9

ALCHEMY, CHEMISTRY, PHARMACOLOGY AND PHARMACEUTICS

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Contents

Part One

ALCHEMY AND CHEMISTRY IN ISLAMIC CENTRAL ASIA

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The Central Asian contribution to these scientific disciplines has been the subject of very little detailed study; the kind of specialized overview that would set the history of chemistry and the related sciences throughout the region in a proper perspective is, for the moment, lacking. This is obviously due in part to the fact that the subject calls for an interdisciplinary approach involving chemists, historians, archaeologists, geologists, botanists, medical and pharmaceutical scientists and other specialists.

Origins

The very earliest work on chemical processes and transformations was done in the ancient world, in Egypt, Mesopotamia (Assyria and Babylon), India and China. But the roots of chemical and pharmacological knowledge are also to be found in Central Asia's distant past. In so far as chemical science is concerned with substances, their transformation and their properties, its origins are interwoven with the emergence of those productive activities which later developed into crafts. Unlike many other parts of the world, the heartlands of Central Asia were well endowed with raw materials that permitted the local development of metallurgical activities; the Zarafshan valley in Sogdia was particularly rich in deposits of copper, arsenic, lead and antimony, the principal constituents of bronze.

During the early Middle Ages, irrigation-based agriculture constituted the principal human activity in Central Asia. But mining and handicrafts also underwent considerable development. Deposits of raw materials in Ferghana and Sogdia (gold, cinnabar, copper, iron ore), at Ilaq (lead, silver and gold) and in the region of Shahr-i Sabz (red salt) were worked intensively. Traditional handicrafts of all types continued to thrive. The period between the fifth and the eighth century saw significant progress in silk-weaving, glass-making and pottery.

The Eastern tradition of early chemistry and alchemy

After the advent of Islam in the Middle East and the lands to the east, into which Islamic civilization gradually penetrated, knowledge of the Graeco-Roman scientific, mathematical, astronomical and medical heritage was passed to such regions as Khurasan, Transoxania and Khwarazm. Notable scholars in the Islamic East included the chemist and physician, and pupil of the alchemist Jābir b. Hayyān, Abū Bakr Muhammad b. ZaHariyyā al-Rāzī (865–925), who worked in his native Rayy and in Baghdad and was connected with the Buyid rulers there.

AL-RĀZĪ

Although al-Rāzī was a polymath, his major works were devoted to medicine and alchemy, including no fewer than 26 treatises on chemistry,[1] only 4 of which, however, have survived. Among these is his *Kitāb al-Madkhal al-ta^{c}līmī* [An Introduction to Teaching], a basic manual containing brief descriptions of the substances and apparatus used in alchemy. Most importantly, in the final section of the work, al-Raāzī provides summaries of another dozen of his works, which were also devoted to alchemy.

The *Kitāb al-Asrār* [Book of Secrets] constitutes al-Rāzī's principal and most detailed contribution to chemistry.[2] Among its component sections are two devoted respectively to apparatus and operations. In the first of these, he divides apparatus into two groups: apparatus and implements used in the smelting of metals; and apparatus used in the processing of non-metallic substances. The first group includes furnaces, bellows, crucibles, hammers, tongs, kilns with superimposed crucibles known as *but-bar-but* (literally, 'crucible-on-crucible'), scissors and crushers. The second group includes various types of alembic (*anbīq*); the kiln known as *mustafād*; assorted cups, bottles and phials; glass mortars; pestles; the stove known as *attūn*; braziers; ventilators; clay boxes; and round stoves. Mention is also made of moulds, pitchers, bottles for rose-water, clay pitchers, kettles, the aludel (a condensing vessel), lids, baker's ovens, glass funnels, sieves made of metal, horsehair and silk, pans, basins, dishes, lamps, sand and water baths, troughs, jars, glass cups, *dann* (a container for wine), *sardāb* (a filtration jar), fine sieves, pitchers, pans, griddles, files, iron ladles, oil lamps and other objects. Obviously, al-Rāzī's laboratory contained all that was

[1] Karimov, 1957, pp. 37–9.
[2] Ibid., pp. 60–1.

needed to carry out successful chemical experiments and did not differ significantly from a British laboratory 1,000 years later.[3] The section on chemical operations describes smelting, decantation, filtration, digestion (steeping at high temperatures), distillation, sublimation, amalgamation, diffusion, coagulation and others.

The *Kitāb Sirr al-asrār* [Book of the Secret of Secrets], written by al-Rāzī at the request of his closest disciple and collaborator, Abū Muhammad b.Yūnus of Bukhara, contains a wealth of information on chemistry and chemical technology during the ninth and tenth centuries. Whereas his *Kitāb al-Asrār* is a treatise on chemistry as it was understood and practised at the time, in this other book, the author describes the actual operations whereby different alloys resembling silver and gold may be obtained, mentioning not only the most common methods, but also methods whereby these processes may be speeded up.

Al-Rāzī's philosophy was of an elemental-materialistic nature, based on the five pre-eternal principles: creation, soul, matter, time and space. According to him, all bodies consist of indivisible particles (atoms) with empty space between them. The atoms are eternal, unchangeable and of specific dimensions. The fundamental properties of substances, which correspond to the four Aristotelian essentials of earth, water, air and fire, as well as their qualities of lightness or heaviness, opacity or transparency, and softness or hardness, are determined by the dimensions of their constituent atoms and the surrounding vacuum. The size of the empty space between the atoms which make up the four essential elements determines their natural movement. Thus the dense elements, water and earth, move downwards, while fire and air move upwards. While Aristotle ascribed movement to a primal shock, or creational impulse, al-Rāzī considered that the principle of movement was inherent in bodies themselves.[4] To some extent, he anticipated in his *Kitāb al-Asrār* the phlogiston theory later developed by the German chemists Becker (1635–82) and Stahl (1660–1734). Al-Rāzī held that all metals and substances are composed of flammable (i.e. sulphurous and oily) ingredients and ash; burning or roasting consumes the combustible part (and, according to Stahl, releases phlogiston), leaving the calcinated part behind.[5] He was also familiar with the reverse process – known as *istinzāl* (descent) – whereby metals were purified by smelting: metallic oxides were mixed with olive oil, soda or copper (which Stahl believed to be rich in phlogiston) and heated in a special piece of apparatus known as the *but-bar-but*. In the course of firing, the metal, in a reconstituted form, flowed into the lower crucible. Thus 12 drams of lead or copper oxide, or white-lead, yielded 4 or 5 drams of metal.[6]

3 Singer, 1948, p. 50.
4 Karimov, 1957, p. 35.
5 Ibid., pp. 69–70.
6 Karimov, 1957, p. 70.

The *Kitāb Sirr al-asrār* is a veritable laboratory logbook, in which al-Rāzī made notes of the many experiments he conducted in order to smelt various metals in different proportions and establish their chemical composition. Unusual for his time, he recorded his own observations. He was the first to advance the extremely original idea that chemical processes could be accelerated. He was also the first to distinguish between reversible and irreversible reactions, suggesting the possibility that the product of a given reaction could be restored to its original state. He wrote:

> Do you not know that we can reconstitute [a substance]? When the operation is irreversible, this cannot be done. For example, glass, which is obtained from sand and potash, cannot be made to revert to those two original components. Nor can glazed earthenware be changed back into clay and water . . . But if you take burnt copper, heat it to incandescence, extinguish it in olive oil and subject it to *istinzāl*, then it will once again revert to copper.[7]

AL-FĀRĀBĪ AND HIS SUCCESSORS

Another outstanding philosopher and encyclopedic scholar of medieval Central Asia was Abū Nasr Muhammad al-Fārābī (d. 950); as an advocate of the importance of alchemy, he was the author of a treatise entitled the *Risāla fī Wujūb sināᶜat al-kīmiyā'* [On the Need for an Art of chemistry]. In the succinct encyclopedia of technical terms of both the 'Arab'; and the so-called 'foreign' arts and sciences, the *Mafātīh al-ᶜulūm* [Keys of the Sciences], by Abū ᶜAbd Allāh al-Khwārazmī (*fl.* second half of tenth century), there is a section on alchemy which is in three parts. The first part describes the apparatus used in alchemy; the second is devoted to substances; and the third deals with ways and means of processing substances. His eleventh-century compatriot, ᶜAbd al-Hakīm al-Khwārazmī, made a special study of the weights of the substances used in alchemical experiments. Surviving manuscripts on alchemy include works by many other medieval scholars, including Ibn Umayl al-Tamīmī (*c.* 900–*c.* 960), al-Khwārazmī al-Kāsī (eleventh century), the Seljuq vizier al-Tughrā'ī (d. 1121) and Ibn Arfaᶜ Ra'sahu (twelfth century).

An authority on alchemical literature, U. I. Karimov, divides the basic sources in Arabic into two distinct groups. To the first, he assigns works of a genuinely scientific nature, lacking all trace of mysticism and containing clear and unambiguous descriptions of practical operations, comprehensible to the modern scientist. These include many of the works of Jābir b. Hayyān and al-Rāzī, and of scholars from Khwarazm and elsewhere. The second group comprises works on alchemy which have a religious and mystical character and are written in an incomprehensible language of allegory and veiled allusion. These include the almost certainly apocryphal treatises of the Umayyad prince Khālid b. Yazīd (d. *c.* 704),

[7] Ibid., pp. 64–91.

traditionally regarded as the proto-alchemist, and the works of the shadowy figure Ibn al-Wahshiyya (ninth century), Ibn ᶜUmayl al-Tamīmī, Ibn Arfaᶜ Ra'sahu and others.[8] Several of the scholars in the first group were natives of Central Asia or Khurasan and their works are written in a scientific vein, reflecting an abundance of factual material accumulated in various branches of practical chemistry and throwing light on the level of development and the technology of many branches of small-scale manufacture, including, for example, glass-making, metallurgy and the production of building materials.

Medicine and pharmacology

AL-RĀZĪ

Al-Rāzī's most famous medical work was his great compendium on medicine, the *Kitāb al-Hāwī fi'l tibb* [Comprehensive Work on Medicine], on which he laboured for 15 years and which was still unfinished at his death. This enterprise, which was completed by his pupils, comprises 30 volumes, covering all branches of medieval medicine. It is set out in the form of a vast overview of the subject and includes quotations from the ancients, Greek and Indian, complemented by the author's own commentaries and personal observations. Diagnosis and prognosis, and their consequences for the choice of therapeutic measures, are treated in considerable detail. Al-Rāzī was a powerful advocate of the use of chemical substances in medical practice, and of testing medicines on monkeys before prescribing them for human beings. As the director of a hospital in Baghdad, he was the first Eastern specialist to bring order to the study of the history of different illnesses; he made daily notes of changes in the condition of his patients from the time they entered his charge, and used the information so obtained to determine the specific nature of diseases and their effect on the human organism.[9]

His second most important medical work was the 10-volume study that he dedicated to the Samanid governor of Rayy, Mansūr b. Is'hāq, the *Kitāb al-Tibb al-Mansūrī* [Book of Medicine Written for Mansūr]. Each book of this was devoted to a specific medical topic: anatomy and physiology; temperament; simple medicines; the means of preserving health; skin diseases and cosmetics; dietary principles for travellers; surgery; poisons (toxicology); the pathology of different organs of the human body, from head to toe; and fevers. The ninth book, on pathology, enjoyed great popularity in Europe and was a seminal work in medicine up to the sixteenth century. Al-Rāzī further devoted particular attention to anatomy and physiology, individual diseases, surgery and the practice of medicine,

[8] Karimov, 1957, p. 18.
[9] Kadyrov, 1994, p. 43.

concerning which he wrote on such subjects as the preparation of remedies; purging in the case of a 'hot' mixture of humours (*mizāj*); chemical preparations; mud cures; and the properties of intoxicating and non-intoxicating wines.[10]

An apothecary's shop and adjacent chemical laboratory, which have been dated to the late eighth century, were discovered during archaeological excavations in the small trading centre of Paikent, 44 km from Bukhara (Fig. 1). The premises contained everything necessary for the preparation of medicines: kilns and furnaces of various types; storage pits; areas and covered spaces for vessels to contain the medicines; a cellar (*sardāb*) for storing chemical substances and raw materials; ceramic vases and bowls; cups; an ink-well; a hand-mill; fragments of glass and 13 intact glass vessels. All the glass vessels belong to a single type of the special apparatus known in the literature as *al-anbīq* (from which the word 'alembic' is derived).[11] There is an especially wide selection of ceramic vessels and bowls characteristic of laboratory equipment. Here, too, together with a large collection of copper coins (*fulūs*, sing. *fals*) dating from the early ᶜAbbasid period (second half of the eighth century), were found two ceramic jars inscribed in Arabic. One bears what appears to be a list of personal names; and the other, a date corresponding to 30 June 790. A small bronze cup with traces of wax on the bottom was also found in the same place. Wax is known to have been very widely used in Eastern medicine as a component of ointments and medicines. In fact, finds of vessels containing vestiges of medicines are by no means rare.

OTHER EARLY AUTHORITIES

Among the scholars of Eastern Islam who wrote pharmacological and pharmaceutical textbooks was Abū Mansūr Muwaffaq b. ᶜAlī Harawī, with his *Kitāb al-Abniya ᶜan haqīq al-adwiya* [Book of the Foundations of the True Essence of Drugs and Medicines], written in New Persian in 950 under the Samanids. It contains descriptions and recipes for 585 medicines, including 466 obtained from plants, 75 from mineral substances and 44 from substances of animal origin.

The author makes a clear distinction between (called *natrūn*) and potassium carbonate (*kelī*), writes about arsenic and copper oxides, silicic acid and antimony, describes the poisonous effect of copper and various compounds of lead, and refers for the first time to the use of distilled water for pharmaceutical purposes. Such early treatises as these not only contain descriptions of the substances most frequently employed by apothecaries (resin, balsams, essential oils and colourants), but also go into some detail on the subject

[10] Kadyrov, 1994, p. 89.
[11] *EI*², 'al-Anbīk' (E. Wiedemann).

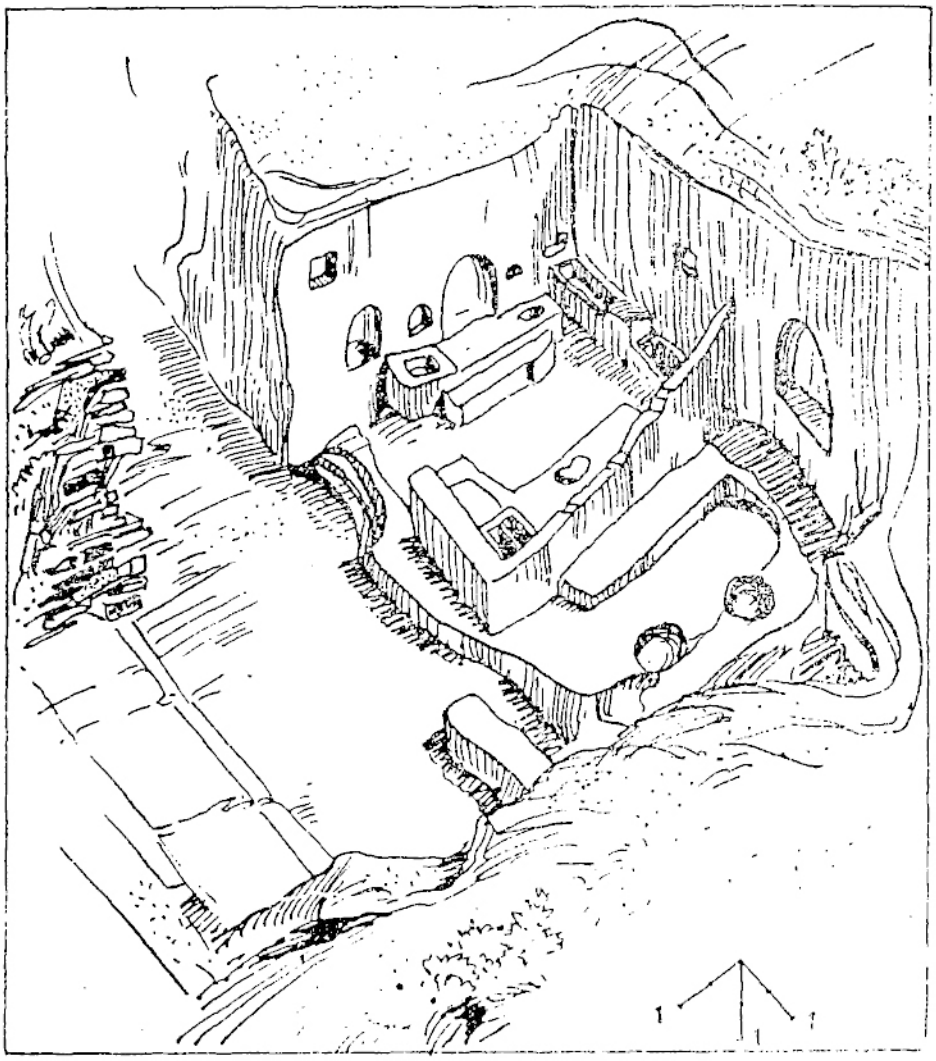

Fig. 1. Paikent. Apothecary's shop and chemical laboratory (late eighth century). (Drawing: Courtesy of A. Abdurazakov.)

of quality-testing. Thus one scholar gives a recipe for testing indigo, while the Syrian ᶜAbd al-Rahīm al-Jawbarī (*fl.* first half of thirteenth century) describes different ways of faking apothecaries' wares.

IBN SĪNĀ

Ibn Sīnā (*c.* 980–1037), a native of Bukhara, was a polymath, but had medicine as one of his principal fields of interest. He was the author of more than 400 works, more than 30 of which cover medical subjects. Among the latter, the most important is the *al-Qānūn fi 'l-tibb* [The Canon of Medicine], an encyclopedic study pored over by generations of Western as well as Eastern medical students for almost 600 years. It provides an account of ancient Greek and Eastern medicine and bears witness to the wealth of personal experience accumulated by the author himself. It comprises 5 separate books, each of which is devoted to a specific aspect of medical knowledge: the first, to generalities; the second, to simple medicines; the third, to disease in specific organs and systems; the fourth, to fevers, tumours, the treatment of wounds and toxicology; and the fifth, to pharmacology.

The second and fifth books of the *Canon* are of particular relevance to the present chapter. The former contains detailed descriptions of 811 simple vegetable, mineral and animal substances. An introductory section dealing with the properties and actions of simple medicines, including their *mizāj*, is followed by instructions for the collection and conservation of medical plants. For Ibn Sīnā, the theoretical basis of ancient Eastern medicine lay in the doctrine of *mizāj*, i.e. the mixed nature of different substances, including medicines, which reflected the properties of 'heat', 'coldness', 'dryness' and 'wetness'. According to their action, medicines were variously described as being of general or specific application. General medicines exercised heating, cooling, drying and moisturizing effects; specific medicines were used to treat specific diseases. There follows a list of 40 different properties that could be ascribed to medicines according to their action: absorbent, irritant, adhesive, dissolvent and so on. This part also contains detailed accounts of cosmetic substances and of some substitute medicines. Ibn Sānā also drew up an inventory of more than 750 mineral substances (metals, their oxides and salts, acids and alkalis), as well as a list of various substances of vegetable and animal origin.

The *Canon* may also be described as a medical handbook. Of the 396 plants it mentions, 165 species are still used in medicine today.[12] Its fifth book contains what was for its time an exhaustive account of pharmacognosy (the branch of pharmacology concerned with the study of crude drugs of plant and animal origin) and provides detailed information concerning the preparation and utilization of compound medicines, necessary to reinforce the action of the basic remedy or to add properties which the latter does not possess. Sometimes a simple remedy has harmful side-effects which can be countered by the administration of a compound medicine. The main chapter of the book describes different medicines, their preparation and conservation, and another the processes of medication.

Ibn Sīnā's work played an important role in the development of European as well as Eastern medicine. It was translated into Latin as early as the twelfth century and found a place on the shelves of libraries in all the European universities. By the fifteenth century, it had been translated into Latin alone no fewer than 20 times. Much of what is set out in it remains relevant today, notably the author's ideas concerning the role of microbes in the spread of disease; the health implications of external, geographic and climatic factors; the

[12] Kadyrov, 1994, p.72.

psychosomatic aspects of illness; and the beneficial impact on health of personal hygiene, physical culture and sport, to name just a few.[13]

In his mainly philosophical work, the *Kitāb al-Shifā'* [Book of Healing], Ibn Sīnā set out the basic principles of Aristotle's teaching on the terrestrial origin of metals and minerals. A partisan of the sulphur-mercury theory of the creation of metals, he differed from Jābir b. Hayyān and al-Rāzī in firmly opposing one of the principal tenets of alchemy, namely the theory of the transmutation of base metals into gold and silver. He considered that it lay outside the power of alchemists to effect the genuine transformation of substances; they could produce spectacular imitations, for example by decorating alloys with a sheen of gold or silver, but they did not possess the means of transforming one metal into another.

AL-BĪRŪNĪ

Another great scholar who made major contributions to many branches of the sciences in the East was the Khwarazmian al-Bīrūnī (973–1048). In Khwarazm, he took a leading part in the circle of the Khwarazm Shah Ma'mūn b. Ma'mūn al-Gurgānj, which attracted many of the best-known scholars of the time. Medicine was the subject of his *Kitāb al-Saydana fi 'l-tibb* [Book of Pharma-cognosy in Medicine], believed to have been written in collaboration with the physician Abū Hamīd al-Nakhshabī. At the beginning of the preface, al-Bīrūnī provides a definition of the terms *saydāna* (pharmacognosy) and *saydāninī* (pharmacognosist, druggist) and describes the purposes and the place occupied by this science in the medical field.

The first part of the introduction examines the origins of various terms in different languages. The distinction between simple and compound substances is made and the interaction of the human organism with various forms of nourishment, medicines and poisons is discussed. Al-Bīrūnī also discourses on the Arabic and Persian languages, expressing the view that the former is best used for scientific purposes, and the latter, 'for the tales of Khusraw and bedtime stories'.

The main body of the text is subdivided into 29 sections, each corresponding to a character in the Arabic alphabet. They contain paragraphs devoted to the characteristics of the 1,116 medicinal substances known at the time when the *Kitāb al-Saydana* was compiled, these being distinguished by al-Bīrūnī as being of vegetable, animal or mineral origin. Out of the total of 1,116 entries, 880 relate to medicinal plants, mention being made of some 750 different species. Medicinal substances of mineral origin account for 117 entries, and substances of animal origin for 101; there are some 30 compound remedies (including

[13] Kadyrov, 1994, p. 75.

antidotes and various dietetic substances). For purposes of comparison, we may note that Dioscorides' work *De materia medica* contains 570 entries devoted to plants (mention being made of 400 species); 100 to animal derivatives; and 80 to substances of mineral origin.

The second book of Ibn Sīnā's *Canon* contains 811 paragraphs, 590 of which are devoted to vegetable substances (with mention of 400 species of plant), 125 to animal and 85 to mineral substances. Thus al-Bīrūnī provides accounts of a larger number of medicinal substances, especially those of vegetable and inorganic origin, than these earlier works. His sources are wide, dating from the earliest times to his own period and including ancient Indian, Greek, Alexandrian, Byzantine, Hebrew and Arab authors. The *Saydana* mentions 56 well-known authorities and 34 authors who have not been identified, as well as 14 unascribed texts.

In contrast with other works on the same subject, the *Saydana* does not refer to the properties and effects of the substances described or their medical applications. Instead, the author takes special pains to establish the composition of the substances described, the sources from which they are obtained (vegetable or animal), the signs which indicate their purity and high quality, and so on.

In the medieval East, pharmacognosy was considered either as a first stage in the acquisition of the physician's art or as an independent science in the service of medicine. Al-Bīrūnī offers a more specific definition, remarking that *saydana* is the knowledge of medicinal substances according to their origin, aspect and most proper forms; and of the composition of compound remedies in accordance with written recipes or with the prescriptions of a trustworthy and precise investigator. It follows that the pharmacognosist's task is to collect medicinal plants, to select the best species and to prepare compound remedies according to different recipes. In al-Bīrūnī's opinion, research and development are matters best left to the physicians, whose task it is 'to strive to perfect this art, lifting it up on the wings of theory and practice, and transmitting it to reliable pharmacognosists, helping them in the way that they are helped by the naturalists'.[14]

Much can be learned about the history of chemistry and chemical production in Central Asia during the Middle Ages from al-Bīrūnī's accounts of chemical substances and ways and means of obtaining them. Particularly valuable in this connection is his *Kitāb al-Jamāhir fī ma*ᶜ*rifat al-jawāhir* [Comprehensive Book on the Knowledge of Precious Minerals], which is packed with information about medieval mineralogy, as well as the author's own experimental observations. Considerable space is accorded to methods of assaying and obtaining the minerals described. Al-Bīrūnī was the first scholar to concern

[14] Al-Bīrūnī, 1973.

himself with the physical and chemical properties of minerals and synthetic materials (their degree of hardness, their response to tempering and their specific weight); he established a classification of minerals and advanced a number of ideas concerning their origin (see further on mineralogy in Chapter 8 above).

Many other scholars are known to have frequented the court circle of the Khwarazm Shah Ma'mūn b. Ma'mūn al-Gurgānj, even if all we know are their names, such as Abū Sahl Masīhī and Abu 'l-Khayr Khammār.

Medicine, biology, chemistry and technology in the later medieval period

Ahmad b. ᶜUmar b. ᶜAlī, known as Nizāmī ᶜArūdī Samarqandī (d. 1157), a native of Samarkand, was a well-known scholar, poet and philosopher, who also concerned himself with science, and with medicine in particular. His *Majmūᶜ al-nawādir* [Collection of Strange and Curious Things] contains not only 30 separate discourses on the lives and activities of notable savants but also some interesting remarks on the structure and function of living organisms, both vegetable and animal. The author stresses that the living world emerged from inert matter as the consequence of a multiplicity of transformations. As well as comprehensive and informative accounts of medicine and other sciences, this work contains information of another type, which makes it possible to assess the scale of mineral exploitation at the time. In one anecdote, the author describes how the ruler presented him with the profits from the lead mines at Warsad, a mountainous region adjacent to the Hari Rud valley and to the east of Herat in Afghanistan. 'Summer was at its height,' he writes, 'a time of great labour: in the course of 70 days, 12,000 *manns* of lead were smelted, of which one-fifth came to me.' It thus seems that output from this one twelfth-century mine amounted to 36 tons of lead in 70 days, indicative of the productivity of the mining industry in Central Asia at the time.

At this period, scientific development was accompanied by significant progress in different branches of chemical-based craft industries. Thus, the traditional trades of metallurgy and metal-working, together with the production of ceramics and construction materials, mineral pigments and paints, glassware and leather goods, all flourished. chemistry and pharmaceutics benefited considerably from the availability of vessels and apparatus made of glass, specimens of which have been discovered in the course of archaeological excavations throughout Central Asia. For example, alembics dating from the eighth century have been found in the ancient township of Afrasiab at Old Termez and at Khasiyat-tepe. Miniature flasks in different shapes and colours, used in perfumery, have been found almost

Fig. 2. Miniature flasks. Tashkent Museum. (Photo: Courtesy of A. Abdurazakov.)

everywhere (Fig. 2). Glass spoons or ladles have been unearthed at Kasan and Afrasiab (Fig. 3). Pieces of chemical apparatus resembling modern flasks and retorts have been found at Afrasiab, Akhsikath, Gumushkand, Old Termez, Hauz-Khan-kala, Gormali-tepe, Kal'-tepe, Bazar-dare, Tashkent and Kanak (Fig. 4). One particularly interesting item is a jar-like vessel in two parts which are separated by a thin piece of perforated glass (Fig. 5). Glass alembics dating from the ninth to the thirteenth century have been discovered in particularly large numbers at sites throughout Central Asia (Fig. 6), as have glass test-tubes (New Nasa, Merv, Kal'-tepe, Uzgend and Taraz), and weights of different sizes at Afrasiab.[15]

The disruptions of the Mongol invasions caused some dislocation, but the early 1360s saw the creation of the powerful Timurid state. Timur set great store by the applied sciences, i.e. astronomy, mathematics, medicine and history. The Dār al-Shifā' (House of

[15] Abdurazakov, 1993, pp. 339–407.

Fig. 3. Glass spoons. Tashkent Museum. (Photo: Courtesy of A. Abdurazakov.)

Healing) in Samarkand at this time attracted distinguished physicians such as Mīr Sayyid Sharīf, who came from Jurjan at Timur's invitation, and Mansūr b. Muhammad b. Ahmad, who wrote three medical works, one of which describes the properties of various simple and compound remedies.[16]

Timur's grandson Ulugh Beg (1394–1449) was especially attracted to the exact sciences, i.e. astronomy and mathematics (see Chapters 6 and 7 above). He also took great

[16] Kadyrov, 1994, p. 99.

Fig. 4. Flask used for chemicals. Tashkent Museum. (Photo: Courtesy of A. Abdurazakov.)

interest in medicine and studied the works of various physicians, including Ibn Sīnā's *Canon* and Muhyī al-Dīn al-Juwaynī's *Nigāristān* [The Picture Gallery], which contains a section on medicine. Himself the author of a short treatise on medicine, Ulugh Beg protected scholars, ensuring that they enjoyed a good standard of living, and presided over the construction of hospitals and his famous observatory, so that during his reign, Samarkand became the meeting-place of a veritable pleiad of learned men. The later Timurid ruler Sultān Husayn Bayqara (d. 1506) and his vizier Mīr ᶜAlīshīr Nawā'ī (d. 1501) also extended generous patronage to scholars, poets, philosophers and physicians. Among them was Hākim ᶜAbd al-Razzāq Kirmānī (*fl.* late fifteenth-early sixteenth century), a versifier as

Fig. 5. Chemical jar-like vessel. Tashkent Museum. (Photo: Courtesy of A. Abdurazakov.)

well as the author of a work on medicine which contains accounts of different medicinal substances of vegetable and mineral origin, and of useful animals and birds, together with an appendix listing the names of medicines in the Arabic, Persian and Chaghatay Turkish languages. Mīr ᶜAlīshīr Nawā'ī himself frequently returns to medical themes in his own writings.[17]

The development of chemistry and production technologies in the post-Mongol period can only be assessed on the basis of a few archaeological excavations, written sources on the subject being virtually non-existent. Glassware dating from this period has been found

[17] Abdurazakov, 1993, p. 26.

Fig. 6. Glass alembics. Tashkent Museum. (Photo: Courtesy of A. Abdurazakov.)

at 30 sites; the transformation of Samarkand into the capital of a great empire was accompanied by the expansion of glass production on a significant scale, and notably of window glass, as well as of glazed tiles and majolica ware. The Registan square in Samarkand was entirely occupied by craftsmen's workshops, and excavations here have brought to light the kilns and furnaces used by metal-workers, pharmacists, jewellers and ceramists, as well as crucibles, containing opaque coloured substances, which probably belonged to glass blowers or potters and were used to heat fritt, basic materials that served in the preparation of glazes and glass. Window glass is reported to have been found in the ruins of the ᶜIshrat-Khana mausoleum and the Gur Amir complex in Samarkand, in monuments associated with Ulugh Beg in Bukhara, at Anau in Turkmenistan and in the ancient settlement of Shahr-i Sabz.

Obviously, technical advances in paper-making and the preparation of coloured inks and dyes for illustrations and miniatures facilitated the development of artistic and literary activity during the age of Timur. There is also some evidence that Timur was the first to use firearms and artillery on a large scale during siege warfare, suggesting that gunpowder or other 'fiery' substances were produced in the Timurid state and that practical chemistry had reached a fairly high level of sophistication.

Accordingly, it may be concluded that in Central Asia, during our period, there were considerable advances in the understanding and use of natural and synthetic materials, which were widely used in different fields of activity.

Part Two

TIBETAN AND MONGOLIAN PHARMACOLOGY

(*Ts. Haidav*)

Originating on Indian soil, Ayurvedic medicine was taken a stage further outside the subcontinent. In the rich repository of Indian-Tibetan traditional medicine, we have records of hundreds of medicinal raw materials comprising plant, animal and mineral products for the treatment of various ailments.

Between the eighth and the tenth century, Tibetan medicine reached a new stage of development, one greatly influenced by the traditional medicine of neighbouring countries. Tibet had relations with the medical systems of Afghanistan, Central Asia, Iran and the Arab countries, as well as Mongolia, which also contributed to the development of Tibetan medicine. A well-known book of Indian medicine, *The Secret Oral Tradition of the Eight Branches of the Science of Healing*, was introduced into Tibet under the title, the *rGyud-bzhi* [The Four Treatises].

In the seventh century, an imperial state was established in Tibet under Soronzongombo (619–49) and it was during this period that Indian Buddhism flourished, together with medicine and the arts, including astrology, in Tibet.[18] This trend was accentuated by the elder Yutok Yondongombo (708–839). During the reign of Tesrondevzon in the ninth century, a well-known Buddhist scholar, Badamsambo of Kashmir, was invited to the court of the emperor, where he enthusiastically translated Buddhist doctrines into Tibetan. Other physicians from neighbouring countries were also invited to bring their medical skills: Sumagerde from Nepal, Lhagvajantsan from Mongolia, Dambalodoi from Kashmir, the Indian physician Sri Ananda, the Persian physician Ayurvaya and physicians from China are said to have participated in this task.[19] After this influx of physicians from various countries, the younger Yutok Yondongombo (1138–1213) rewrote and edited the

[18] Dashieva, 1991, pp. 2–4.
[19] Berezov, 1982, pp. 270–1.

rGytid-bzhi; it was thus enriched by the medical culture of neighbouring countries,[20] and without revision, has been in use up to the present time.

Besides material concerning the theoretical basis of the five elements (space, air, fire, water and earth), the *rGyud-bzhi* also demonstrates Chinese medical concepts as regards the 5 internal solid organs (the heart, lungs, liver, spleen and kidney) and the 6 hollow organs (stomach, small intestine, large intestine, gall bladder, seminal vesicle and bladder). The treatise consists of 4 volumes and 156 chapters. It covers a large number of disorders, which can, however, be condensed into 404, clearly subdivisible into 4 groups: 101 that can be cured by medicine, 101 treated by spiritual *mantra*, 101 treated by medicine blended with spiritual *mantra*, while 101 disorders are considered as incurable. In the fourth volume of the *rGyud-bzhi*, we have details of medicinal raw materials. The *Merged Gara-yin Oron* [Dictionary of Medicine] gives an account of medicinal products mentioned in the *rGyud-bzhi*. Compiled by many Tibetan and Mongol scholars, it was edited by Bolbidorj (1717–62).

The pharmacological science of Tibet and Mongolia leads us to study the effectiveness of drugs and their relationship to organisms, animals and human beings. Oriental pharmacology was based upon the interrelationship of five elements (the five external substances). It was believed that the universe originated from the space element, and was then re-formed into air, thereby producing space and the universe. During this period, the young sun shone brightly over space and the universe, melting ice, which then formed the ocean and thereafter created the earth. This is why the universe was considered the structure of the five elements: space, air, fire, water and earth.

Man, being a product of nature, is also composed of five elements, and to determine the physiological function of a human body, the five elements were generally classified accordingly: air for the space element, whereas the sun was connected with the fire element; the two elements, water and earth, were attached to the three elements, and from here originated the concept of the three elements (essences) – *hii* (air or wind), *shar* (bile or fire) and *badkan* (phlegm). The fire element, from its yellow colour, was bestowed as *shar*; water and earth, because of their moistening, heavy properties, were regarded as *badkan*. In Sanskrit, the term *badkan* denotes water and earth.[21]

In the encyclopedia of Chinese medicine, the three elements are described as follows.

- The *hii* (air or wind) element has light, rough, cool, thin, strong, mobile characteristics, the light property being the opposite of heavy. A person with a light, quick, hasty, highly excitable temperament possesses light characteristics. The rough quality has

[20] *Dictionary of Chinese Traditional Medicine*, 1986, Vol. 2, pp. 30–1.
[21] *Dictionary of Chinese Traditional Medicine*, 1986, Vol. 2, pp. 30–1.

contradictory types, being both oily and mild. A person having a rough, harsh skin and harsh characteristics represents the specific quality of roughness. The rough property subsides under the oily and mild qualities. The mobile element is the opposite of the solid property. *Hii* is responsible for the entire movement of the body. Instability, awakeness and forgetfulness are the specific constituents of the mobile element. It takes shape in mobile qualities and subsides under the influence of the warm property.[22]

The term *hii* is an abstract notion and should not be understood by the simple meaning of hydrogen air or azot, the chemical characteristics in atomic physics of hydrogen, or any substance with the form of wind. References to *hii* in the sources define it as the force which keeps everything in motion; it is responsible for the entire movement of the body, conducts the physiological functions and runs through the white channels (nerves). The space element, in fact, gives an opportunity for it to manifest itself and provides space for *hii* in movement.

The prominent Tibetan physician Darma Lubsanchoidog (sixteenth century) wrote a book called *The Golden Set*. In the chapter entitled 'Physical Conditions', he describes *hii* as follows. After the formation of the embryo in the mother's womb, a *hii* with its specific name emanates from the embryo. It changes form as it grows and becomes larger. Then, four weeks after the formation of the embryo, a circle named *hii* appears and the embryo changes into the form of a fish.[23] Every week, a certain named *hii* is created from the embryo, thus producing the system of organs. In the 38th week, the 'birth condition' *hii* is produced and the child is then ready to be delivered with his head facing downwards. From this point of view, the *hii*, according to the theory of oriental medicine, is the energy source which is responsible for bodily movement and growth. A human being has two large veins, one white and one black. The white is said to be the spinal cord, and the black is considered the aorta. The concept of *hii* running through the white channel is understood to be the nervous electric potential.

The *hii* element has six characteristics and these act upon the opposing relationships according to the theory of 'wisdom and methodology'. For example, the light property of *hii* is the opposite of heavy, cool is the opposite of warm, and so on. Every phenomenon has a contradictory side, and this expression is relevant to the symptoms of disease. The mechanism of the action of drugs is also explained accordingly. To treat *hii*, a herb is given as an example: *li-shi* (*Eugenia carophyllota*, or Thumb) is

[22] Ibid.
[23] Luvsanchoidog, 1984, pp. 43–5.

considered to be the most important remedy for *hii* deseases. Grown in South-East Asia, this aromatic herb contains 1.7–2 per cent of essential oil, of which 70–85 per cent is evgenol.[24] The herb was utilized in medicine from very ancient times in India, Egypt and China. *Li-shi* has warm, heavy, oily, solid, soft and dry properties.

The medical texts give descriptions of how *hii* disorder is to be treated. Lightness of *hii* is treated by the heavy property of *li-shi*, roughness of *hii* by oily substance, firmness of *hii* by the soft property of *li-shi*, thinness of *hii* by the dry property and, finally, coolness of *hii* by the warm property of *li–shi*. This theory of pharmacology expresses the principle of treating the characteristics of disease by their opposites. Tibeto-Mongol pharmacological theory involves multi-ingredient drugs, attaching importance to the taste and to the properties of the drugs that are intended to alleviate diseases and which produce no side-effects in the organism.

- The *shar* (fire or bile) element has hot and sharp properties. It has seven characteristic varieties. According to wisdom and methodological concept, *shar* belongs to the wisdom characteristic, and according to the five elements' idea, *shar* is the fire element. It is responsible for intelligence, memory and enthusiasm. In the medical texts, *shar* is described as creating warmth and preserving equilibrium with the *badkan*.

  The essential qualities of *shar* are hot, sharp, light, wet and oily. The *shar* element resists cold and is responsible for thirst and appetite. The sharp quality is the opposite of lightness and oiliness and is usually warm. The oily substance always subsides under the cool characteristics, and the light property develops more in the fire element. Man knew of the energy of sunlight, but failed to understand the nature of internal warmth. This brought out the abstract notion that fire is the factor that preserves warmth in the organism. Yellow-coloured bile (*shar*) was equated with the sun for its sharp quality.

  The concept of the fire element or the *shar* element is ancient, indicating that the scholars of the time were acquainted with the notion of 'free energy'. The living organism is a free, open system, which receives potential energy from organic substances to a certain extent, and as a result, certain actions are performed. These energies are called free energy; and the first energy source of living organisms is sunlight. Green plants photosynthesize with the help of sunlight and produce organic substances such as amino acids, and oily substances, the process of producing organic

[24] Muraeva and Gammarman, 1974, pp. 41–3.

substances from non-organic ones. Other living organisms directly receive the organic substance, and through an assimilation process, acquire the energy sources.[25]

In medical literature, *shar* is linked with intelligence and courage, in other words, it is responsible for intellectual functions in the body, producing body heat or energy. Its qualities are hot, sharp and oily. The *shar* disease also reflects these characteristics. Therefore, one chooses medicinal drugs to decrease this heat. The medicinal herb *Mormodica cochinchinensis* (Lour) is most often used in traditional medicine to treat this. It is a perennial herb of the family of Cucurbitaceae and grows in cool climatic conditions. The seed is used in medicine; its fruit and seeds contain oily substances. The oil contains 44.4 per cent of oleini acid, 14.7 per cent of linolenin acid and 33.8 per cent of palmitinin acid, and also yields a strong compound of sanotoxin which is said to kill fish.[26]*Mormodica cochinchinensis* is bitter in taste and possesses cool, cold and astringent, light, rough properties. This is why the hot quality of *shar* is alleviated by the cool, and the roughness is treated by the astringent. According to modern pharmacology, *Mormordica cochinchinensis* in general controls the metabolic state and inhibits adrenalin activity.

- The *badkan* (phlegm) element is the third constituent of organisms. This element comprises water and earth elements. It has seven characteristics: heavy, cold, oily, smooth, compact, sticky and firm. The heavy characteristic of *badkan* is responsible for stability and sound sleep; calmness is also due to the heavy quality of *badkan*, which is connected with the earth element. The cold characteristic of *badkan* is directly opposed to the hot property and is therefore considered as the water element.

In the theory of wisdom and its methodology, hot is described as the sun and cool as the moon, indicating the two sides of one particular object. There are also other theories stating that if wisdom and methodology exist in a normal state, then the whole state is said to be in equilibrium. According to this theory, in the equilibrium state of *shar* and *badkan*, the *hit* element exists inversely as a buffer between these two elements.

If any of these elements becomes excited or spoiled, it produces disease and is also responsible for the degeneration of the body. *Hii* has six characteristics, whereas *shar* and *badkan* each have seven. In some classical books, it is said that the first two characteristics of the three elements originate directly from the mother's womb. The last four characteristics of *hii* and the five characteristics of *shar* and *badkan* are considered to be generated

25 Berezov, 1982, pp. 270–1.
26 Turova and Sapojnikov, 1987, pp. 340–3.

later. According to modern physiological science, these reflect the concept of conditional reflexes.

The theoretical basis of Tibeto-Mongol pharmacology follows the concept of the three essences or humours. It tries to understand the characteristic role of the three humours, and the causative factors of their imbalance, and is concerned with proper diagnosis. The manifestation of these disorders is determined by the following inspection methods: questioning the patient, taking the pulse, and observation of the urine that includes colour, odour and foaminess. The methods of the ancient physicians are still of great interest today. The ancient physicians freely used toxic substances such as aconitine and strychnine in medicine.

In the traditional medical schools of India, China, Tibet and Mongolia, there was a tradition of teaching students the methods of identifying medicinal products by taste, a method practised even today. Thus Luvsan's *Dictionary of Mongol medicine* has a brief description of taste by the tongue. The quality and quantity of a drug are commonly determined by five basic tastes. Physicians were also taught how to determine the dose of each ingredient that is mixed in a medicine. The five basic tastes are sweet, bitter, saline, astringent and sour. The taste of any product is related to the theory of the five elements. The earth, water, fire and air are combined in several different ways and taste is defined accordingly. The space element does not form the main component in taste. If more than two tastes are combined, then it is called a complex taste. Thus the combination of sweet and sour, and the combination of sweet, sour and saline, are complex tastes. For example, *Ribes rubrum* is said to possess five different tastes, and six different tastes have been determined in *Terminalia chebula*. In ancient medical sources, great emphasis was attached to taste. The ancient physicians considered taste to be an important source for determining treatment, because they held that taste is an indicator of potency with respect to counteracting disorders. Thus the sweet taste decreases *shar* and thereby produces *badkan*. Medicine of a sour taste suppresses *badkan* and *hii*, but activates *shar*. The pharmacological system of Tibet and Mongolia thus defines the mechanism of a drug by its taste.

Substances and food with a sweet taste have the potential to improve bodily strength, regulate the blood, promote weight, nourish the bone marrow, increase regenerative fluid and breast milk, and provide a good complexion. The saline taste prevents constipation, releases spasms in tendons, widens blood vessels and thereby improves blood circulation. The bitter taste decreases body temperature and reduces poisonous substances accumulated in the organism. From the principles of the various tastes, the efficacious, qualitative and potential values of drugs are determined.

Thus the traditional pharmacology of Tibet and Mongolia corresponds to the theory of the 5 elements based on oriental medical philosophy and the theory of wisdom and methodology. Supported by these theories, drugs were prepared on a basis of the disturbances of the 20 characteristics related to *hii*, *shar* and *badkan*. Physicians were required to acquire knowledge and experience of identifying at least 73 tastes in a medicine. The medical texts give examples of 2 types of taste in 15 plants and 3 types of taste in 20 kinds of medicinal plants. Medical texts teach that a physician who can detect the taste of dried medicinal herbs should be accepted as a pharmacologist. There are 15 plants or animal products possessing 4 tastes, 6 ingredients having 5 tastes and a few medicinal products comprising 6 tastes; if a physician can distinguish all these tastes, he is regarded as qualified.

In this way, traditional medicine speaks of the potencies of ingredients in terms of their tastes, and describes how medications with different tastes and potencies work in the treatment of diseases and conditions.