of these suggestions was tested or proved. We have no knowledge that Cusanus actually tested many of his theories himself. The work is certainly partly speculative; Cusanus' active mind formulated the problems and suggested proof of them by laboratory methods. A few of the geometrical and astronomical problems gave him much thought and he even solved correctly some of the mathematical ones. Undoubtedly, he pondered over them while traveling on his donkey throughout Europe. Once, when riding in a carriage, he noticed the track of a fly thrown off from the rim of a wheel, and from this observation he solved a mathematical curve.

"De Staticis Experimentis" contains so much of importance that one feels justified in producing a complete English translation of it. For this, I am indebted to the late Sir William Osler, who had the translation made for me in London from his own first edition of the works of Cusanus.



The Hospital at Cues, Germany

Let me conclude this brief and very incomplete paper by a summary note on the position Cusanus holds in history. He was not a "great" figure, when comparison is made with the stellar lights of the Renaissance who came after him, but even his relative importance has not been sufficiently emphasized. Burdened as he was by medieval theology, nevertheless, he saw and stated clearly certain principles of science and medicine that were either new or had been dormant in men's minds for centuries. His work in mathematical physics and on measurement and specific gravity once again called the attention of the world to the importance of science. In spite of his ecclesiastical standing, he was able to make, and had the courage to announce, his revolutionary theories of astronomy. To say that the earth was not the center of the universe when no one considered it otherwise, was an important and courageous stand to take. It was not, however, the first observation of this kind, but it was a restatement of the fact at an important and critical time in the history of world thought. Most thinkers of his time, entrusted by the popes as he was, were absolutely submissive to the will of the Church, and accepted without question all of the medieval canons upon which the Church stood.

In relation to medicine, his observations in "The Experiments on Statics" are fundamental. His great achievement was the counting of the pulse, which, as Norman Moore says, "had been felt and discussed in many ways, but never counted. The first method of a new invention is often unnecessarily cumbrous, but this does not detract from the merit of the man who first discerns its principle."[2]

In addition to his scientific achievements, we ought to remember Cusanus as an author and philosopher of rare ability. His philosophy is perhaps best expressed in the following quotation:

> To know, to meditate, to see the truth is a perpetual joy, and the older one grows the greater is the delight which it affords, and the more one gives one's self up to it the greater is one's longing for the possession of all truth. As love is the life of the heart, so is the endeavor after knowledge and truth the life of the mind. In the midst of the movements of time, of the daily work of life, of its perplexities and contradictions, we should lift our gaze fearlessly to the clear vault of heaven and seek ever to obtain a firmer grasp of, and keener insight into, the origin of all goodness and duty, the capacities of our own hearts and minds, the intellectual fruits of mankind throughout the centuries, and the wondrous works of nature around us; but ever remembering that in humility alone lies true greatness, and that knowledge and wisdom are alone profitable in so far as our lives are governed by them.

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DE STATICIS EXPERIMENTIS[3]

By

NICOLAUS CUSANUS

The layman's treatise concerning static experiments begins pleasantly.

The well-known Roman orator used to keep company with the idiot so that he might now and then hear his ideas, which pleased him.

When the orator praised a balance as being the scales of justice and an instrument of necessity to the state, the idiot replied:

Idiot. Although nothing in this world can reach absolute precision yet we endeavor to establish more accurate judgment and so it is accepted on all sides. But tell me, pray, since it is not possible for a weight to be of the same size in circumstances of diverse origin, should not each weight be tested by different experiments?

Orator. I have neither read nor heard so.

Idiot. I wish some one would furnish such a verification. Even were it spread over many volumes, I would gladly give attention to it.

[2] According to Allbutt, Herophilus was the first to count the pulse, using a pocket water-clock made in Alexandria. (Allbutt, "Greek Medicine in Rome," London, 1921, pp. 139, 163, 301.)

[3] Translated from the Flach, Strasburg Edition, 1488–90. (Hain 5893[1]) in the library of the late Sir William Osler.

Orator. If you felt inclined to do it, I do not think anyone would do it better.

Idiot. Anyone who wished could do it, for it is quite easy, but I lack the time.

Orator. Just speak of its usefulness and system. I will see if I, or someone else can finish it.

Idiot. I think the mysteries of things are more truly solved by the differences of their weights, and that a great deal might be ascertained by a more accurate interpretation.

Orator. What you say is really excellent. For this the prophet tells what is the weight and balance, while the decision is His, who has created all things in number, weight and measure, and has launched springs of water and weighed out the mass of the earth, as the wise man writes.

Idiot. If therefore a measure of the water of one spring is not of the same weight as an equal measure of another, the decision, as to the different nature of the one and the other, is better attained by a scale than by any other instrument.

Orator. You say well. Vitruvius writing on architecture advises that a site for a house should be chosen, which has lighter and sharper waters, while one which has heavy and earthy waters should be shunned.

Idiot. Thus the waters of the same spring seem to be of the same weight and nature, whilst those of different springs are of different weight.

Orator. You say they seem, as though they were really something else.

Idiot. I admit that weight varies with time —perhaps sometimes imperceptibly, for undoubtedly the weight of water is at one time this and at another time that. So too there is one weight of water round about a spring, another at a distance from the spring, but the differences being scarcely perceptible are considered of no consequence.

Orator. You think then that in everything it is just as you have said in respect of water.

Idiot. Certainly I think so. For by no means have things similar in size, yet different in quality, the same weight. Hence since there is difference in the weight of the blood and urine of a healthy man and of a weak one, of a young man and of an old, of a German and an African, would not a physician hold it of the greatest value to have all these differences registered?

Orator. Most certainly. Indeed through having the weights authenticated he would think himself in an admirable position.

Idiot. Now I think a physician would be able to come to a truer decision from the weight of urine and from its color at the same time, than from a deceptive color.

Orator. Most certainly.

Idiot. So also, as the roots, stems, leaves, fruits, seeds and sap of herbs have their own weight, if the weights of all herbs were registered with their various situations, a physician could better arrive at the nature of them all from their weight and odor, than from a deceptive taste.

Orator. You speak excellently.

Idiot. He might then learn from comparing the weights of herbs with the weight of blood, or urine, to arrive at the amount to be applied from the similarity and difference of the drug, and to make wonderful prognoses, and so from experiments by the scale everything knowable could be reached by a more accurate inference.

Orator. It is greatly to be wondered at that hitherto so many hard working researchers have been inactive in registering weights.

Idiot. Do you not think that if you let water flow from the rigid opening of a water clock into a basin for so long as you could feel the pulse of a healthy youth beat a hundred times, and did similarly in the case of a weak lad, that differences of weight betwixt the waters would fall under your notice?

Orator. Who doubts it?

Idiot. From the weight of waters therefore, the differences of the pulses would be arrived at, in the young, old, healthy, infirm, and so a truer knowledge of the disease; since there necessarily turns out to be one weight in one infirmity, another in another. Wherefore a more accurate judgment might be arrived at by such a difference resulting from an experiment of the pulses, and by the weight of the urine, than by the touching of a vein and the color of urine at the time.

Orator. You speak excellently.

Idiot. If what has already been affirmed up to this point from the position of the weights of water affects spitting or breathing by inspiration and expiration, would it not still give a more accurate inference?

Orator. It would, certainly.

Idiot. For if, while water flowed from a clock, 100 expirations were counted in a boy, and similarly in an aged man, it is not possible that the waters should turn out to be of the same weight. So I say in respect of other diverse ages and constitutions. Then when a physician had definitely fixed the weight of the breath of a healthy boy or young man, and likewise of a man suffering from various weaknesses, undoubtedly by such an experiment he would arrive more surely at the knowledge of health and of a fall away from it, and at the quantity of the remedies.

ORATOR. Yes, even at inferences of their period.

IDIOT. You speak well. For if he were to discover in an uninjured youth the weight of an old and decrepit man, he would infer that he was surely about to die, and he would make wonderful inferences of this kind. If still in the case of fevers he could register by a similar method the conditions, hot and cold, by the differences of the weights of the water, would he not be able more truly to arrive at the effectiveness of the disease and the fitness of the remedy?

ORATOR. Undoubtedly he could, for he would test the ascendency of one quality over another, of heat over cold, and conversely, and according to the condition he had found, he would apply certain measures.

IDIOT. Still I say in different nations, districts and types, these conditions change at the same period of age. Whence although difficult, it would be very useful to have them all registered according to their weights.

ORATOR. It is just as you say.

IDIOT. It seems, however, that the weight of each thing should be taken as the average of its weights, as they vary in different climates. As, for instance, if the weight of a man be considered in comparison with another animal; then the man should be considered, not as living in the North or South, where here or there he is beyond the average; but rather as living in an average climate.

ORATOR. You speak excellently. The ancients called that climate "Dyarodon" for it stretched from East to West through the island of Rhodes. But I should like to know how you would proceed, if you were seeking the weight of an entire man, in comparison with any other animal.

IDIOT. I should place the man on a scale and should hang a weight equal to him on another part of it; then I should put the man into water, and again outside the water I should hang a weight, equal to him, from another part; and I should note the difference of the weights. Also I should do the same with the given animal, and I should note down what I had learned from the various differences of the weights. After this I should direct my attention to the difference of the weights of man and animal out of the water, and then adjust and write down what I had found.

ORATOR. I do not approve of this principle of adjusting.

IDIOT. I will show you.

And having taken a light piece of wood, whose weight was as III, while that of water filling the same space was as V, he divided it into two unequal parts, one of which was double the size of the other. He put both in a tall cask and held them down with a stick, while he poured water over them, and when he withdrew the stick, the pieces of wood jumped to the surface of the water, and the larger piece quicker than the smaller.

Look, you see the difference of motion in exact proportion with its cause, for in light pieces of wood, there is more lightness in the larger one.

ORATOR. I see and I am greatly pleased.

IDIOT. So I say adjustment ought to be made. For, if a man because of his greater size was heavier than an animal he would sink in water quicker than an animal of the same proportion. Wherefore then the adjustment of a difference that has been discovered ought to be made by proportionally diminishing its excess.

ORATOR. I understand now. But tell me how the water hinders the wood sinking.

IDIOT. Because the greater heaviness hinders the less. Wherefore if you have pressed a round piece of wood into wax and drawn it out, filling its place with water, and have noted the weight of this water and similarly of the wood, you will find that if the weight of the wood exceeds the weight of the water, the wood sinks; if not, it floats, and a part of the wood remains above the water in proportion to the excess of the weight of the water over the weight of the wood.

ORATOR. Why do you talk of round wood?

IDIOT. If it is of a broad shape, it will cover more of the water and will float higher. Hence ships in waters of little depth ought to be of a wider bottom.

Orator. Go on with what you have begun. Could the weight of animals be arrived at in any other way?

Idiot. I think they could. For if you filled a balance with water up to the brim and put the same into another, then took the weight of a man outside the water, after this made him sink in the former scale and collected and weighed the water that flowed out, proceeding in like manner with another man, or animal, or any other thing, from the differences of the weights by an acute calculation you would arrive at what you sought.

Orator. Plainly I have often heard, that at times the difference of metals has been discovered by this system, and that some men have noted how much gold, silver, copper, and so of all metals, is collected by pouring out an ounce of wax.

Idiot. He who observes the quantity during its pouring out deserves to be praised. For he sees that if gold occupied as much space as an ounce of wax, then its weight would be so much. Thus too of other metals. For it is very certain that gold has one weight, silver another and other metals in relation to their quantity. And the weight of anything you like is one thing in air, another in water, another in oil, or in other liquid. Then, if anyone had all these weights registered, he would know forthwith how much heavier one metal is than another in air, or how much in water. Hence whatever mass were given, through the difference of its weights in air and water, he could tell to what metal or to what mixture, the mass belonged, and as it has been settled regarding air and water, so also it could be settled concerning oil, or any other fluid, in which an experiment has been made.

Orator. So without pouring out the mass, or separating the metals, the mixture would be found out, and this system would be useful in mints to find out how much copper has been mixed with gold or silver.

Idiot. You say well. Certainly it would be of very great value in ascertaining how far the works of sophistical chemistry fall short of reality.

Orator. If anyone therefore proposed to write a book on weights he ought even to register the difference of every metal, as it seems; for the gold of Hungary has one weight, the gold of Obren another. And so of each metal.

Idiot. From the foregoing statements it is certain that as in springs, so also in mines difference of weight is found. Gold, however, wherever it is found, is always heavier than any other metal. So that golden glitter is found to vary in weight within a certain limit. And so of the rest.

Orator. From the position of the weights of metals, can the position of their masses be sought for.

Idiot. Lead is much like gold in weight, but not at all as regards its perfection. So, I do not consider that attention should be given to one weight alone, but to each weight in turn. For if anyone gives attention to the molten fire both of gold and lead, he will find that lead approaches gold less than any other metal; and if anyone gives attention to the weight of the fire of melting iron, he will realize that iron approaches gold more nearly than does any other metal: question how far this is of less importance in comparison with gravity. Wherefore all sorts of weights ought to be given attention—not gravity only, and thus we find silver to be nearer to gold.

Orator. Vitruvius says concerning the weight of the substance of gold that it alone sinks in quicksilver, of however little heaviness it may be, whilst other metals float of however great mass they are.

Idiot. Quicksilver can be compared with all metals on account of the property common to itself and them; but it clings more closely to gold, as the least perfect in its quality to the most perfect. Hence those who have leisure for experimenting in chemistry seek to overcome quicksilver by fire, when not only does it not vanish from the fire, but keeps all other metals, to which it is united, fixed with itself and not only this, but brings them to the weight of gold by its permanent nature of flowing and its malleable moisture, and tinges them with a fixed and permanent color.

Orator. Do you think then it is possible to accomplish what they propose?

Idiot. Accuracy remains unattainable, but how far they have progressed the scale shews, without which they can accomplish nothing certain, for by this judgment of fire and scale, investigation of this subject can be made.

Orator. Can all precious stones be weighed in like manner?

Idiot. There is no doubt that all can be weighed by one system, for a diamond has one weight as compared with a piece of lead of equal size and a sapphire has another, likewise compared with a piece of lead of equal size and from their different sizes the relation of the leaden weights of each is known. And similarly concerning all stones, so that by that method of experiment with a scale, it would be very useful to have the weights registered with their different sources, so that if any falsities were made in beryl or colored crystal they could be detected.

ORATOR. As a stone has one weight in air, another in water and another in oil, it would be good to have their differences noted, so that without referring to lead or any other third matter, the differences of their weights might be known.

IDIOT. You speak excellently.

ORATOR. Tell me if it appears to you that the value of stones could be weighed by any other method.

IDIOT. I think that the value of a loadstone might be weighed, if iron having been placed on one side of a scale, and loadstone balancing it on the other side, then, the loadstone, weighing so much, having been taken away and another weight substituted for it, if the loadstone were held over the iron so that the iron fixed on the double sided balance were attracted upwards to the loadstone, by this movement out of level with the other side the weight would be made heavier until the iron was pulled back to the level while the loadstone remained unmoved. I think the value of the loadstone might be said to have been relatively weighed through this drawing back of the weight (to its former level position). Similarly also the value of a diamond might be arrived at from how far it is said to prevent a loadstone from attracting iron, and other values of other stones from their control and also from the difference of the size of their substance, since in a larger substance would be larger value.

ORATOR. Could not also a skilled man find out how much quicksilver and how much sulphur any metal, or stones contain?

IDIOT. He could certainly by the agreement and disagreement of weights closely search out all such questions, and likewise the elements of quicksilver from the difference of its weight in air, water, and oil, compared with water and oil and with the weight of ashes of the same size. So also of sulphur. Thus through this method he could arrive by a more accurate inference at the elements of all metals and stones and at the weights of their elements.

ORATOR. These are admirable ideas. Could it not also be done in respect of herbs, woods, flesh, animals and fluids?

IDIOT. In respect of all, I think. For when wood has been weighed and after being burned its ashes weighed too, one learns how much water was in the wood, for only water and earth have a heavy weight. Likewise it is known from the difference of the weight of wood in air, water and oil, how much that water in wood is heavier or lighter than the pure water of a spring. So too, how much air (was in the wood) and from the difference of the weights of the ashes how much fire, and thus the elements are searched for by a more accurate inference; although absolute precision may be always unattainable. Also what has been said concerning wood may likewise be said of herbs, flesh and other things.

ORATOR. It is said that no simple element can be found in the way in which we have done this experiment by scale.

IDIOT. If anyone having put 100 lbs. of earth in a cask, afterwards packed up the 100 lbs. excluding herbs, or seeds, which had been thrown upon the earth, after first being weighed, and in a short time again weighed that earth, he would find it diminished in weight. From which he would gain an opinion that the herbs he had gathered had been made heavier by water. The waters therefore mingled with the earth have attracted these herbs, belonging to the earth. The actions of the sun too on herbs are congested. If these herbs were burned would you not infer through the differences of all the weights how much earth over 100 lbs. you had acquired? It is manifest also that the extra weight had been added by that water. Elements are partly converted into one another, as we find when glass is placed upon snow we discover that the air on the glass is condensed into water, like a fluid on the glass. So we find that certain water is turned into stones like water into ice, and there is a quality, for hardening and turning into stone, in certain springs, which turn things placed in them into stone. So it is said that Hungarian water is found, which, on account of vitriol in it, turns iron into copper. Indeed it is established by such capacities that waters are not simple elements but are made up of elements and it would be most valuable to possess the weights of all these waters of various capacities, so that from the difference of their weight in air and oil, we might make a close inference of their capacities.

Orator. So also concerning earth.

Idiot. Yes, also concerning earth; since one kind is fertile another sterile, and in one we find stones and minerals, which are not found in another. It would therefore be very useful to know the various weights of different earths in water, air and oil, for the purpose of enquiring into their separate natures—so also from the difference of the weights of urines, wax, oils gums, aluminum, squills, leeks and all such weights. I think that the capacities they possess in different forms could in some way be found out.

Orator. These things could scarcely be written in a very large book.

Idiot. Experimental science demands extensive treatises, for in proportion as these have been more numerous so much the more infallibly can the knowledge concerning experiments, which they bring to notice, be arrived at.

Orator. Perchance even the weight of air can sometimes be arrived at by acute conjectures.

Idiot. If anyone were to hang a quantity of wool, dry and scorched, on one side of a large scale, and on the other side stones up to the same level, in a district and atmosphere of mild temperature, he would find that the air became moist, the weight of the wool would increase and that as the air inclined to dryness it would shrink. So by means of such variation he weighs the air and might make similar inferences concerning the changes of seasons. So should anyone wish to find out the varying strength of the sun in different climates, if from the more fertile fields of one as of the other climate he weighed a thousand grains of wheat or barley, from the difference of their weights he would find the varying strength of the sun; for, with a definite quantity and a field of equal fertility in any place you like, there could be no difference, save by reason of the sun. Thus indeed from the difference he would be able to seek after the strength of the sun in a region of mountains and of valleys, on the same line, East and West.

Orator. If anyone let fall a stone from a high tower, while water was flowing from a rigid opening into a basin, meanwhile weighing this water that flowed forth, and likewise did the same while a piece of wood of the same size was falling, could he not discover the weight of the air from the difference of the weights of the water relating to the wood and to the stone?

Idiot. If anyone did this from different towers of equal height and at different times he might at length reach an inference. Still he would discover the weight of the air quicker through different forms of equal length. For instance, if I let fall a pound of lead in spherical form from a turret, and gathered up the water from the clock, and then let out a pound of similar lead of a broad shape, similarly gathering up the water, from the difference of the weights of the waters, the weight of the air would be found out. For we find that birds with wings spread out remain steadier, because they take up more air. So also in water a compact weight of spherical form sinks quicker than when extended into a square, and so by such a method the weight of air, and of water too, can be discovered, and conversely the different value of forms.

Orator. I have heard that the depth of the sea is sought by some such method.

Idiot. It might be done with lead made into the image of an eight-day moon, with one horn heavier and the other lighter and upon the lighter should be hung a fruit or other light thing of similar nature, and after the lead had dragged the fruit to the bottom, first touching the earth with its heavier horn and then bending over, the fruit having been released from the horn would return to the surface. Knowledge would be obtained by using a similar lead and fruit in other water of known depth for from the different weights of water flowing out of a clock from the time the lead was cast forth to the return of the fruit (to the surface) in different waters the question is answered.

Orator. I believe that in such and other ways the depths of waters can be investigated. But tell me whether the speed of a ship's movement can thus be ascertained?

Idiot. As how?

Orator. Why by throwing a fruit into the water from the bow, and letting water flow from a clock until the fruit has reached the stern, and then comparing the weights of the water at one and the other time.

Idiot. Certainly by that or another method, as through the shooting forth and arrival of the ship like an arrow quicker or slower as compared with the water from the clock.

Orator. The knowledge of the power of works and engines seems able to be investigated relatively, through the flow of water from a clock from the moment when an arrow is shot diametrically upwards till it returns to earth, so long as the different engines have arrows of the same size.

Idiot. The power of bombarding engines certainly and of wind, so also of the rapid movements of men and animals and of their strength and anything similar that can be mentioned could be investigated by inference from experiments with scales and by the flow of water from a clock.

Orator. How can the power of a man be found out?

Idiot. You will see what weight, placed on one pan, a man can raise to a level with the empty pan by dragging down the latter. Then subtract the weight of this man from the weight he had pulled up and what remains of the heaviness of that article is proportionate to the power of the man.

Orator. So also the breath of a man can be weighed.

Idiot. There is one weight of a man drawing in and holding his breath and another of his breathing out, also one of a living man and another of a dead one; so also among all animals. Whence it is admirable to have registered these differences among diverse animals and diverse men and among men of diverse age, so that inference may be able to reach up to the weight of living breaths.

Orator. Cannot the heat and cold and drought and moisture of a season be sought by such a method?

Idiot. Certainly it can. For if you have marked the weight of water in a cold season, before it has frozen and afterwards, you will find it different. For when you see ice on the top of the water you will notice that it is lighter than the water. So according to the intensity of the cold the variation of its weight increases. So also, if in a hot season you have exposed water to air, the weight will vary according to the season. Or again, if you have weighed green wood, after some time you will have found its weight altered, and will realize from this the excess of heat and cold, as also of dampness and drought.

Orator. Cannot also the time of day be thus weighed?

Idiot. If you have taken the water flowing from a clock from sunrise to sunrise and have weighed it, and again have made it flow on another day from sunrise, by comparing this weight of the water which has flowed out, with the first weight, you will be able to learn the hour and time of day.

Orator. Perhaps also the time of year!

Idiot. Yes, if throughout the year from sunrise to sunset by means of the clock you have noted all the days, you will always be able to arrive inferentially both at the day of the month and the hour of the day; although on those days which have little variation in their brevity you will do it less surely than at other times.

Orator. I perceive that by such a system the motion of celestial bodies can be arrived at, as Nemroth is said to have done and Hisparthus to have described.

Idiot. You say right and it is granted that their work was done with assiduity and careful consideration. For if anyone, when he had noted a star set on the Meridian line, gathered the water flowing from a clock, until the star returned and did likewise in respect of the sun from sunrise to sunrise, he would discover the movement of the sun towards the East from the difference of the lesser weight of the water belonging to the movement of the star from the Meridian line till its return to the same, also the sun's movement from rise to rise. For in proportion as the movement were less, so would its weight compare with the weight of the entire circle.

The movement would be in connection with the equinoctial circle, not the zodiac, which is not marked over the poles of the earth, but its own. So if anyone wished to find out, by means of this same star, how far the sun had moved in 15 days, he could do it by this very method, from the varying distance of the sun's rise as compared with the situation of the star on the Meridian line.

For instance, if today the difference of the position of the star on the line from the rising of the sun was found by the clock to be in a certain proportion to the weight of the water of the entire revolution of the star, then in 15 days another proportion would be found, owing to the difference of the movement and always in connection with the Equinox.

Orator. Cannot motion in the Zodiac be found in this way?

Idiot. It can certainly from the movement of the sun from midday to midday and from rise to rise and from rising to setting. For by these differences the declination of the Zodiac from the Equinoctial line can be traced.

Orator. What about the difference of motion which is said to take place from the Eccentric Circle?

Idiot. This also will be found when during the year dissimilarity is found in the Zodiac on similar days. For the sun does not move from the Equinox in an equal number of days during the summer, it returns to the Equinox just as in winter, when it does so quicker for it will not be found to have traveled from the "Scales" to the "Ram" in just so many days as from the "Ram" to the "Scales." This difference would disclose the eccentric or small orbit of the different movement.

Orator. What about the size of the sun's body?

Idiot. By the weight of the water that flows from a clock, from the beginning of the sun's rising on the Equinoctial line, till it is entirely over the horizon, as compared with the water of the star's revolution, the appearance of the size of the sun's mass is known in relation to its sphere. Nevertheless its size can be sought after by another method—namely solar eclipses.

Orator. How?

Idiot. We find the moon's movement in the same way as the sun's. Then from its eclipse and movement through the shadow of the earth we seek the size of the moon, in line with the fickle shadow of the earth, and from these we infer its average proportion to be of a certain size in comparison with the earth. Then from the movement of the moon and the eclipse of the sun we seek the distance of the sun from the earth and its size by an acute calculation—though still by inference.

Orator. From these instances, which you have related, it seems that all differences of movements and eclipses of luminary bodies, indeed the advances, halts, retrogressions, movements in straight lines, movements away from the center, of all planets, can be arrived at from the same and unparalleled system of the scale and clock.

Idiot. Yes indeed, you can, if you are sufficiently accurate in picking up the variations.

Orator. But what about the evidence of stars?

Idiot. I think also that from the difference of the weights of water in one and another year, and by certain other differences of the weights of trees, herbs and grains of corn, coming fertility or decay can be more quickly inferred from past experiments than from the movements of stars. For if in March the weight of water, air and trees be found to be of a certain degree, fertility of the earth ensues; if otherwise barrenness or mean harvests. So also of wars, plague and all similar ordinary events. And this is the root of the matter when from these stars in succession we seek the evidence of stars, just as people seek the age of the moon from signs of the marrow in animals, fishes and crabs, from trees also and rushes, and its zone from the flow of the sea.

Orator. I have heard that from the flow and ebb of the Nile the Egyptians foresee what is going to happen during the year.

Idiot. There is no country which if it directed attention to such investigations would not make discoveries, and in accordance with this system from the fatness of fishes and reptiles at the beginning of winter, we anticipate extreme and lengthy cold, against which keen-scented nature has made provision for the animals.

Orator. What of the questions asked by astrologers? Can a favorable reply be made to them all by your system?

Idiot. Well, if not favorable, at all events some reply, I think, can be made. But by what method an inference can be drawn in respect to these questions, needs considerable investigation. Nor can the appropriate method be ascribed to scales, for he who is replying may perchance not be able to ascertain the weight of his reply, except from the weight of the question. And indeed the ardour for asking a question for the purpose of investigating some foresight of a future event seems to be misplaced. Possibly it does not appear whence the desire comes, just as if a man who feels something in his eye, which he does not see, looks for it from another point in order to see what is not there.

Orator. I think you indicate you would like replies to be sought for just as in the wheel of Pythagoras the method is handed down from the varying combination of the name of the mother asking the hour of the day and the light of the moon, or that one should sum up his inference as seers do from oracular responses, or by chance readings of books of the Sibyls, or from a stringed instrument, or houses, or geometrical figures, or the twitterings of birds, or the twirling flame of fire, or from reference to a third person, or some other casual intervention.

Idiot. There have been people who used indirectly to seek for an answer out of a conversation, which they were having with their questioner regarding new dispositions in the order of a country as though a sudden opinion would make itself known in lengthy discussions. For if their conversation inclined to sadness, so it was thought would be the issue of the matter; but if towards joy, joyful would be the result. But I, having regard to the face, beard, movement of the eyes, style of words and the prophecy of the weights of the subjects, which I make my questioner tell me in repeated forms, used to consider that by giving such attention opinions can be formed. Still they are worth more when they come from a man, who lights upon truth without previous consideration, in whom a certain foreseeing spirit seems to speak. Nevertheless I think it is not possible to make a trade of such a matter, nor can a man who has discernment communicate it, nor should a wise man have leisure for these things.

Orator. You speak excellently, for St. Augustine relates that there was a bibulous man in his time, to whom the thoughts of minds lay open and who used to detect thieves and brought other secrets to view, though strange to say he was most unstable and had very little sense.

Idiot. I know I myself have often related many things as the spirit gave me utterance and was almost ignorant of their reason. At length it appeared to me that a serious man ought not to speak without cause and I became more silent.

Orator. Well, after that it seems sufficient has been said concerning the movements of stars; something must now be added about music.

Idiot. Yes, in respect of music experiments by scale are most useful. For from the difference of the weights of two brass bells, sounding a tone together, it is known in what relation of harmony the tone consists. So also concerning the weight of shepherd's pipes, and the proportion of the amounts of water fitting the pipes is known,—*viz.:* Octave 5 notes, 4 notes and of all harmonies that can be made at all. So also from the weight of hammers, whose fall upon the anvil causes harmony of some description, and of drops falling from a rock into a pool, making various notes, and of flutes, and of all musical instruments, a system of considerable value is obtained by the scale.

Orator. So too of voices and songs.

Idiot. Yes, in general all concordant harmonies are traced out more accurately by weights. Indeed the weight of an instrument is peculiar to its harmony, a relation sprung from the varying combination of different things. Yes, friendships and enmities of animals and men of the same figure and manners and whatever of such a kind is weighed with regard to its concordant harmonies and contrary discords. So too the health of man is weighed as harmony, also his weakness, yea fickleness and seriousness, prudence and simplicity, and many such things, if attention is minutely directed towards them.

Orator. What do you think concerning geometry?

Idiot. I think the close proportions of circles and squares, and all others which concern the different capacities of figures, can be tested more appropriately through weights than any other way. For supposing you have made a pillar-shaped vessel of known diameter and height together with another cubic one of the same diameter and height, and have filled each with water and weighed them, their proportion will be known to you from the difference of the weights of the square in comparison with the circle to which it is assigned, and by this means a near inference can be formed of the circle squared and whatever else concerning this matter that you desire to know. So, if you have taken two wholly equal plates and have bent one into a circle to make a columnar vessel, and the other into a square for setting up a cubic vessel, and have filled these vessels with water, you will learn from the difference of their weights, the difference of the capacity of a circle and of a square of the same periphery. Thus if you have a number of such plates you will be able to form them into a triangle, a pentagon, a hexagon, and so investigate successively their various capacities. In like manner by weight you will be able to arrive at the knowledge of the capacities of vessels of any shape whatever, and how scales may be made as instruments for measuring and weighing, how one pound lifts up 1000 lbs. owing to its distance from the pivot and its varying way of descent, whether straighter or more curling, and how all the fine lines of ships and machines ought to be made. Whence I consider that this knowledge gained by experience of weights is most useful for all geometrical arts.

Orator. Now you have sufficiently explained the appropriate reasons for weights of things being taken on a balance, and registered one after another and over and over again. For it seems a book like that would be most useful and sought after among distinguished men, so that in different regions its contents may be authenticated and unified, that we may be led more easily to the knowledge of many things hitherto concealed from us. I certainly will not delay from hastening it in every respect.

Idiot. If you love me, be diligent—farewell—Thanks be to God.

The book of the layman concerning experiments with weights is finished, on the day of Fabian, 13th September.

Nicholas, Cardinal of St. Peter.