solids moving through them, is represented in Fig. 3, and the result is no resistance at all! Surely this case, requiring no calculation, might have been a warning of the extreme wrongness of the doctrine in connection with resistance of fluids against solids moving through them. The nullity of the resistance in the case represented by Fig. 3 according to the assumption of a wake of "dead water" having the same pressure, Π, as the distant and near water flowing uniformly in parallel lines, follows immediately from an easily proved theorem which I stated in the combined meeting of Sections A and G in Oxford last August, to the effect that the longitudinal component of the pressure on each of the ends, E, E′, in Figs. 3, 4, 5, whatever their shapes, and whether "bow" or "stern" provided only that it ends tangentially in a cylindric "mid-body" long in comparison with the greatest transverse diameter of the solid, is equal to ΠA, where A is the area of the cross-section of the cylindric part of the solid.

§ 29. Figs. 4 and 5 represent two varieties of a case wholly free from the inconceivable endlessness of Fig. 1, and carefully chosen as thoroughly defensible by holders of the doctrine of discontinuity if it has any defensibility at all. I venture to leave it with them for their consideration. KELVIN.

PARACELSUS.[1]

"THEOPHRASTUS VON HOHENHEIM was adjudged by most eminent physicians to be a man of genius, indeed of superlative genius. . . . By others, who refused to follow him, he was thought to be less deserving than the cooks, the bellows-blowers, and the charcoal-burners." Thus spoke Lukas Gernler, Rector of the University of Basel, in 1660. Häser, in his "History of Medicine," says: "Probably no physician has grasped his life's task with a purer enthusiasm, or devoted himself more faithfully to it, or more fully maintained the moral worthiness of his calling, than did the reformer of Einsiedeln." And of this same reformer, Zimmermann, who was physician to Frederick the Great, wrote: "He lived like a pig, looked like a drover, found his greatest enjoyment in the company of the most dissolute and lowest rabble, and throughout his glorious life he was generally drunk."

As with these, so with others who have tried to form an estimate of the character of Paracelsus. Some praise him inordinately; others as inordinately abuse him. It is only men of power and character who are thus extolled and thus abused. You may neglect an ordinary man; you must either praise much, or anathematise more, a great man.

Even as regards the name of the "reformer of Einsiedeln" there are divergencies of opinion. Kahlbaum, in the pamphlet cited below, says that he never called, or signed, himself by the sounding name that was given him by some of his followers, who thought to awe the common people by styling their master "Philippus Aureolus Theophrastus Paracelsus Bombastus ab Hohenheim." For himself, Theophrast von Hohenheim was sufficient. On one occasion, says Kahlbaum, he used the name Aureolus, to distinguish himself from Theophrastus a disciple of Aristotle. The father of Paracelsus was a natural son of a member of the noble family of the Bombasts of Hohenheim, and he adopted their name as his own. In accordance with a fashion of the times, the name von Hohenheim was paraphrased into the classical tongues. *Paracelsus*, which may perhaps be rendered as "belonging to a lofty place," seems to be a kind of Græco-Latin form of von Hohenheim, the family name of Theophrastus. As von Hohenheim became *Paracelsus*, so Lieber became *Erastus*, and Schütz became *Toxites*; and in modern times the Jewish Neumann emerged from the baptismal font as *Neander*.

Paracelsus was born at Einsiedeln, in the canton of Schwyz, towards the end of the year 1493. He was educated for a time by his father, then by the monks of a convent in the valley of Savon, and then in the University of Basel. After leaving the University, Paracelsus studied under Johannes Trithemius, Abbot of Sponheim, and then under Siegmund Füger, a rich nobleman at Schwaz in the Tyrol. Both Trithemius and Füger were celebrated adepts and students of occultism, and from them Paracelsus may have imbibed the doctrines which he afterwards developed. Paracelsus was a great wanderer: he visited Tübingen, Heidelberg, Ingoldstadt, Vienna, Leipzig, Cologne, Toulouse, Paris, Salerno, and many other towns; he probably also spent some time in the East, and he is said to have received the stone of wisdom from an adept at Constantinople. Wherever he went he always eagerly sought fresh knowledge.

In 1527 he delivered lectures in the University of Basel, with the sanction of the Rector. Paracelsus attempted to institute a method of testing the apothecaries of the town as to their knowledge of the business of making drugs and determining the purity of the materials they dispensed. He spoke scornfully of the decoctions, tinctures, extracts, and syrups that the apothecaries delighted to prepare, calling them all "soup-messes" (*Suppenwust*). Of course the dealers in decoctions were up in arms against the man who attacked their trade. Paracelsus also roused the physicians. He taught that they should go to nature, and not to books, for their knowledge; he rebelled against the doctrine that was then held by almost every medical man, "the truth is to be found only in the ancients." He boasted that for ten years he had not opened a single book written by a follower of Galen, and he spoke of the Galenists as men who tried to hide their folly under red cloaks; and, worst of all, he delivered his lectures in German. The physicians and apothecaries of Basel could not stand these things. Paracelsus was abused not only publicly, but also in anonymous pamphlets; it is said that one of these productions was found on a Sunday morning affixed to the door of the Minster, with the superscription, "The Shade of Galen to Theophrastus, better called Kakophrastus." Of the attacks made on him Paracelsus exclaimed, "These vile ribaldries would raise the ire of a turtle-dove." Matters came to a head when a Canon of St. Clara, who had been cured by three laudanum pills, refused to pay Paracelsus the 100 florins he had promised, and sent six florins instead. Paracelsus sued the Canon for the money, but the court dismissed his suit. In his indignation Paracelsus seems to have put himself into the wrong; hearing that the magistrates had resolved to arrest him, on the advice of his friends he fled from Basel in 1528. After wandering about over a great part of Europe, Paracelsus found a resting-place at Salzburg, under the protection of the Archbishop Ernest. But he did not live long to enjoy the repose that had come at last. He died on September 24, 1541, after a short illness, in his forty-eighth year.

It is not possible to form a just estimate either of the character or the work of Paracelsus. The evidence is not sufficient, nor sufficiently trustworthy. Nevertheless we can draw some kind of picture of the man, and we are able to trace, in a hesitating way, the effects of his labours and his teaching on the progress of science. The pamphlet by Kahlbaum is concerned with dates, and the outward paraphernalia of the life of Theophrastus. Kopp gives a short account of the work of Paracelsus in

[1] "Theophrastus Paracelsus: ein Vortrag gehalten zu Ehren Theophrasts von Hohenheim, am 17 Dezember 1893, im Bernoullianum zu Basel." Von Georg W. A. Kahlbaum. 72 pp. (Bruno Schwabe, Basel, 1894.)

chemistry, pharmacy, and medical chemistry. The essential doctrines inculcated by the cosmogonist of Hohenheim are put into the language of modern mysticism by Hartmann, in his "Life of Philippus Theophrastus, Bombast of Hohenheim, known by the name of Paracelsus; and the substance of his teachings," published in 1887. A collection of the works of Paracelsus was made by Dr. E. Schubert; that author, and also Dr. Karl Sudhoff, have thrown much light on the history of Paracelsus. A pamphlet entitled "Theophrastus Paracelsus, Eine Kritische Studie," was published by F. Mook in 1876; and a criticism of this critique, by Prof. Ferguson, of Glasgow University, appeared in 1877 with the title "Bibliographia Paracelsica."

The difficulty of estimating justly the influence of Theophrastus von Hohenheim on his age is enhanced by the fact that the greater part of the writings that go under his name was compiled after his death by his followers, from fragmentary manuscripts left by their master. Hartmann gives a list of the works attributed to Paracelsus in the edition published by Huser, at the request of the Prince Archbishop of Cologne, in the years 1589-90. The list contains the names of fifty works on medicine, seven on alchemy, nine on natural history and philosophy, twenty-six on magic, and fourteen on various other subjects. In 1893, Prof. Ferguson printed (privately) a very complete annotated catalogue of the different editions of the works of Paracelsus.

The preparation of an inflammable gas by the action of oil of vitriol on iron filings is usually attributed to Paracelsus. He also examined the differences between metals and substances that are like metals, and he asserted ductility to be the characteristic property of all true metals. The differences between the vitriols and the alums were referred by Paracelsus to the presence in the former of metals, and in the latter of earths. He introduced into medicine many new and potent drugs, notably laudanum; and he constantly sought to determine the medicinal effects of the chemical substances that he worked with. Paracelsus was the first to make medicinal use of preparations of mercury, lead, and iron. He held that substances that were poisonous when administered in quantity might have healing properties when given in smaller doses and under proper conditions. In his endeavour to obtain definite substances, freed from admixture with extraneous and unnecessary, or perhaps hurtful, materials, he made tinctures and essences of various plants, and used these in place of the sweetened decoctions of the entire plants that were generally employed at that time. Paracelsus asserted that the aim of chemistry should be not to make gold, but to produce healing medicines. Medicine was for him a branch of chemistry. He insisted that apothecaries ought to be acquainted with the chemical characters of the drugs they compounded, and that only by a knowledge of chemical reactions could the physician restore to the perturbed bodies of his patients that chemical equilibrium which is health.

It is evident that a man who held and practised such views as these could not pay much respect to the physicians of his own time, whose highest ideal was to do what Galen had done, and to administer this or that drug because Avicenna laid it down, on such or such a page, that the drug ought to be administered. What the authorities of the schools were to his contemporaries, nature was to Paracelsus: the supreme court of appeal. Surrounded by prejudices, separated from nature by the thick veils that mediæval philosophy had drawn over men's eyes, bound by the formulas of his age—as we are bound by those of our age—Paracelsus nevertheless knew that the sun was shining on the other side of the mist, and that could he and others break through they would find the light. We can surely sympathise with his struggle. We may perhaps even recognise the essential rightness of the daring claim of the man who felt that the vision of nature could a'one give understanding:—"After me, you, Avicenna, Galen, Rhasis, Montagnana, and the others. You after me, not I after you. You of Paris, you of Montpellier, you of Swabia, of Meissen, and Vienna; you who come from the countries along the Danube and the Rhine; and you, too, from the islands of the Ocean. Follow me. It is not for me to follow you, for mine is the monarchy."

But while we admire the audacity of the man, and even admit the force of his claim, we know that one who attacked the citadel of nature in this mood would dash himself to pieces before the outworks were carried. Yet he might make a breach through which a way for others should lie open. And Paracelsus succeeded in this; we are entering nature's strongholds by some of the ways he helped to open. With few appliances, with no accurate knowledge, with no help from the work of others, without polished and sharpened weapons, and without the skill that comes from long handling instruments of precision, what could Paracelsus effect in his struggle to wrest her secrets from nature? Of necessity, he grew weary of the task, and tried to construct a universe which should be simpler than that most complex order which refused to yield to his analysis.

The struggle is so arduous, nature is so infinitely complex, men are so easily led astray, that the giants alone keep to the quest, and they only go always forward to the goal. The syren-songs of the miracle-men are very soothing, and few escape. It is so pleasant to lie still and dream; it is so hard to get up and act. In the time of Paracelsus the air was filled with the soporific murmurings of industrious human bees. They were all busy secreting the wax of philosophising, that with it they might construct symmetric cells to be filled with the syrup of their own wisdom. Paracelsus, too, was obliged to become a wax-gatherer and a universe-maker. And a very remarkable universe he produced. The facts of nature that he sought were found so slowly that, in his impatience, he supposed the aim of science was to produce a completed scheme of things; and such a scheme he set himself to construct.

It would be out of place here to attempt more than the briefest sketch of the outlines of the Paracelsian conception of the order of nature. Paracelsus was essentially of the order of mystics. He would have adopted with enthusiasm the words of Blake: "I assert for myself that I do not behold the outward creation, and that to me it is a hindrance, and not action. 'What,' it will be exclaimed, 'when the sun rises do you not see a round disc of fire somewhat like a guinea?' Oh, no! no! I see an innumerable company of the heavenly host crying 'Holy, holy, holy, is the Lord God Almighty.' I question not my corporeal eye any more than I would question a window concerning a sight. I look through it, and not with it." Paracelsus insisted on the unity of all things; he taught that in everything in nature there is an inner and essential principle, which is itself a part of the universal life. There was for him an absolute and attainable knowledge; and although he admitted that much is to be learned from external nature, he taught that this real knowledge must be discovered by each man in himself. "Each man has . . . all the wisdom and power of the world in himself; he possesses one kind of knowledge as much as another, and he who does not find that which is in him cannot truly say that he does not possess it, but only that he was not capable of successfully seeking for it." Chemistry was regarded by Paracelsus as a spiritual art; an art that deals with the spiritual principles of things. Everything in nature was thought of by him as having a threefold character,

as consisting of "a body and a soul held together by the spirit, which is the cause and the law." "To grasp the invisible elements, to attract them by their material correspondences, to control, purify, and transform them by the living power of the spirit—this is true alchemy." The pure, invisible, intangible, universal elements constituted the highest of the three orders of things; the second order was composed of "elements that are compounded, changeable, and impure, yet may by art be reduced to their pure simplicity"; and the third order contained the "twice compounded elements" which served as vehicles for drawing down the pure ethereal elements and fixing them in the substances of the second order. The laboratory was the place for learning the properties of the things of the second order; "for from these proceed the bindings, loosings, and transmutations of all things." Paracelsus speaks of the three substances of which all things are composed; these three things are "sulphur, mercury, and salt"; but he adds, "they are acted on by a fourth principle which is life." "These three substances," he says, "are not seen with the physical eye. . . . If you take the three invisible substances, and add the power of life, you will have three invisible substances in a visible form. . . . They are hidden by life, and joined together by life. . . . All things are hidden in them in the same sense that a pear is hidden in a pear tree and grapes in a vine. . . . A gardener knows that a vine will produce no pears, and a pear-tree no grapes"

I think it is possible from these extracts to construct, in a general way, the non-natural scheme of nature that was upheld by Paracelsus. A great deal may be said in its favour, if only we agree to construct the nature that is to be explained from our own consciousness with closed eyes. This certainly may be asserted in favour of the so-called spiritual science of Paracelsus and the mystics of his school, that their method is infinitely easier than the method of natural science, or, as it is called by the modern Paracelsians, materialistic and sceptical science. Whatever judgment may be passed on natural science when it is contrasted with supernatural mysticism, it is at any rate ludicrously erroneous to say that the former is proud, dogmatic, and conceited, while the latter is humble, suggestive, and ready to learn. The answer to the conception of the universe that Paracelsus framed is to be found in the history of science, and in the history of humanity, since the Middle Ages.

But however radically a modern naturalist may differ from the mediæval alchemist, he must recognise the great debt which those who to-day seek the knowledge of natural laws owe to the man of the sixteenth century who boldly declared against authority, and besought his followers to go to nature, who insisted on the interdependence of the various branches of natural knowledge, who taught the essential unity of the forms of matter and of the forms of energy, and who, by his discoveries in medicine, helped forward the blessed work of alleviating the miseries and soothing the sorrows of human beings. Whatever else he was, Paracelsus was certainly a true man; he lived earnestly; he was not regardful of the conventionalities of life; he received blows, and he returned them; he suffered much, and he bore his troubles on the whole with patience and some nobility. With his own words we may leave him:—"Have no care of my misery reader; let me bear my burden myself. I have two failings: my poverty, and my piety. My poverty was thrown in my face by a Burgomaster who had perhaps only seen Doctors attired in silken robes, never basking in tattered rags in the sunshine. So it was decreed that I was not a Doctor. For my piety I am arraigned by the parsons, for I am no devotee of Venus, nor do I at all love those who teach what they do not themselves practise." M. M. PATTISON MUIR.

ON HOLLOW PYRAMIDAL ICE CRYSTALS.[1]

I. *The Lava Cavern of Surtshellir.*—The lava cavern of Surtshellir forms a long subterranean channel—over a mile in length—in the post-glacial lava-field which encompasses in a vast semicircle the ice-covered Eyrîksjökull (Iceland). The farthest recess forms a chamber about 30 feet high, and from its floor and ceiling spring ice-stalagmites and stalactites of rare beauty. (Fig. 1.)

The north-western wall is gracefully draped by a long curtain of icicles resembling somewhat the pipes of an organ. From those parts of the vault not covered by icicles a thousand glitterings and sparklings are seen, at every movement of the candle, to be reflected from ice crystals which stud the walls.

The ice crystals have the form of hexagonal funnels, or hollow hexagonal pyramids. In size they range up to two inches long, with a hexagon side of half an inch. The triangular sides of the pyramids are built of most delicate steps of ice, arranged in the manner of a staircase.

The attachment is invariably by the apex, and the hexagonal bases turn trumpet-like towards the interior of the cave. (Fig. 2.) When these observations were made in June 1892, the temperature of the air in the cave was + 0·5° C.

There are some minute cracks in the roof of the cave, through which water trickles scantily. At such places *icicles* are formed, but not crystals. The crystals are not formed from the water percolating into the cave, but from the moisture contained in the air, and as such they must be regarded as a kind of *hoar-frost*.

II. *Hoar-frost.*—During Christmas week 1892 an unusually fine hoar-frost prevailed over the North of England. In various parts of Yorkshire, Lancashire, and Cheshire, we found the rime to consist almost entirely of hexagonal "hopper" crystals. (Fig. 3, *a*, *b*, *c*.) The basal hexagons varied up to about ⅜ inch in diameter, and the majority of the crystals measured in height about twice the diameter. (Fig. 3, *a*.) Some, however, were more obtuse. (Fig. 3, *b*.) The forms were often obliquely truncated (Fig. 3, *c*), certain faces having grown more rapidly than others. A spiral arrangement was noticed in some cases, and occasionally a double spiral resembling the helix of an Ionic capital. (Fig. 3, *d*.)

There was a marked tendency for the simple pyramids to group themselves into compound forms. (Fig. 3, *e*, *f*.) The groups exhibited hexagonal outlines (Fig. 3, *f*), and the primary pyramids on the periphery were, as a rule, better developed than those in the interior. The secondary hexagons often measured more than 1½ inches in diameter. Even a tertiary grouping could be made out in a few cases. In a few rare instances the primary hexagons were studded at the corners with small hexagons resembling bastions. These bastions were either solid or hollow. (Fig. 3, *g*.)

III. *Crystals under Ice-Crusts.*—On January 3, 1894, we found in Cheshire, during a severe frost, similar hexagonal hoppers on the under-surfaces of ice-crusts covering hollow spaces over ruts in clayey soil, or covering ponds where an air-space divided the ice from the water. No ice crystals were found on the sides and bottom of the ruts, and there was no trace of *hoar-frost* on adjacent objects.

These observations suggested the idea that *hoar-frost might be made at will* on any cold night. We accordingly spread pieces of black cardboard and black velvet over grass, and on examining these after two days of hard frost we found the *under*-surfaces coated with an abundance of hollow pyramidal and other forms of ice

[1] From a paper read before the Royal Society, by Dr. Karl Grossmann and Joseph Lomas.