



Chemical Education

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Chemistry in Medicine

Bringing Chemistry to Medicine – The Contribution of Paracelsus to Modern Toxicology

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Abstract: At the heart of Paracelsus' medical theory is the belief that all matter can be reduced to three basic elements: sulphur, mercury and salt. Their unique properties can be harnessed in the preparation of specific medicines. In this way, poisons can become medicines since it is the dose that determines toxicity.

Keywords: Alchemy · Chemical education · Dose-response · Paracelsus · Poison

Few figures in the history of medicine and sciences are credited with having had as much influence, and at the same time are surrounded by as much controversy, as Paracelsus. This starts with his name. Born around 1493 near Einsiedeln (SZ) as Theophrastus Bombastus of Hohenheim, son of a German physician, the name “Paracelsus” which he used in some of his later writings, is variously thought to mean “surpassing Celsus” (a Roman physician), a greco-latinisation of his family's origin “Hohenheim”, or a reference to “a new heaven”.^[1] He trained as a physician, but is also known as alchemist, astrologer, lay theologian, mystic, natural philosopher and social ethicist. A true Renaissance Man (Fig. 1).

So why is he acknowledged by some as the father of modern toxicology, revered by others as a founder of homeopathy, but vilified by the contemporary medical establishment? Undoubtedly, he courted controversy by challenging the accepted medical practice of the time. During his only substantive (and ill-fated) public appointment as city physician and university professor in Basel (1527–28), he managed to antagonise his students, colleagues and employers by announcing nothing short of a complete overhaul of medical theory and practice.^[2] Paracelsus believed that the basis of treating diseases was both observation of nature and spiritual knowledge. Indeed, his theological writings rival his medical and natural-philosophical works in volume and substance.^[3] His theory of medicine, elaborated in his *Paragranum* of 1529, rested on four pillars. The first pillar, (natural) philosophy, stresses the importance of the physician having to be educated by nature itself. The second, astronomy, relates to the cosmic influences on human life. The third pillar, alchemy, is the art of refining materials to transform their toxic actions into healing attributes; and the fourth, propriety or virtue, concerns the physician's ethical, moral and religious foundation as a prerequisite for his healing powers.^[4]

In one of his earlier works, the *Volumen Medicinæ Paramirum*, he had described diseases as originating from five influences (“*entia*”): *astrale* – influence of the stars; *veneni* – action of poisons; *naturale* – natural constitution; *spirituale* – evil spirits; *dei* – acts of god. Paracelsus set this against the prevailing theory of



Fig. 1. Portrait of Paracelsus. Digital image provided by U.S. National Library of Medicine, Bethesda, NLM Unique ID 101433857.

medicine at the time which dated back to Galen and Avicenna and was based on the theory of balance between the bodily fluids (humors) blood, phlegm, yellow bile and black bile. Disturbances of this balance would result in diseases, and treatments would aim to restore it. In contrast, Paracelsus argued that simply reducing diseases to imbalances in humors ignored all other influences and would lead to the use of inappropriate treatments.^[5]

In his theory of medicine and the origin of diseases, alchemy played a central role as he applied his detailed knowledge of minerals and their transformation. The term “*spagyric*”, first used in his Basel lectures (from the Greek *spao* = separate and *ageiro* = unite) and then in his *Opus Paramirum* of 1531, reflects the methods by which alchemists would seek to transform organic and inorganic matter, e.g. through heating or distillation.

“For this reason you should learn alchimia, otherwise known as spagyria: it teaches how to separate the false from the just.”^[6]

Thus, by applying chemistry to medicine, Paracelsus paved the way for a new understanding of pharmaceutical properties. In his customary style of mixing observation and deduction with philosophy and theology, he argued that all matter, including the human body, consists of three basic substances: sulphur, mercury and salt. However, they should not be thought of as chemical ele-

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ments in the modern sense, but rather as basic principles which the physician must recognise in order to be able to treat each illness appropriately. Here, alchemy provides the tools for the transformation of substances and their reduction to original elements, for example through the action of fire destroying a piece of wood: what we see burning is sulphur, the smoke is mercury, and the ash is salt.^[7] This, then, forms the basis of his challenge to the humoral theory of medicine:

“Now you have the human being whose body is nothing but a sulphur, a mercury, a salt. In these three [things] stands its health, its illness, and everything that concerns it. And just as there are only [three], so, too, these three are the cause of all diseases, not four humors, qualities, or similar things.”^[8]

It is understandable that this did not make him popular with the practitioners of traditional medicine, particularly since he accused physicians and pharmacists of being fools and amateurs who deceive their patients by giving potions and ointments which are at best useless and at worst dangerous. In his *Paragranum*, Paracelsus argued that the remedies of the time were concoctions that were thrown together without any regard of their properties, toxic or otherwise. Instead, he maintained that each disease had its underlying “*arcantum*” (secret) for which a preparation with its own specific “*arcantum*” should be used.^[9] And the way to prepare his medicines was to separate the toxic parts from those with healing properties:

“Who is there who would deny that all good things also contain poison? Everyone must acknowledge this. This being the case, the question I ask is: must one not separate the poison from what is good, taking the good and leaving what is bad? Of course one must.”^[10]

Nowadays we would call the “*arcantum*” of the disease its underlying mechanism which would require a specific treatment. For Paracelsus it was clear that a disease which was caused by a poison would therefore require a treatment that originated from this poison but where the toxic part had been separated. A keen observer, he studied the diseases of the miners and smelters working in the Austrian Alps. His treatise *Von der Bergsucht und anderen Bergkrankheiten* (Of the mine affliction and other miners’ sicknesses) provides descriptions of diseases which he thought to be due to inhalation of vapours from the ores themselves but also from the smelting process.^[2] He accurately described features of arsenic intoxication and distinguished acute from chronic illnesses. From this, he deduced that some form of arsenic from which the toxic property had been separated would provide a cure:

“When you know the arsenicum and its nature, then you also know how to detect the arsenicum in the body. Now you truly know all about the kind, quality, essence, origin, and nature of the excretions. Having this, you are shown the remedy, because arsenicus heals arsenicum, anthrax anthracem, namely poison.”^[11]

Little wonder, therefore, that Paracelsus is seen as one of the forefathers of homeopathy which is based on the principle “*Similia similibus curentur*” (let like be cured by like), although it is a matter of debate whether Paracelsus would have approved of the principle of potentiation by dilution.

Following his hasty departure from Basel, Paracelsus spent the rest of his life more or less on the move in Southern Germany, Switzerland and Austria. He also increasingly felt the need to defend his work against his numerous critics, culminating in the publication of *Die Verantwortung uber etliche Unglimpfungen seiner Mißgönner* (Justifications against a number of slanders by his begrudgers) in 1538/39.^[12] In seven defenses he attempted to justify his whole life and works: his new theory of medicine, his definition of new illnesses, the writing of new prescriptions, his constant moving around, his denouncement of the medical

establishment (“false doctors”), but also his temper and abrasiveness, and finally, that (even) he could not know everything. In the third defense he deals with the accusation that his prescriptions were in reality poisons. He asserts that there must be something useful even in poisons since they were made by God and points out that the treatments given by his detractors are also poisonous if given at the wrong dose or in the wrong form. He uses the example of mercury (“*argentum vivum*”) that was commonly used by physicians in its different chemical forms to treat syphilis, and mocks the use of white lead to allegedly reduce its toxicity. He picks up the theme of the use of poisons as therapeutics from the *Paragranum* but adds (Fig. 2):

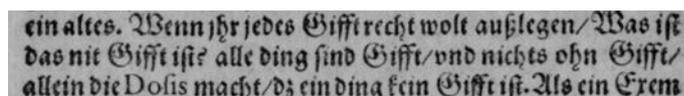


Fig. 2. Quote from the Third Defense.^[13] Digital image provided by Bayerische Staatsbibliothek, München, urn:nbn:de:bvb:12-bsb00022503-6.

“When you want to correctly evaluate a poison, what is there that is not poison? All things are poison and nothing is without poison; only the dose determines that something is not a poison.”^[13]

With this, he is credited with the first description of the dose-response relationship which is at the heart of modern toxicology. However, it seems that his own understanding of a toxic dose was by no means perfect and perhaps closer to that of his critics than he would have admitted. In his alchemic studies he frequently experimented with mercury and a forensic examination of his bones showed a high mercury content, perhaps also as a result of trying to treat his own illnesses.^[2] However, it is not known whether this contributed to his death at the age of 48. Like many aspects of his life, his death is also shrouded in mystery.

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- [9] HE, Vol. 2, p. 74.
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- [12] HE, Vol. 2, p. 157.
- [13] HE, Vol. 2, p. 170; translation from ref. [2]