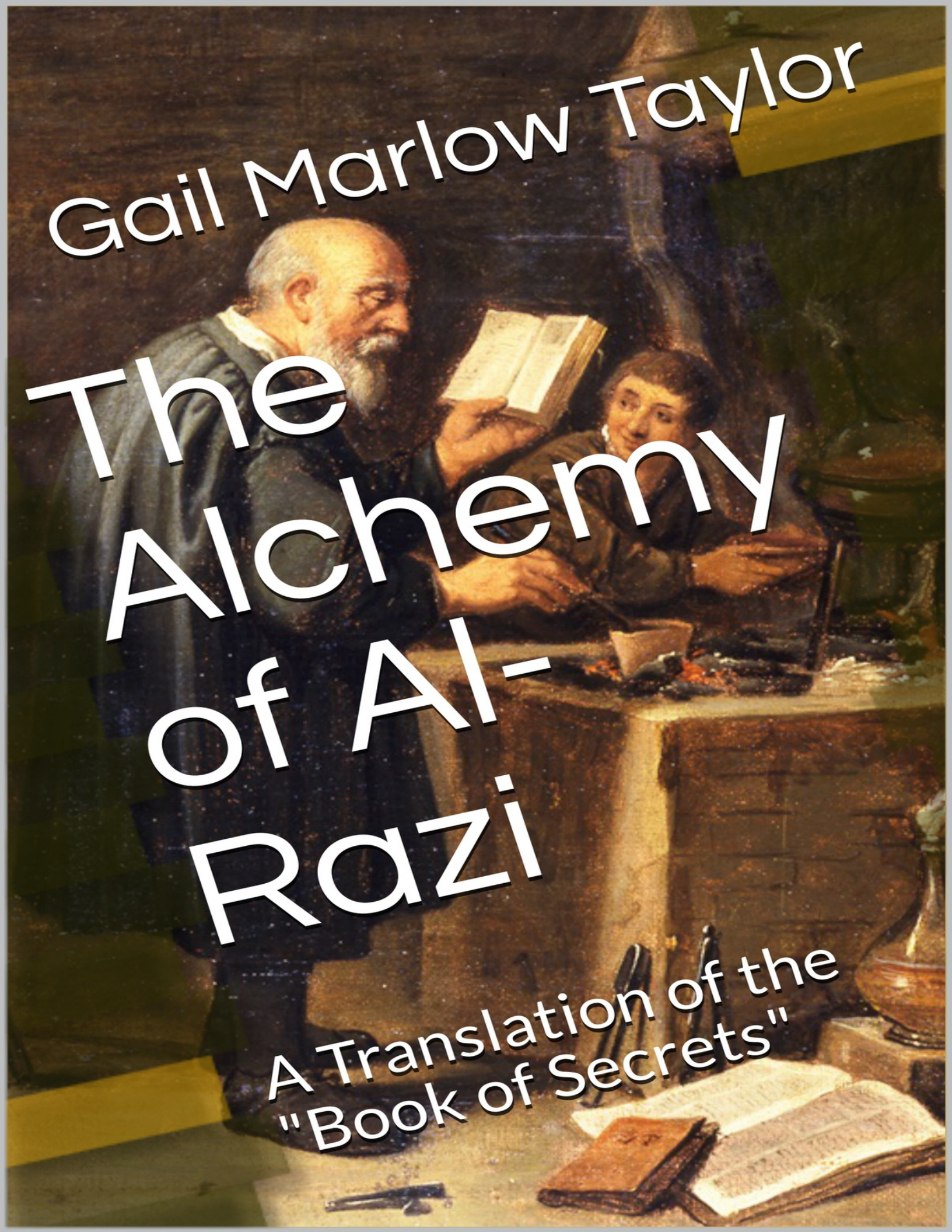
Gail Marlow Taylor
The Alchemy of Al-Razi
A Translation of the "Book of Secrets"

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Gail Marlow Taylor

ABOUT THE AUTHOR

Gail Marlow Taylor began her graduate studies in history following a 25-year career in laboratory medicine. She completed her master's degree in 2008 with a thesis entitled: "Al-Razi's *Book of Secrets*: The Practical Laboratory in the Medieval Islamic World." This analysis, which included her English translation of the *Book of Secrets*, won the 2009 Outstanding Thesis Award at California State University, Fullerton.

In June, 2014, she was awarded a doctorate in history at University of California, Irvine. Her dissertation analyzed the reception of New World medicinal plants in sixteenth-century Germany, and included a year of research in Wolfenbüttel on a Fulbright Scholarship. She lives in Rancho Santa Margarita, California, where she enjoys spending time with her children and grandchildren and writing her blog, "History's Edge."

ABOUT THE COVER PHOTOGRAPH

Because complicated alchemical procedures required written instructions, books have become an iconic part of alchemy in artistic representations. In this seventeenth-century painting, the alchemist stirs the crucible with book in hand, while assistants prepare ingredients and monitor the critical level of heat. Detail from *The Bald-Headed Alchemist*, after David Teniers II, Fisher Collection. (Courtesy of the Chemical Heritage Foundation Collections. Photo by Will Brown. 00.01.258.)

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Heartfelt thanks are due to two people who helped me see this project as living history: Father Jose Luis de Valle Merino at the Real Biblioteca Monasterio del Escorial, who let me hold the Escorial manuscript of the *Kitāb al-Asrār* in my hands and scanned in a digital copy for me to take home, and Thomas Ruska in Berlin, who graciously gave me permission to use Julius Ruska's translation of al-Rāzī's work and invited me to contribute a printed copy of my translation to the archive of his great grandfather's distinguished works.

The book itself owes its existence to the many readers who read about my thesis and translation in my blog and asked me where they could find a copy. Hearing from people in ten different countries and from a variety of backgrounds served as both an inspiration and a testament to the enduring interest in al-Razi and his contributions to chemistry. I am more than grateful for the encouragement and support of my thesis advisor at California State University, Fullerton, Dr. Jochen Burgtorf, and my thesis committee members Dr. Nancy Fitch and Dr. Lynn Sargeant, who received my prospectus with such contagious enthusiasm. A big measure of thanks goes to my doctoral advisors at University of California, Irvine, Dr. Ulrike Strasser and Dr. Laura Mitchell, who urged me to follow through and publish this work.

My friends and colleagues throughout my hospital career not only unwittingly shaped my laboratory persona, but even read parts

of this book, making it almost a laboratory result in itself. Of course, any failures to meet quality control standards are purely my own.

As for the unfailing love of my father, my children, my grandchildren, and especially my husband, a tireless and expert proofreader, words cannot express my gratitude for your patience with the hours I have spent in al-Rāzī’s laboratory.

“Alchemy was never at any time anything different from chemistry. It is utterly unjust to confound it, as is generally done, with the gold-making of the sixteenth and seventeenth centuries. . . . Alchemy was a science, and included all those processes in which chemistry was technically applied.”

—JUSTUS VON LIEBIG
FAMILIAR LETTERS ON CHEMISTRY
LONDON, 1859, 54.

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PREFACE

Over a thousand years ago, the Persian physician and alchemist Abu Bakr Muhammad ibn Zakariya al-Razi presented his students with a book of alchemy instructions called the *Kitab al-Asrar* or *Book of Secrets*. For over seven hundred years this systematic text on managing chemicals, equipment, and procedures was translated and imitated throughout Europe. Using historian Julius Ruska's authoritative 1937 German translation, I have translated al-Razi's *Book of Secrets* into English for the first time and analyzed it from the practical hands-on perspective of my own laboratory experience.

With its promises of gold and prolonging life, alchemy has long attracted scholars, kings, and charlatans while over the centuries the practice of material transformation undertaken in this quest laid a foundation for the chemistry, metallurgy, and medical laboratory techniques of our times. From the tenth century, the *Kitab al-Asrar* or *Book of Secrets* of al-Razi speaks to us of the instruments, measurements, and reproducibility that are the essence of laboratory practice today. As a laboratory technologist, I recognized the structure and procedures *Book of Secrets* to be those of a laboratory manual, much as we see in any chemistry laboratory class. I based the argument of my master's thesis on this similarity, calling it: *Al-Razi's Book of Secrets: The Practical Laboratory in the Medieval Islamic World*.

This thesis, which includes my English translation of the

book, won the 2009 Giles T. Brown Outstanding Thesis Award at California State University, Fullerton, and generated articles in a variety of journals. Papers based on the research done for the original thesis have won prizes at conferences given by the World History Association and Phi Alpha Theta, the history honorary fraternity. Since its completion, the thesis has taken on a life of its own. It has been cited, requested, and Tweeted by scholars in ten countries outside the United States, including the Netherlands, France, Morocco, Malaysia, Iran, Canada, the United Kingdom, New Zealand, Australia, and Japan. I have shared it freely, for there is no greater source of satisfaction and pride than to contribute to the body of international scholarship.

Because of the interest this thesis has generated, I have decided to make it available as a published book. I have chosen to self-publish, in order to leave the thesis intact and to present the material in my own way. To this end, I have added this preface at the beginning and changed some of the pictures to take advantage of photographs that I have acquired since writing the original thesis.

Translations always require some explanation, especially where a translation of a translation is concerned. The *Kitab al-Asrar* was originally written in Arabic, the scholarly language of al-Razi's time. In 1937, Julius Ruska, a German scholar with expertise in both historic Middle Eastern languages and sciences, located three Arabic manuscripts from different places and times, but closely resembling each other, and used them to translate the book into German. I translated Ruska's German translation into English in order to analyze al-Razi's book as a laboratory manual with practices and procedures which are reflected even in modern laboratory manuals directed to very different goals. My English translation has the distinction of making this fascinating tenth-century work accessible to a much wider range of scholars than

ever before.

The commentary section of the thesis first looks at the Kitab al-Asrar in its original context of medieval Islamic alchemy and then establishes its place in the practice of chemistry by comparing it to medieval and modern works. Laboratory practices that have persisted through time are illustrated with examples from the translated text. Modern laboratories are highly trusted institutions, which analyze virtually everything we touch from the food we eat to the clothes we wear. Yet the basis of laboratory testing, the procedure manual defining equipment, materials, and procedures, can be seen in this tenth-century alchemic handbook. Read with this perspective, the translation that follows the analysis is both revealing and accessible on many levels.

INTRODUCTION

If I did not know that my days are numbered, and that my death is near, and if it were not for my concern that this service that I want to render out of friendship might be prevented by my death, I would not have brought all this together in my book and I would not have tried to bring it to such a state of perfection.[1] *Al-Razi, Book of Secrets.*

THE LABORATORY AND THE BOOK

Alchemy, the most ancient form of chemistry, brought the book and the laboratory together. Centuries before the test tube and the Bunsen burner, the written manual held the key to repeatable results, the essential focus of laboratories to this day. Over a thousand years ago Persian physician and chemist Abū Bakr Muhammad ibn Zakarīyā al-Rāzī (c. 865 - 923) presented his students with such a manual, a guide to the transformation of metals embodied in the practice of alchemy.[2] Calling it the *Kitāb al-Asrār* or *Book of Secrets,* he told them, "In this book are chapters that the adept and the scholars have not seen."[3] Al-Rāzī was not the first alchemist to have a laboratory; the story of alchemy traces its beginnings to ancient Egypt, India,

and China. Nevertheless, his manual bears witness both to the original contributions of early Islamic science and to the development of laboratory methodology, as we understand it today. Because al-Rāzī wrote a book, his laboratory is accessible to us and his influence is tangible.

The proliferation and influence of laboratories in our age is unprecedented. Four hundred years ago, when the word *laboratory* first occurred in the English language, it evoked a sooty medieval workshop rather than a pristine haven of orderly investigation.[4] Today *laboratory* suggests a restricted area where information is produced by experiment and analysis in a controlled environment. It commands an authoritative and trusted space for testing medical specimens, food, building materials, or legal evidence, and for carrying out an enormous range of research and development activities from pharmaceuticals to alternative fuels. In its more legitimate applications, the modern laboratory has become increasingly subject to institutionalized regulatory oversight.[5] This growing degree of public credibility and accountability depends on reproducible results[6] based on written standard operating procedures. William Tillstone, director of a large forensic laboratory, addresses modern standards of quality assurance in these words: "Once you have a manual you must follow it. . . If it turns out that there is a better way to do something than detailed in the manual, change the manual."[7] The written word dictates laboratory procedures and the laboratory in turn dictates the written word.

At first glance, Al-Rāzī's *Book of Secrets* may seem far removed from the modern laboratory's book of standard operating procedures, but it too specifies procedural steps and controlled conditions designed to produce a predictable outcome. Written in about 920 C. E., it continued to have influence for over six centuries as it was translated, transcribed, and imitated through the ages. The most valuable "secrets" in the *Kitāb al-Asrār* are written specifications for proportions, temperature, timing, and endpoints, the same tools for achieving reproducibility that laboratories use today. This analysis combines historical research and my own laboratory experience to examine the *Kitāb al-Asrār*'s historical context, systematic organization, theoretical foundation, and technical procedures. It will compare the *Kitāb al-Asrār* with selected medieval and early modern laboratory texts, demonstrating a continuity of laboratory practice and empirical methods despite the fact that al-Rāzī was pursuing an alchemical goal, the transmutation of metals.

Although al-Rāzī was best known for his medical works, Latin translations of the *Kitāb al-Asrār* circulated in Europe into the seventeenth century, when chemistry's horizons expanded and alchemy slowly faded into disrepute. Then in 1921, German scholar Julius Ruska (1867-1949), an expert in the language and history of Islamic science, recognized an Arabic manuscript of the *Kitāb al-Asrār* in the library of the University of Göttingen.[8] The manuscript, dated 1561, had rested in the archives since 1878, when it first came to Germany from the Coptic monastery Amba Buscâi in Libya.[9] Ruska's find represented a keystone in the study of Arabic alchemy because the text was complete, and its authorship was documented.[10] The same clarity, empirical approach, and lack of mysticism which attracted Ruska's interest make the *Kitāb al-Asrār* ideal for the study of an early laboratory environment.

Julius Ruska had already completed studies on earlier alchemic works while teaching at the University of Heidelberg. Although financial and occupational uncertainties kept him from completing a full translation of al-Rāzī's book for more than a decade, Ruska began to read and analyze it immediately. In 1923, he published an article in the *Deutsche Literatur-Zeitung* entitled, "Al-Rāzī as the Trailblazer of a New Chemistry."[11] Convinced that the development of Western chemistry rested on Arab rather than Greek science, Ruska continued his wider research on the status of Islamic chemistry prior to al-Rāzī, publishing studies on Jabir ibn Hayyan, the chemical apparatus of Arabs and Persians, and early alchemical texts such as the *Emerald Tablet*.[12] He found that, although based on earlier works, the style of the *Kitāb al-Asrār* stood apart, remarking that "the gulf between the endless variety of forms of the Jabir manuscripts and the realistic matter-of-fact style of Rāzī's work is so great, that one can hardly find any further relationship other than a common foundation."[13]

Even in the tenth century alchemy was controversial and al- Rāzī wrote energetic defenses of the controversial art of transforming the state of metals under artificial conditions. The debate centered on feasibility, rather than theory. Ores came out of the mines in an impure state, base metals mixed with precious ones, as if in a state of flux and thereby supporting Aristotle's postulate that the four bodies, earth, air, fire, and water, share an elemental substrate which is transformed and purified when subjected to heat and pressure in the depths of the earth.[14] The crux of the debate questioned

whether these conditions could be duplicated under artificial conditions in the laboratory.[15] If the right substances were mixed in correct proportions and subjected to controlled heat, might not the natural metamorphosis of metals be accelerated? Or perhaps under the right conditions a seminal element, the fabled "Philosopher's Stone" might accelerate the transformation, "like dye permeates through cloth or leaven raises dough."[16] The human fascination with this possibility was the first application of theoretical chemistry – the use of the workspace, not to mix ingredients for a dye or perfume, but to recreate the forces of nature in the laboratory and transform the substance of matter itself.

Although al-Rāzī defended alchemy in other works, his *Kitāb al-Asrār,* written in c. 920, is a practical procedure manual that yields no space to debates on theory.[17] The result is a book that is confident, self-contained and systematic, giving it a modern resonance that contrasts with more theoretical medieval texts, such as the *De Mineralibus* of Albertus Magnus (c.1193–1280), and allegorical documents, such as the *Compound of Alchemy* by George Ripley (c.1415-1490).[18] In fact, the structure of al-Rāzī's tenth-century book closely resembles the late sixteenth-century chemistry text *Alchemia*, which was written in Germany by Andreas Libavius (c. 1555-1616) and is often referred to as the first chemistry textbook.[19] Prominent alchemical texts written during the intervening seven hundred years that share elements of this structure include *The New Pearl of Great Price* (c. 1330) by Petrus Bonus and the thirteenth-century *Summa Perfectionis* of Pseudo-Geber.[20] A close analysis of the organization and procedures of the *Kitāb al-Asrār* and comparison with medieval European alchemical texts shows that al-Razi's strategies for repeatability and his basic laboratory manual structure of chemicals, equipment, and procedures continued far beyond the publication of Libavius's *Alchemia* in 1597.

SOURCES AND STRUCTURE

In this modern age of unparalleled confidence in laboratory testing, it is timely to probe the foundations of the laboratory concept. Like Ruska, I started in the library, where I came across a partial list of al- Rāzī's chemicals and equipment under "Arabic Alchemy," in the *Encyclopedia of*

the History of Arabic Science. Tracking down the *Encyclopedia's* citations, I found that Julius Ruska had translated the text from Arabic into German in 1937 and published it with commentary. As an historian and a laboratory professional, I resolved to translate this work into English for the first time and examine its competency as laboratory manual. Twenty-five years of hands-on laboratory experience as a licensed Clinical Laboratory Scientist and the authorship of countless written procedures give me a direct approach to al-Rāzī's alchemic handbook that complements and expands the scholarly analysis of previous historians.

While *Kitāb al-Asrār* resembles in many ways the books of standard operating procedures found in modern laboratories, at the same time it highlights changes in the way laboratory manuals are used and understood. Working manuals today address compliance with regulatory requirements as much as they do instructions for performing processes and procedures. No more are laboratory procedures expected to last through the ages. Rapid changes in automation and computer technology over the last fifty years have brought an expansion of laboratory functionality as well as increased public accountability, keeping procedure manuals in a state of constant revision. Like its modern counterparts, Al-Rāzī's manual reflects the priorities of his time and place, and yet alchemists from very different backgrounds referred to it over six centuries of active use. Still, if one looks past the specific goal of converting base metals into gold or silver in order to focus on the methodology of how to use solvents safely, obtain the right temperature, or identify the endpoint of a reaction, the universality of standard chemical operations comes through.

Even before the publication of Ruska's translation in 1937, contemporary historians confirmed the originality of al-Rāzī's chemistry. In the comprehensive *History of Science* (1927) George Sarton labeled the second half of the ninth century "The Time of Al-Rāzī," because, "The Persian al-Rāzī was not simply the greatest clinician of Islam and of the whole Middle Ages; he was also, as we have seen, a chemist and physicist."[21] Among his sources, Sarton cited two articles by Ruska on al-Rāzī dated 1923 and 1924.[22] At the same time, British historian Henry E. Stapleton, principal of the Presidency College in Calcutta, India, commented on translated excerpts from the *Kitāb al-Asrār* in his book *Chemistry in Iraq and Persia in the Tenth Century A.D.* based on incomplete Arabic manuscripts he had collected from Leipzig, Germany; the Escorial Library

near Madrid; and Lucknow, India, as well as the Medieval Latin manuscript, *Liber Secretorum Bubacaris*.[23] Although Stapleton, who was in correspondence with Ruska, deferred to Ruska's forthcoming translation for a thorough analysis of the *Kitāb al-Asrār*'s significance and content, he did not hesitate to claim that: "For the first time in the history of the world we find a systematic classification of carefully observed and verified facts, regarding chemical substances, reactions, and apparatus, described in language which is almost entirely free from mysticism and ambiguity."[24]

Not until 1937 did Julius Ruska, by then 70 years old and Director of the Research Center for the History of Natural Sciences in Berlin,[25] achieve his goal of publishing a complete translation of the *Kitāb al-Asrār*, based primarily on the Göttingen manuscript he had discovered, but also referring to three other Arabic manuscripts, including the one from Leipzig and photographic copies of manuscripts that Stapleton shared with him from Lucknow and the Escorial.[26] He did not use the two Medieval Latin translations, judging the Arabic manuscripts to be more accurate, and throughout his translation he carefully documented the occasional discrepancies between the four Arabic manuscripts. Ruska introduced his translation with information about the manuscripts themselves and detailed commentary on al-Rāzī's chemicals and equipment. A short preface to his article, published in the *Quellen und Studien zur Geschichte der Naturwissenschaften und der Medizin (Sources and Studies on the History of Natural Sciences and Medicine)*, celebrates Ruska's achievement: "The editor and publisher express heartfelt best wishes to the master of the history of alchemy, Julius Ruska, on his seventieth birthday, February 9, 1937, from Dr. Paul Diepgen and Dr. Ferdinand Springer."[27] Ruska's German translation provides a solid foundation for the English translation based on his expertise and his discovery of the Göttingen manuscript, which has the fullest text of the *Kitāb al-Asrār*.[28]

This book is not a history of alchemy. Its goal is to examine al-Rāzī's alchemy book in its role as a laboratory manual. The analysis focuses on the history and the content of the *Book of Secrets*. First I will present evidence of shared organizational patterns in alchemy manuals and the influence of the *Kitāb al-Asrār* in Europe through the early modern period, comparing it to European alchemic texts up to 1597, when the first edition of Libavius's *Alchemia* was published. In the second section I will analyze the

content of the *Kitāb al-Asrār*, focusing on the essential elements of laboratory procedures and the internal components that make them repeatable, comparing the *Book of Secrets* with texts from 1597 to the present. I use modern examples of laboratory testing in the areas of food, forensics, and diagnostic medicine, fields in which laboratory testing is relatively recent (twentieth century), but well-established and increasingly regulated. Three earlier European texts will represent the late sixteenth to the early nineteenth centuries: *Alchemia* (Frankfurt, 1597, 1606) by Andreas Libavius,[29] *Elementa Chemiae* (Leiden, 1732) by Herman Boerhaave,[30] and *Chemical Manipulation: Being Instructions to Students in Chemistry on the Methods of Performing Experiments of Demonstration or of Research, with Accuracy and Success* (London, 1827) by Michael Faraday.[31] All three authors actively carried out laboratory procedures themselves and, like al-Rāzī, they taught laboratory methodology on a practical level. Although these three laboratory manuals differ in style, they share many common elements of procedural content with the *Kitāb al-Asrār* and with each other. Like al-Rāzī, Libavius was educated in medicine and philosophy. His massive work, *Alchemia*, definitively expanded the processes of chemistry to include medicines, oils, and dyes along with the transmutation of metals, ensuring that the sphere of chemistry would outlive the demise of any one application. *Alchemia* originally written in Latin, is available today in two German translations. In 1964 several German chemical firms sponsored a German translation of Libavius's 1597 Latin text.[32] More recently, in 1996, Bettina Meitzner translated the section on equipment from Labavius's expanded 1606 edition from Latin into German for her doctorate at the University of Hamburg and published it in *Die Gerätschaft der chemischen Kunst.*[33]

Like Libavius and al-Rāzī, Dutch professor Boerhaave (1668-1738),[34] author of *Elementa Chemiae*, was both physician and educator. His lectures at the University of Leiden were so popular that his students had them printed without his authorization, and these were translated into English as *A New Method of Chemistry* in 1727.[35] His classifications and procedures strongly resemble those in the *Kitāb al-Asrār*. The third author, Michael Faraday, was one of the last self-educated chemists at a time when chemistry and medicine had become separate specialties. Like his predecessors, he enjoyed bringing the principles of chemistry to the next generation, and created a popular Christmas lecture series for young people, in which he

performed lively demonstrations to illustrate chemical and physical principles.[36] In contrast to al-Rāzī, Libavius, and Boerhaave, Faraday was neither physician nor professor, but a professional chemist able to support both himself and his wife with analytic laboratory work at the Royal Institute in London. He wrote *Chemical Manipulation* for the beginning chemist in 1827, as laboratory science approached the threshold of professionalism.

ALCHEMY AND CHEMISTRY

As the names of these three laboratory manuals suggest: *Alchemia* (1597), *Elementa Chemiae* (1732), and *Chemical Manipulation* (1827), a linguistic transition had begun to occur by the early eighteenth century. Because of this, the shifting usages of the words alchemy and chemistry may appear arbitrary or even capricious during this period. Until the sixteenth century, the word *alchemy* from the Arabic *al-kīmiyā* [37] was the only term for transformation of matter in the laboratory and it referred primarily to procedures for converting ordinary metals into noble ones, producing life-prolonging elixirs, and, by the end of the fifteenth century, mixing laboratory medicines. The word *chymistry* or *chemistry* and its Latin variations came into use around 1600, about the same time as the word *laboratory*, a time when the applications of alchemical methods and the literature describing it were expanding considerably.

Modern alchemy historians William Newman and Lawrence Principe, have proposed using the word *chymistry* in writing about laboratories of the early modern period in order to avoid the preconceived connotations that the words *alchemy* and *chemistry* carry today.[38] Although this convention works well when discussing early modern texts, when medieval texts are at issue, the word alchemy seems more appropriate because it was the only word the writers themselves used. For the sake of consistency, therefore, I will continue to use the words alchemy and chemistry, reflecting the usage of the authors as much as possible. It will be evident as the arguments unfold that, in the laboratory, I see them as two aspects of the same activities.

Authors used the two terms, alchemy and chemistry, with various spellings, interchangeably or with varying modes of differentiation until well into the eighteenth century. For example, in 1597, Libavius uses *Alchemia* for

his overall title, the heading *Alchemie* for the section on equipment and basic processes and the heading *Chymie* for the numerous applications of these basics, including, but certainly not limited to, the transmutation of metals.[39] Boerhaave, in 1727, traces the history of chemistry back to the metallurgy of the Egyptians and Greeks, then to the Arabs who "gave it the name of Alchemia or Alchemy."[40] He then includes both "the making of gold and finding the philosopher's stone" under alchemy, but subsumes the whole section within his "History of Chemistry."[41] Thus, in his university lectures, Boerhaave was teaching in terms of a chemistry with wider applications, in other words, chemistry as expanded by Libavius.

By the nineteenth century, the term *alchemy* had gone full circle, starting with the transmutation of metals, then encompassing a wider range of transformations, and finally retracting back to its original meaning, as chemistry became the broader term. By the nineteenth century alchemy had been excluded from the history of chemistry and dismissed into the realm of occult superstition.[42] Hence Faraday refers only to "chemistry." Alchemy was marginalized by chemists like Pierre Joseph Macquer (1718-84), who proclaimed the scientific advancements of a new age, while observing: ". . . however we cannot follow it further without having mentioned a singular obsession which attacked the heads of all the chemists . . . for which the cure, which only began to appear in the last century, was a real time of renewal of this science and of its progress toward perfection."[43] For the Enlightenment chemist, chemistry and alchemy no longer shared the same conceptual space.

Unlike chemistry, there is no earlier equivalent for the word *laboratory*. Does it even make sense to call the alchemical workspace a laboratory and speak of laboratory conditions, when the word did not come into use until nearly 1600? I take the position that it does. The laboratory existed as soon as curious individuals assembled equipment, apparatus, and chemicals into a dedicated space and labored mightily to test a theory. From the time of al-Rāzī through the Early Modern Period, many practiced alchemy, some to deceive, some in ignorance and vain hope, and yet still others who studied the difficulties and varied their approaches because they could see no reason why they could not transform matter, if the conditions were right. The more determined alchemists not only read books -- they wrote them. In recording their procedures, they framed reality as they saw it. In this respect, they were no different than later laboratory investigators.

British science historian David Gooding, who studies early modern chemists like Antoine Laurent de Lavoisier and Michael Faraday, points out, “Writing up is part of the discovery process,” in which selected observations are construed in a way that makes sense to the scientist.[44] A historian might recognize this concept.

Laboratories are a window into the larger society around them. They are not only economically dependent on outside support, but in gaining this support they have strongly influenced society’s views of disease, safety, quantitation, and the nature of knowledge. Laboratories both change and are changed by society’s prevailing values. In recent years, science historians, like Gooding, and social scientists, like Bruno Latour and Nicholas Jardine, have observed the mechanisms of these interactions, by examining how scientists assign significance to the phenomena they see, and how their interpretations can both reinforce and be reinforced by existing political, economic, and societal concerns.

Latour, for example, shows the mutual reinforcement forged between Pasteur’s investigation of the causes of disease and the social agenda of the hygienists in nineteenth-century France.[45] Gooding, observes how experimenters commonly blame unexpected results on flaws in their test system rather than in their theories.[46] Although both theorists studied early modern and modern chemists, the alchemy laboratory was no different. For example, to the alchemist, changes of color, malleability, or solubility were proof of a change in substance. Failure to get expected results indicated that something in the test methodology was not right -- perhaps the intensity of heat in the furnace or the number of sublimations. Alchemy was practiced in laboratories of varying means, results, and intentions, but through the persistence of the more resolute alchemists, the laboratory became a place for testing and the possibilities of this space expanded. Science historian Owen Hannaway, speaking of the laboratory Libavius describes in *Alchemia*, maintains that “the appearance of the laboratory is indicative of a new mode of scientific inquiry.”[47] Yet I maintain that when Libavius called his workspace a *laboratorium*, he was not founding a new entity, but christening one that had already existed from the time of the *Kitāb al-Asrār*.

Both Ruska and Stapleton, who worked closely, with the *Kitāb al-Asrār* maintained that it represented a break with its alchemic precedents. In his extensive commentary accompanying his 1937 translation *Al-Rāzī’s Buch: Geheimnis der Geheimnisse* (*Al-Rāzī’s Book: Secret of Secrets*), Ruska

states: “In any case, the credit goes to al-Rāzī for bringing alchemy to a strictly scientific format for the first time.”[48] Henry E. Stapleton was aware that Ruska’s translation was forthcoming when he postulated in his 1927 *Chemistry in Iraq and Persia in the Tenth Century A.D.* that: “in 900 A.D. such a degree of exact knowledge of chemical substances and apparatus was displayed that historians may henceforward be justified in antedating the birth of Scientific Chemistry by—in all probability—at least 900 years.”[49] Consequently, mid-twentieth-century writers such as E. J. Holmyard, author of *Alchemy* in 1957, and Robert P. Multhauf, who wrote *The Origins of Chemistry* in 1966,[50] took note of al-Rāzī’s systematic methodology and his classification of chemical substances. “Razi,” states Holmyard, “in fact brought about a revolution in alchemy by reversing the relative importance of experiment and speculation.”[51]

More recent historians have referred to the *Kitāb al-Asrār* briefly as “influential”[52] or “a straight-forward manual of chemical practice.”[53] Not only are the modern references to al-Rāzī more cursory than in years past, but ever since Holmyard, authors have based their appraisals directly or indirectly on Ruska and Stapleton rather than bringing their own perspectives to bear on the significance of his work. The result is that, in spite of a general consensus that al-Rāzī’s work was ground-breaking, his work has not been analyzed in English for eighty years, nor, to my knowledge, has it been systematically compared to later works on laboratory practice. It is time to take a fresh look at the *Kitāb al-Asrār* (figure 1).

Figure 1. Book in the right hand, flask in the left, the master views his results. *The Alchemist*, Mattheus van Helmont, 17th century. (Courtesy of the Chemical Heritage Foundation Collections, Photo by Will Brown, 00.01.277).

THE *KITĀB AL-ASRĀR* IN HISTORY

THE DURABILITY OF THE PRACTICAL LABORATORY MANUAL

What does it mean when a modern chemistry historian, such as Richard Morris in *The Last Sorcerers*, notes that the *Kitāb al-Asrār* is "a comprehensive and practical laboratory manual?"[54] The modern laboratory, inextricably integrated into today's economy, is an expensive space that uses specialized equipment for repetitive testing. Whether its purpose is testing antibiotics or the safety of new food additives, mistakes can be costly and randomness has no place. The written manual of today addresses equipment, materials, safety, quality, and testing processes, in conformance with a structural framework defined by the institution and subject to regulatory oversight. The *Kitāb al-Asrār* is suggestive of a modern manual because it provides exactly what is needed in a manner free from theory, speculation, and digression. When al-Rāzī wrote the *Kitāb al-Asrār*, his goal was to extract the essentials from his prior works and compile "one compact concise book on this subject."[55] He produced a practical manual with a systematic structure, interrelated procedures, and specific instructions.

The *Kitāb al-Asrār* follows an overall organizational plan with an introduction, list of materials, equipment, and procedures. The user can see at once how to select chemicals, instruments, ovens, and containers without having to look at each procedure, interpret allegory, or wade through pages of theory. The book has no conclusion, consistent with modern manuals, which may begin formally with a statement of purpose, but end abruptly with the last procedure. Al-Rāzī does however clearly label the last chapter, which in the days of manuscripts indicated to the reader that he had the complete document at hand.[56] With this assurance and the necessary materials, the

user was ready to continue to the procedures, which constitute the main body of the book.

Table 1 shows that the 389 procedures in the *Kitāb al-Asrār* can be divided into four basic types: primary, intermediate, reagent, and preparation methods. The 175 procedures termed primary are procedures that directly produce an agent that changes metals into gold or silver. They are supported by 127 preparatory procedures (softening, calcination), which in turn refer to 51 reagent preparations (solvents, tinctures), and 36 instructions for commonly needed processes such as mixing or dissolving. The arrangement of these procedures in the *Kitāb al-Asrār* follows a systematic pattern. Al-Rāzī groups the procedures in each section first by type of process (sublimation, calcination, softening), then by substance (mercury, sulfur, metals, stones), and finally he arranges the procedures sequentially in the order needed. He uses cross-referencing to avoid repetition.

Table 1. A Classification of the Procedures in the *Kitāb al-Asrār*.

Type of Procedure	Purpose	Count	Percent	Example
Primary	Produces a substance that transforms metals into gold or silver	175	45	Sublimation of Mercury
Intermediate	Prepares materials required for primary procedures	127	33	Calcination of Silver through Burning
Reagent	Produces a chemical used in other procedures	51	13	Liquids that dissolve or color
Preparation	Instructions for a method used in other procedures	36	9	Mixing through pulverizing and roasting
Total		389	100 %	

The procedures in the *Book of Secrets* can be divided in four types, each dependent upon the others. The use of separate instructions for reagents and preparation processes makes the book as a whole more efficient by avoiding repetition.

For example, the instructions for calcination of tin require the addition of the sublimated quicksilver already prepared in a prior procedure, so the sublimation procedure is not repeated. However, the last step of the tin procedure requires a reagent, “crushing water,” a strong solvent that must be prepared separately. This step refers the user to the chapter on dissolving, where the information for making that solvent is found.[57] Al-Rāzī usually provides the procedures in the order they are performed, but uses cross-referencing when a laboratory manual has a number of procedures that share some of the same preparation methods or reagents. Cross-referencing also anticipates the user’s need for more information, especially when reagents such as “crushing water” (a strong solvent) are mentioned for the first time. These internal citations show that al-Rāzī designed the manual as an integrated whole and was familiar enough with the processes to anticipate what the person performing them might need to know.

Not only are the procedures arranged logically in respect to one another, but each procedure also contains the specific information required to perform it. For example, the procedure for the sublimation of quicksilver specifies the required materials, the quantities, their preparation, containers, ovens, timing, and tests for the desired endpoint. Details such as instructions to allow the hot container to cool before collecting the residue on the sides protect the worker as well as facilitate a larger yield of the final product. In order for any laboratory procedure to be repeatable and to avoid waste, the practitioner should not have to guess the amounts, the timing, or whether the process is complete. Alchemic procedures in other texts are often vague, but al-Rāzī’s manual anticipates the user’s need for specific information.

The overall arrangement of the *Kitāb al-Asrār* into introduction, materials, equipment, and procedures sounds obvious, even intuitive. Yet there were alternatives. During the Middle Ages in Europe a variety of alchemical texts proliferated with a multitude of styles. Over the centuries, however, the simple functional approach never entirely disappeared. Al-Rāzī’s laboratory manual was designed to last, supported by the enduring name recognition of its author.

ABŪ BAKR MUHAMMAD IBN ZAKARĪYĀ AL-RĀZĪ: ALSO KNOWN AS RHAZES

Al-Rāzī ’s name reflects his birthplace. He was born around 865 C.E.[58] in the Persian city of Ray, a prosperous commercial center in the foothills of the Elburz Mountains, not far from Tehran, which was then just a village. Situated on a fertile strip of land flanked by desert and mountains, Ray served as a natural port of call on the ancient Silk Road between Baghdad and Samarkand, tempting merchants and travelers with fine textiles, ceramics, and fresh spring water (Figure 2).[59] Its strategic location provided a thoroughfare for conquerors from Alexander to the Mongols. Even during al-Rāzī’s lifetime Ray was contested territory between the caliphs of Baghdad to the west

Figure 2. The abundant spring water at Ray made it a destination on the Silk Road. Here workers wash Persian carpets in a spring near Ray called Cheshmeh Ali. Photo by Harry Marlow, 1955.

and the Samanid rulers of Transoxiana to the east.[60] It is not hard to imagine Al-Rāzī searching through Ray's eight bazaars[61] for talc and alum from Yemen, red vitriol from Cyprus, salmiac from Khorasan and Samarkand, and other chemicals from the distant places he names in the *Kitāb al-Asrār*.[62]

Although historians of the Islamic world discussed al-Rāzī's ideas and listed his works over the next three hundred years, personal details about his life are scarce and those that exist may not be accurate by historical standards today. What we have are anecdotes that portray an intelligent and appealing human being consistent with Al-Rāzī the kindly teacher we see in the *Kitāb al-Asrār*. Historian and philosopher Sa'id al-Andalusi (1029-1070) of Toledo, Spain, writes that al-Rāzī first studied music, and then philosophy and theology, before he turned to the study of medicine.[63] Although he was nearly thirty when he began his medical career, he studied, taught, and practiced medicine with great dedication and enthusiasm, building a distinguished reputation that lasted far beyond his own lifetime. He served as medical director of the hospital in Ray and later in the Abassid capital of Baghdad, returning home to Ray a few years before his death.[64]

In historical accounts written after his death, al-Rāzī comes across as compassionate and industrious, the inspiration of colorful stories that illustrate his qualities as an academic, teacher, physician, and indefatigable writer. The Persian scholar Al-Biruni (973-1048) records, "He was always studying and had a great number of students. He took care to place his lamp in a niche in the wall and stood facing it, propping his book against the wall, so that if sleep came over him, it would fall out of his hands and awaken him, so that he picked up where he had left off."[65] The *Fihrist* of Al-Nadim, written about sixty years after al-Rāzī 's death in 987 C.E., describes an elderly man from Ray who remembered how al-Rāzī taught clinical medicine by referring a patient's symptoms first to his younger students, and then, if they could not arrive at a diagnosis, turning next to the intermediate students and finally to the most experienced students. Only after hearing the advanced students' best efforts would al-Rāzī himself discuss the case.

The dedicated teacher was also known as a caring doctor: "He was so kindly compassionate with the poor and the sick," the man from Ray continued, "that he used to bring them substantial rations and provide nursing for them." Yet most of all, al-Nadim's observer emphasized, al-Rāzī was

always writing: “I never went in to him without seeing him transcribing, whether it was to make a rough draft or a revised copy.”[66] Al-Rāzī himself proudly confirmed this: “In a single year I have written as many as 20,000 pages in a script as minute as that used in amulets.”[67]

Book inventories from early historians support this claim. The *Fihrist of al-Nadīm* catalogs 154 of al-Rāzī’s works, Arab historian Ibn al-Qiftī lists133 titles, and Ibn Abī Usaib’a, a physician and historian, records 225 titles. The Persian scholar al-Bīrūnī names 184 works by al-Rāzī, including 89 on medicine, 21 on alchemy, and 74 on astronomy, philosophy, and other sciences.[68] One reason for the discrepancy in numbers may lie in the wide range of al-Rāzī’s writings, which vary from multi-volume compendiums of medical knowledge like the ten-volume *al-Mansūrī* and the twenty-four volume *al-Hāwī* (*Continens*) to short monographs such as *Smallpox and Measles* or *Stones in the Kidney and Bladder*, and pointed opinion pieces: “Doubts concerning Galen,” “Refutation of al-Jāhiz concerning the deficiency of medicine,” and “Refutation of al-Kindī about his refutation of the Art [of alchemy].”[69]

As these titles indicate, al-Rāzī did not hesitate to challenge accepted philosophical and medical opinions, whether of his contemporaries or revered authorities of the past, including the Greek philosopher Aristotle (384-322 B.C.E.) and the renowned physician of the Roman world, Galen (129-217 C.E.), whose books later stood with those of al-Rāzī in the medical libraries of European universities. Even in the introduction to the *Kitāb al-Asrār* he notes that he still needs to finish rebuttals to two other scholars, Muhammad ibn al-Sinnī al-Rasā ilī and al-Kindi (d. 873), an opponent of alchemy. [70] Not surprisingly, al-Rāzī ’s strong opinions brought criticism. Sa’id al-Andalusi, an eleventh-century philosopher from Spain, took offense at al-Rāzī ’s disagreements with Aristotle, claiming that al-Rāzī rashly argued with philosophers beyond his understanding: “He squelched scholars whose ideas he was not able to apprehend and whose ways he was not able to see.”[71] Al-Biruni disparaged al-Rhazi’s fascination with alchemy, saying: “I do not hold him to be a deceiver, but rather one who is deceived, who allowed himself to be convinced.”[72] Yet the same historians in the Islamic world held him in high esteem, particularly as a gifted physician and clinician. Al-Andalusi calls al-Rāzī: “the unparalleled physician of the Muslims, and one of the ablest in the science of logic, geometry, and other

branches of philosophy."[73]

Although many of al-Rāzī's books were lost in the centuries following his death, his most important medical books were preserved even through the Mongol destruction of Ray in 1220. His two most translated books include *Smallpox and Measles*, the first book to differentiate the diagnosis of smallpox from other type of skin rashes, and the ninth volume of the *al-Mansūrī*, a practical medical guide. He would have been gratified to know that, through the efforts of his students, his unfinished encyclopedic work, the twenty-five-volume *al-Hawi* was published after his death.[74] For this compendium, he had spent years of his life collecting Greek, Syriac, Hindu, and Persian medical texts, organizing them by subject, and adding his own commentary and case histories.[75] Because he documented his sources, the *al-Hawi* preserves parts of older medical texts which would have otherwise been lost, such as the writings of the distinguished eighth-century physician, Jurjis ibn Bakhtishu, from the Persian medical center Jundishapur, whose family served the Caliph in Baghdad for generations.[76] We owe the story of how the al-Hawi was saved to a descendent of the Bakhtishu family. Soon after al-Rāzī's death, scholar Ibn al-Amid purchased the notes and manuscripts for the *al-Hawi* from al-Rāzī 's sister in Ray and arranged for some of al-Rāzī 's former students to complete the book.[77] Representing al-Rāzī's most influential medical and alchemical works, the *al-Hawi* and the *Kitāb al-Asrār* not only survived, but were widely distributed in Europe through the sixteenth century under his Latinized name, Rhazes.[78]

Physicians became familiar with the writings of Rhazes in European universities where Latin translations of two works became standard texts: the ninth volume of the *Kitāb al-Manşūrī*, called *Nonus Almansoris*, and the *al-Hāwī*, Latinized as the *Continens*, which entered the University of Paris medical library as early as 1395.[79] Medical historian Donald Campbell lists Latin publications of *Continens* in 1486, 1500, 1506, 1509, and 1542.[80] The *Nonus Almansoris*, first published in Milan in 1481 and many times thereafter, was included in the medical curriculum of the new German University of Tübingen in the same year, the medical school in Vienna in 1520, and was still required at the University of Frankfurt (Oder) after 1588.[81] Medical writers frequently quoted this work. For example, the *Dispensatorium Medicum*, a book of medicines translated from Italian into German in 1606, gives an eye treatment and then states: "The place that

Rhases describes this is the Chapter on Boils of the Eyes in the Ninth Book of the Almonsorem."[82] Medical schools in Holland continued to require al-Rāzī's medical books into the seventeenth century.[83] Alchemy was not a university subject, but the wide distribution of Rhazes' medical works may have contributed to his reputation as an alchemist, especially since many European alchemists were themselves university-educated physicians and clerics.

From the first Latin translations of his books in the twelfth century until the seventeenth century, however, most scholars either knew Rhazes either as a physician or as an alchemist. Modern historians have also viewed his works in separate categories. In the tenth-century, al-Nadīm places al-Rāzī's medical works in one section of *The Fihrist* and his alchemical works in another, as does science historian George Sarton in his 1927 *Introduction to the History of Science*.[84] Medical historian Donald Campbell looks at al-Rāzī 's medical works, whereas science historian E. J. Holmyard analyzes his systematic chemistry.[85] Yet when one surveys al-Rāzī's body of work as a whole, the clear, organized methodology of the *Kitāb al-Asrār* is no longer an anomaly among alchemic texts, but the natural outcome of an analytic mind. As medical director in Baghdad, relates science historian Yvon Houdas, "he was equally an organizer . . . organizing external consultations, home health care, and medical assistance for the needy."[86] His medical works refer not only to clinical treatment but also to chemical methods and mixtures. Chapters from the *Continens* include divisions on "the potentialities of drugs and nutriments," "compounded drugs," and "weights and measures," showing that al-Rāzī applied chemical ingredients and processes to medicine.[87] It is possible that this area of al-Rāzī's work influenced later European physicians whose writings incorporated both alchemy and laboratory pharmaceuticals, such as Paracelsus (1493-1541) and Andreas Libavius (c. 1555-1616).[88]

The name Rhazes appeared not only in the confines of university libraries but occurred regularly in lists of famous classical physicians found in popular culture. *The Romance of the Rose*, a thirteenth-century poem by Guillaume de Lorris and Jean de Meun, enjoyed in both France and England for 300 years, includes Rhazes among medical authorities: "And we have not seen any of the physicians themselves escape from her [Death], not Hippocrates or Galen, no matter how good physicians they were. Rhases, Constantine, and Avicenna have left her their skins."[89] The fourteenth-

century English poet Geoffrey Chaucer attested to the learning of the physician in *The Canterbury Tales*, when he wrote, “Wel knew he th’olde Esculapius, And Deiscorides and eek Rufus, Old Ypocras, and Haly, and Galien; Serapion, Razes, and Avicen . . .”[90] Two Islamic physicians, Rhazes and Geber (Jabir’s Europeanized name) join Aristotle, Dioscorides, Galen, Hippocrates, Hermes, Ramon Lull, Vesalius, and Paracelsus in a stone frieze of ten renowned medical authorities commissioned in 1612 to adorn the first pharmacy in the German county of Lippe (Figure 3).[91] This carving features the portraits of medical authorities like Galen and Hippocrates with alchemical figures such as the semi-legendary Egyptian Hermes and Ramon Lull, a thirteenth-century Catalan monk. Most appropriately for a pharmacy, a place where medicines are mixed, Rhazes and Paracelsus represent the close relationship of medicine and chemistry. Throughout late medieval and early modern Europe, al-Rāzī was publicly associated with well-known figures of medicine and science.

Figure 3. This stone frieze in the German city of Lemgo, commissioned in 1612, shows Rhases holding an open book next to Galen and Hippocrates as part of a group of ten medical authorities. Photo by author, 2012.

Not only physicians but also European alchemists knew Al-Rāzī as Rhazes, and many used his name to give authority to their works either in connection with specific procedures or as one of a list of established authorities. Abufalah, an eleventh-century alchemist from Sicily whose procedures are reminiscent of the *Kitāb al-Asrār*, starts one process with: "A distinguished combinatory operation, tested by Rusis . . ." [92] Similarly, the *Libellus de Alchemia*, ascribed to Albertus Magnus (c. 1193-1280), begins a procedure, "A better way to sublime mercury is given by Rhases . . ."[93] "Rhasis, in his *Seventy Precepts*, affirms that mercury is the root of all things," states Petrus Bonus, who cites al-Rāzī by name at least thirteen times in *The New Pearl of Great Price*, written around 1330.[94] Al-Rāzī is quoted as a source of sound advice in the *Speculum Alchymiae: The True Glass of Alchemy*, attributed to Roger Bacon (c. 1220-1292) and in *Écrits Alchemiques*, the chronicle of Nicolas Flamel's fifteenth-century quest for the philosopher's stone.[95] Alchemists tend to associate Rhazes with alchemists of the past, rather than with physicians. For example, Thomas Norton (c.1433-c. 1513), in *The Ordinall of Alchemy*, portrays al-Rāzī conferring with Geber, Arnold of Villanova, and Hermes.[96] These authors had no way of knowing whether al-Rāzī actually wrote all the texts attributed to him. Alchemists frequently ascribed their texts to a well-known author or incorporated another author's words into their own works. However, their frequent references to al-Rāzī show that alchemists throughout the Middle Ages valued his name as an affirmation of their work and recognized him as an authority in their field. Yet this claim brings up the question of how much access they had to the *Kitāb al-Asrār* and what made it stand out from other alchemical works.

THE *KITĀB AL-ASRĀR*: THE SECRET IS OUT

Many European alchemists accessed the *Kitāb al-Asrār* through one of its Latin translations, the *Liber Ebu bacchar et Raisy* and the *Liber Secretorum de voce Bubacaris*, now housed in the Paris National Library in a collection of thirteenth- to fourteenth-century manuscripts.[97] British archivist Dorothea Singer refers to copies of the *Liber Secretorum* at Oxford in the fourteenth century and at Cambridge in the fifteenth century.[98] Historian

Raphael Patai, noting the popularity of al-Rāzī's work among Jewish alchemists, describes a partial Hebrew translation in "a Yemenite Judeo-Arabic manuscript" now in Jerusalem as well as in Book Thirteen of the Gaster Manuscript, "a major seventeenth-century Hebrew alchemical manuscript."[99] Julius Ruska based his German translation of the *Kitāb al-Asrār* primarily on an Arabic manuscript from North Africa dated 1561. In his commentary and translation he also referred to less complete Arabic manuscripts in Leipzig (Germany), the Escorial (Spain), and Lucknow (India).[100]

Although only a handful of copies now survive, the fact that this tenth-century book was repeatedly transcribed, translated, and archived at different times, on three continents, and in at least three languages demonstrates that it attracted readers in a variety of cultures and attests to its importance (Table 2). Ruska points out:

If we remind ourselves that Rāzī's work was copied over and over again for centuries by experts and non-experts and that the four or five manuscripts that we have now are only the last remnants of written documents that once extended from Morocco to India, then we will be less surprised at the gaps and deviations than we are at the large degree of correspondence between the texts.[101]

Table 2: Known Manuscripts of the *Kitāb al-Asrār*

Location	Language	Approximate Date	Comments
Calcutta	Arabic	Unknown	Not in good shape per Stapleton.
Lucknow	Arabic	Unknown	Incomplete.
Escorial	Arabic	15th century?	Incomplete. Catalogued MS 700,1884.
Leipzig	Arabic	Unknown	Incomplete. Acquired 1710.
Göttingen	Arabic	1561	Acquired 1878 from the Coptic monastery Amba Buscâi in Libya.[102] The basis for Ruska's translation.
Paris	Latin	13th-14th century	*Liber Ebu bacchar er Rasy*. Included in the Manuscript of Palermo, early 14th century[103]
Paris	Latin	13th-14th century	*Liber Secretorum de voce Bubacaris*. Translator unknown[104]
Oxford	Latin	14th century	*Liber Secretorum de voce Bubacaris*

Cambridge	Latin	15th century	*Liber Secretorum de voce Bubacaris*[105]
Jerusalem	Hebrew	Unknown	Incomplete Yemenite Judeo-Arabic manuscript[106]

In addition to translations and transcriptions shown in Table 2, the content of the *Kitāb al-Asrār* spread throughout Europe unrecognized at the hands of authors who incorporated parts of it into their own works. Two of the most widely-read alchemical texts in the Middle Ages owe much to the *Kitāb al-Asrār*. They are the twelfth-century chemical treatise *De Aluminibus et Salibus* (*Of Alums and Salts*) attributed to al-Rāzī and the longer, more theoretical thirteenth-century *Summa Perfectionis* attributed to Geber, the Latinized name for the alchemist Jabir of eighth-century Baghdad. These texts are examples of pseudepigraphia, the practice, not uncommon among medieval alchemic writers, of attributing their text to an author with an established reputation. While the *Kitāb al-Asrār* was so widely distributed in Arabic that there are multiple manuscripts still in existence, there is no known Arabic manuscript of the *Summa Perfectionis*, and only one Arabic manuscript of *De Aluminibus et Salibus*, which originated in Andalusia.[107]

Ruska surmised that this Arabic original of the *De Aluminibus et Salibus* was written by an alchemist in Spain in the eleventh or twelfth century. It soon became available to European alchemists through the Latin translation of Gerard of Cremona (d. 1187).[108] Two prominent early alchemists, Dominican encyclopedist Vincent de Beauvais (c. 1190-c. 1264) and Franciscan scholar Roger Bacon (c. 1214-92), both clerics, cited it in their work. Historian Robert Steele, who published the Latin text in 1927, states, “It purports to be, and no doubt is in substance, the work of . . . al-Rāzī.”[109] Both Ruska and historian Robert Multhauf describe the influence of the *Kitāb al-Asrār* on *De Aluminibus et Salibus* which shares its concise matter-of-fact style.[110] The facts that *De Aluminibus et Salibus* bore al-Rāzī’s name, had content similar to the *Kitāb al-Asrār*, and was influential in the thirteenth century give this work, at the very least, a compelling role in the spread of al-Rāzī’s reputation and style. The *Summa Perfectionis* represents an even stronger example.

Written in the late thirteenth century, The *Summa Perfectionis* of Pseudo-Geber influenced some of the most important alchemy texts of its time. Like *De Aluminibus et Salibus*, the name of the author associated with it was misleading. The author of the *Summa* originally attributed it to the eighth-century Islamic alchemist Jabir, westernized “Geber,” but, unlike *De Aluminibus et Salibus*, scholars failed to find an Arabic text and began to suspect that no such document existed.[111] In a 1935 article, Ruska, after a

textual comparison, suggested that an unknown European author wrote both the *Summa Perfectionis* and the *Liber Secretorum de voce Bubacaris*, a Latin version of the *Kitāb al-Asrār*, but that only a "patient investigation of the sources" would prove or disprove it.[112] Half a century later, historian William Newman identified this unknown European author as Paul of Taranto, a teacher and alchemist of the late thirteenth-century.[113] Newman documents the descent of the *Summa* from the *Kitāb al-Asrār*, in *The "Summa Perfectionis" of Pseudo-Geber: A Critical Translation and Study*.[114] *The Summa Perfectionis* had an enormous influence on major fourteenth-century alchemical works, including *Rosarium* attributed to Arnauld of Villanova, *Libellus de Alchemia* attributed to Albertus Magnus, *The New Pearl of Great Price* by Petrus Bonus, and *The Testamentum* attributed to Ramon Lull.[115] While the *Kitāb al-Asrār* was not the only source that influenced the *Summa* and its alchemical descendents, it shares distinguished connections.[116] All of these complexities highlight the unusual opportunities presented by the text of the *Kitāb al-Asrār*, a complete Arabic manuscript of a tenth-century alchemic text with well-documented authorship. Regardless of how they encountered the *Kitāb al-Asrār*, it had a wide appeal to alchemic writers who copied it, translated it, reworked it, and, knowingly or unknowingly, incorporated parts of it into their writings.

A large part of the attraction of al-Rāzī's alchemy handbook must have been in its practical value as an instruction manual. Not every alchemy book included straightforward instructions. One which did was written by Abufalah, an eleventh-century Islamic alchemist in Sicily, whose text, according to historian Raphael Patai, was partially incorporated into the thirteenth-century work *The Gate of Heaven* by Gershon ben Shlomo of Arles.[117] Abufalah's procedure to convert copper into silver reads: "Take of good green arsenic one weight, and grind it well with strong and good vinegar many times, and sublimate it until all of it becomes white . . ."[118] This is comparable in style to a procedure from al-Rāzī's book which reads: "Take whichever of the two you will [sulfur or arsenic], then grind it with wine vinegar which contains a fourth of qali salt, and roast it one night over a gentle fire for sulfur or a medium fire for arsenic. . ."[119] The *Summa Perfectionis*, begins an explanation of the sublimation[120] of mercury like this: "But now we will determine the entire goal of quicksilver's sublimation. The complete totality of that is the cleansing of its earthiness

and removal of its wateriness."[121] Similarly, the *Kitāb al-Asrār* states: "Concerning the sublimation of mercury, there are two methods . . . One takes place on removing its moisture (wateriness), the other serves to generate its dryness, so that it becomes completely dry."[122] Today this kind of step-by-step instruction seems unremarkable. However, many alchemical texts take a very different approach.

Consider how the flamboyant physician and alchemist Paracelsus (1493-1541) uses a descriptive non-quantitative style to describe the preparation of mercury:

The mortification of Mercury, in order that it may be sublimated, is brought about by vitriol and salt. When it is mixed with these two and then sublimated it becomes as hard as crystal and as white as snow. In order that Mercury may be reduced to a precipitate, nothing more need be done than calcine it in the best aqua fortis; then let the granulated aqua fortis be extracted from it five times, more or less, until the precipitate acquires a beautiful red colour.[123]

Some alchemists expressed their mysteries in poetry. The *Compound of Alchemy* written by George Ripley in 1470-71 incorporates religious symbolism into the purification process:

But when these to Sublymacyon continuall

Be laboryd so, wyth hete both moyst and temperate,

That all is Whyte and purely made spirituall;

Than Hevyn uppon Erth must be reiterate,

Unto the Sowle wyth the Body be reincorporate:

That Erth becom all that afore was Hevyn,

Whych wyll be done in Sublymacyons sevyn.[124]

Petrus Bonus, in *The New Pearl of Great Price* (c. 1330) even gives al-Rāzī credit for an allegorical procedure: "The red slave, says Rhasis, has wedded a white spouse."[125] In alchemical literature, red represents sulfur, a masculine element, sometimes portrayed as a red king, which imparts its properties to mercury, the white queen.[126] The *Kitāb al-Asrār*, on the other hand, is all business:

You take one ratl of mercury that has been solidified by covering it with sulfur (for redness) and an equal amount of vitriol, and half as much yellow sulfur as vitriol, grind it with the best wine vinegar a good hour, cast as much roasted salt equal to the vitriol on it and, after its moisture is driven away, let it rise seven times.[127]

That is the voice of a laboratory manual.

In 1597 German educator and physician Andreas Libavius, published a very different scholarly laboratory text, *Alchemia*, in which he compiled a wide variety of alchemic processes accompanied by descriptions of equipment and discourses on theory.[128] In the first few pages, he lists al-Rāzī among his many sources, possibly one of the last chemists to do so.[129] *Alchemia* contrasts with the *Kitāb al-Asrār* in many ways. It is long, pedagogic, and its encyclopedic collection of procedures ranges from transmuting metals and brewing honey-wine to distilling a medicinal oil from forty frogs.[130] Yet the two books share a fundamental structure. In his book *Chemists and the Word: The Didactic Origins of Chemistry*, historian Owen Hannaway gives Libavius credit for developing the characteristic structure of the chemistry textbooks that followed: "But all have a common form of organization: the definition of the art, a description of its instruments, a discussion of operations, followed by preparations – that is, the basic structure of *Alchemia*."[131] He is absolutely right. However, this structure goes back to 920 C.E. It is the structure of the *Kitāb al-Asrār*.

Hands-on alchemy was a book-based endeavor. Al-Rāzī's *Kitāb al-Asrār*, the *Book of Secrets*, introduced a systematic structure that endured through the centuries of alchemy into the seventeenth century. Patterns and pieces of this structure can be traced from the eleventh-century alchemical text of Abufalah through the fourteenth-century *New Pearl of Great Price* by Petrus Bonus to Libavius' *Alchemia* at the dawn of the seventeenth century. Although the *Kitāb al-Asrār* has often been praised by historians for its logical classifications and organization, its scope of influence extended even further, to the formation of a distinct style of laboratory writing and the concept of the laboratory itself.

The historical evidence for this contention encompasses the structure of the *Kitāb al-Asrār*, al-Rāzī's distinguished reputation, the wide distribution of the *Kitāb al-Asrār*, and the extent of its influence on other widely read alchemic texts. The *Kitāb al-Asrār* shared a fundamental structure with *Alchemia*, the first comprehensive chemistry manual of the early seventeenth century. *Alchemia*, however, expanded the applications of chemistry, conceptualizing a discipline that studies the interaction of matter in all its states and applies this knowledge to medicine, metallurgy, dyes, fermentation, and other activities that require altering, isolating, combining, or purifying substances, much the way we think of chemistry today. The

many chemistry books that followed incorporated this wider range of applications. From a historical perspective, the *Kitāb al-Asrār* had an enduring presence throughout the Middle Ages and then retired to the manuscript libraries. Its scope was limited, its goals outdated. Yet its content has a characteristic style that makes it read like a laboratory manual even today.

INSIDE THE KITĀB AL-ASRĀR

THE LABORATORY'S ROLE IN TRANSITION

By the end of the seventeenth century chemists ceased to cite al-Rāzī as an authority. Though they wrote an increasing number of books, they no longer emulated the *Kitāb al-Asrār*. Despite this the *Kitāb al-Asrār* shares a strong conceptual continuity with both early modern and modern laboratory methodology through shared tactics for achieving reproducibility. Repeatable results were required in order for the laboratory to achieve credibility beyond its inner world, and al-Rāzī, like later chemists, embedded successful strategies for reproducibility into the procedures of the *Kitāb al-Asrār*. A modern definition of a testing laboratory reads: "An organization that measures, examines, tests, calibrates or otherwise determines the characteristics or performance of products, materials, equipment, organisms or physical phenomena."[132] Is there a connection between the legions of testing laboratories in existence today and the confined inner world of the *Kitāb al-Asrār*? I argue that what links these laboratory environments is their ability to impose a controlled template upon the vagaries of nature in order to produce repeatable and credible results.

The laboratory as a controlled testing space expanded in numbers, prestige, and power, actively seeking and engaging outside-world connections with universities, industries, and governments. In "Give Me a Laboratory and I will Raise the World," social scientist Bruno Latour recreates how nineteenth-century chemist Louis Pasteur leveraged the invisible microbes grown in his laboratory into a force that transformed society:

The influence of the Pasteurian laboratories reached further, deeper, and more irreversibly since they could intervene in the daily details of life – spitting, boiling milk, washing hands – and at the macroscale – rebuilding sewage systems, colonizing countries, rebuilding hospitals – without ever being seen as a stated political power.[133]

Today laboratories test everything from drinking water to concrete. Every labeled item in the marketplace provides test results. The retail store Crate & Barrel maintains laboratories throughout the world testing dishes for lead content before importing.[134] In an article concerned about the consequences of increased DNA testing, the *New York Times* states: "Genetic information is slipping out of the laboratory and into everyday life."[135] The *Knight Ridder Tribune Business News* reports that laboratory testing of tissue samples has a current national growth rate of 10 to 12 percent.[136] We are a testing society.

SINE QUA NON: THE HIDDEN ASSUMPTIONS

Laboratory manuals depend on certain underlying principles. A full description of every step of every procedure would overwhelm the worker with gratuitous information and interfere with the simplicity that reproducibility demands. These requirements remain unstated just as a road map ignores the physical composition of streets and bridges. Five fundamental assumptions provide a shared, though implicit, infrastructure for the working laboratory: literacy, technical knowledge, space, financing, and reproducibility. The *Kitāb al-Asrār* incorporates these principles.

The first assumption of a laboratory manual is literacy. Al-Rāzī states in his brief introduction that a dedicated student asked him to record his

procedures, “that would be a guide that he could follow,” resulting in a systematic set of standard operating procedures excerpted from al-Rāzī’s other books on the subject.[137] It is difficult to imagine carrying out these complex procedures without a written guide, which may explain why alchemic procedures were translated into vernacular language relatively early. Michaela Pereira, a professor at the University of Siena, describes an alchemical manuscript translated from Latin into Catalan before 1350, alchemy texts in Dutch in the fourteenth century and in German in the 1420s. She found that most of the fifteenth-century manuscripts she studied used Latin for the text discussions and “various vernaculars for the recipes.”[138] This indicates that the actual procedures were read and used by the people in the laboratory, whereas abstract theory remained an academic interest. Literacy, not Latin, was a prerequisite in the laboratory.

Literacy alone, however, is not enough unless the reader possesses the second requirement, the theoretical and technical knowledge needed to follow the procedures. The manual is more concerned with *what* than with *how* or *why*. As a result, the manual reads as though it were outside of contemporary paradigms, because, unlike textbooks, it does not attempt to explain the history behind the discipline or the mechanism behind the reaction. If it is true, as Thomas Kuhn states, that textbooks reinforce current paradigms, by “a persistent tendency to make the history of science look linear or cumulative,” then the singular timelessness of laboratory procedures becomes comprehensible, because they are a terse series of instructions devoid of history and unconcerned with theory. [139]

In 1919, the Office of the Surgeon-General of the United States War Department expressed this succinctly in a small handbook of laboratory procedures for use on the battlefront. Unrelentingly practical, it begins with how to collect sputum samples and ends with instructions for testing drinking water. The first words are: “This manual is in no sense a text-book. It is a collection of formulae and technical methods. . .”[140] This is a perfect description of the *Kitāb al-Asrār* and indeed of laboratory manuals in general.

What is left out of a procedure is as important as what is included. A recent guide to Good Laboratory Practice regulations (the regulations on which the Food and Drug Administration laboratory oversight is based) points out: “An analytic procedure to be carried out by a trained chemist would instruct the chemist to pipette 5 ml of a reagent, but need not provide

the detail of how to pipette."[141] Similarly, the *Kitāb al-Asrār* assumes that the user understands how to handle and store various chemicals and how to work with weights, measures, proportions, degrees of heat, and timed intervals. Consider the techniques that this procedure for the sublimation of arsenic sulfide and sulfur takes for granted:[142]

Take one ratl from either of the two [sulfur or arsenic sulfide] that you will, and add to it an equal amount of salt and half as much iron filings. Now grind the whole amount carefully with wine vinegar on three (E consecutive) days (E each day three times in three hours, one hour at the beginning, one in the middle, and one at the end) and roast it in a medium fire: then take it out, grind it, saturate it with vinegar and roast it.[143]

The student who followed these instructions needed to understand processes like measuring, mixing, grinding, saturating, and roasting. The procedures presume a degree of hands-on training, operation of ovens, and practice in the laboratory or perhaps an apprenticeship. This point may seem intuitive, but it is not. Even practical alchemy texts such as *The Pearl of Great Price* or the *Summa Perfectionis* mix theory with methodology. *Alchemia,* in spite of its wealth of procedures, is too laden with explanations to be convenient in the laboratory. The *Kitāb al-Asrār*, however, stands apart. Even though al-Rāzī actively engaged in the alchemy theory debates of his time, his book of instructions reads much like a chemistry handbook of today because he separated procedure from theory and explanations.

The third assumption is the requirement for a dedicated space. The *Kitāb al-Asrār* never mentions the size or location of the laboratory. One can infer that there is storage space for the required chemicals, crucibles, and alembics, and room enough to accommodate four types of ovens with

perhaps some ventilation.[144] The references to incubating chemical mixtures in dung heaps or selecting a spot exposed to (or sheltered from) the sun or the wind indicate that obtaining the right conditions for some operations required a controlled outdoor space with limited access.[145]

In one procedure, the "Secret of treating sulphur and arsenic sulfide," al-Rāzī emphasizes the need for complete isolation.[146] After placing the sulfur or arsenic sulfide in a sealed container with a single venting hole, the instructions read:

Then go with it to a place where no one will notice the smell, in the desert or elsewhere (L or a place free from inhabitants) and dig a pit for it in the earth and light a medium fire in it, set the kettle on the fire and observe the smoke that comes out.[147]

The instructions that follow indicate that this is a safety precaution, rather than an attempt at concealment. After the smoke turns white, al-Rāzī states, the laboratory worker can take the kettle back and work with the contents "in a house or in your dwelling or where you will, because it will not harm you (now)."[148] This passage illustrates several reasons why laboratory procedures require a controlled space: manipulation of conditions, use of hazardous materials, and the convenience of a dedicated work area, either a separate structure or a part of one's house.

Libavius also envisions a laboratory as part of the household in his Commentaries to *Alchemia*, where he includes a detailed design and floor plan of an ideal laboratory within a city dwelling, complete with toilets and the laboratory waste water drain.[149] This meticulous degree of detail shows, however, that *Alchemia* was not intended for everyday laboratory use. Nor is English chemist Michael Faraday's *Chemical Manipulation*, written over two hundred years later. Faraday brings the physical requirements of the laboratory to the very first chapter of his book, with specific

recommendations (“a room of 20 to 24 feet wide by 16 or 18 feet will answer the purpose”) along with a detailed discussion of appropriate lighting, ventilation, furnaces, sinks, and cupboards.[150] In a procedure manual, however, the characteristics of the physical space are usually implied.

Control of sunlight, inside and out, was an aspect of space management that concerned both Faraday and al-Rāzī because its influence on chemical reactions required it to be both available and avoidable: Al-Rāzī gives specific instructions on using sunlight to facilitate reactions: “Take strong yellow vitriol, as much as you will, and boil it with an equal amount of copper acetate in a copper kettle in four times as much water, until a third of the water is driven off, then purify it and let it solidify in beakers in the sun.”[151] Avoiding sunlight to prevent chemical reactions can be equally important. “The solar rays have been found highly influential in causing chemical change,” explains Faraday, “they effect combinations and decompositions in a manner unattainable by any other agent, and are now frequently resorted to . . .”[152] Chemical reagents purchased for modern laboratory operations often come in dark glass containers with instructions to keep out of the sunlight. In a procedure manual, it is only necessary to specify whether, not why, sunlight is to be used or avoided.

Faraday’s brief discussion of different laboratory arrangements shows how much laboratories had increased in number and importance by 1827. Libavius’s laboratory was probably idealized,[153] whereas Faraday refers to actual working laboratories with an authentic voice of experience. Of these works, the *Kitāb al-Asrār* is closest to the standard operating procedure manual found in laboratories today, where the amount and use of laboratory space is implied rather than stated, and the effort to control conditions is internal to the procedures themselves. Reading through a modern procedure manual, the references to refrigerators, incubators, automated instruments, biohazard containers, and other required equipment would enable one to construct a mental image of what a laboratory must be like, just as the equipment and processes in the *Kitāb al-Asrār* suggest the character of its dedicated space.

Today accreditation inspections require adequate laboratory space, but the definition is usually vague because laboratories are not often in a position to rebuild. “Frequently the laboratory is something of an afterthought in a factory,” sympathizes a manual on food and drink laboratory accreditation, and their requirement is commensurately nonspecific:

> *The laboratory should be designed to be suitable for the activities that will be carried out. There should be adequate space, lighting and heating and it should meet the requirement of any directive, legislation or guidance document that is relevant. Access to the facility should be controlled. . .*[154]

This vague prescription is reminiscent of the thirteenth-century *Libellus de Alchemia* ascribed to Albertus Magnus, which states that the alchemist "should have a place and a special house hidden from men, in which there are two or three rooms. . ." Limited access remains a definitive feature of a laboratory now as in the time of al-Rāzī, and the procedure manual both assumes and attests to its importance.

Space is inevitably linked to finances, the indispensable fourth element which the laboratory manual takes for granted. A laboratory requires an owner, patron, client, or investor who holds a stake in maintaining the operation. The financial relationships between al-Rāzī, Libavius, Boerhaave, Faraday and their laboratories provide snapshots in time that illustrate the shifting economic and political interdependence of the laboratory and society. The *Kitāb al-Asrār*, like modern laboratory manuals, describes hours of labor-intensive work, expensive chemicals, and profligate use of water and fuel, implying an endless supply of money and labor. However, al-Rāzī did not depend on his laboratory for his livelihood. He was a physician, teacher, hospital director, and a writer with powerful patrons, including Prince Abū Sālih Mansūr ibn Ishāq, to whom he dedicated his renowned ten-volume medical treatise, the *Kitāb at-Tibb al-Mansūrī*.[155] Stapleton suggests that al-Rāzī may have given the *Kitāb al-Asrār* to Mansūr as well.[156] For al-Rāzī, however, the laboratory appears to be primarily an outlet of his wide-ranging intellectual interests, like his studies in music and philosophy.

Libavius, like al-Rāzī, did not expect to make his living in the laboratory. His professional life as a civil servant and physician remained divided

between public health and education, and he spent his last nine years (1607-1616) as director of the Academic Gymnasium in Coburg.[157] Although his book, *Alchemia*, was the most encyclopedic work on alchemy and chemistry published up to 1606,[158] his personal laboratory work seems to have been a marginal part of his life and the book appears to be intended as a comprehensive reference for all known applications of the laboratory arts. Economically, however, Libavius and the laboratory seem connected only by any profits he might have made from the two editions of his book.

Boerhaave's professional life, on the other hand, was directly linked to the laboratory. His means of support included teaching, writing, private lectures, and an inheritance, but he exemplifies one of those unbridled enthusiasts that chemistry seems to attract. His biographer, Gerrit Arie Lindeboom, writes, "He was apparently enthralled by chemistry and on many nights he sacrificed his sleep to it."[159] He replicated the procedures of the alchemists, by carrying out lengthy experiments involving distilling and heating mercury which he published in *Philosophical Transactions* in 1735-36.[160] In his earlier years, Boerhaave had his own private laboratory, but when he assumed the chair of chemistry at the University of Leiden in 1718, the position included a laboratory and money to refurbish it.[161] The university emerged as a laboratory patron.

Faraday's position as a full-time chemist in the laboratory of the Royal Institute[162] indicates that by the nineteenth century the laboratory's support reached beyond personal and academic patronage. Although his salary was low, his reputation put him in demand as lecturer, legal witness, and consultant. One of his industrial projects included improving alloys of steel, stimulated by national interest in the stronger steels found in Bombay.[163] In addition, the Board of Longitude commissioned him to improved optical glass.[164] In other words, by the time he wrote *Chemical Manipulation* in 1827, the laboratory's ability to support public and industrial agendas began to change the world in the small (better telescopes) and large (influencing colonial interests) ways described by Latour.[165] Faraday describes required laboratory equipment in meticulous detail, without direct references to funding. He recognizes, however, that "when the laboratory is attached to a public institution" it can be generously supplied, but lists minimum necessities for the beginning chemist, "if the want of time, or if other circumstances should necessarily limit the pursuit of chemical

research."[166] The chemist and the laboratory had acquired the patronage of government and industry.

The fifth basic assumption of any procedure manual is reproducibility, which requires that a process is carried out by the same method under the same conditions will yield the same result. Without this assumption, laboratory procedures are random exercises, and yet even with the best intentions, perfect replication continues to be elusive, approached but never quite achieved. Reproducibility includes both implicit factors, which are variables not specified in the procedure itself, and explicitly stated factors, which will be the subject of the next section. The implicit factors in a test system can include humidity, the material composition of containers, the quality of the chemicals, and their storage conditions. The most challenging variable, however, is the human component. Like many procedure writers, Al-Rāzī attempted to control test conditions and human behavior by using painstaking specificity: "And be careful to close the lid of the flask before the moisture has dried out," specifies one procedure, "then seal the lid and pile sifted ashes over the kettle."[167]

Frustration with the inconsistencies of human behavior echoes down the centuries of laboratory literature. In the fourteenth century, Petrus Bonus complained about the undependable methods of alchemic masters in *The New Pearl of Great Price* (c.1330): "Amongst these persons are observed a great diversity of method, and a considerable variety even in the choice of their substance."[168] Today's laboratories have the same concern: "When validating a method, it is also vitally important to assess the precision or reproducibility of the method," states a modern guide to laboratory accreditation. Recognizing the impossibility of writing a perfectly reproducible procedure, this book recommends this ultimate test: "If, however, your reproducibility looks promising, or even good, then it is time to try it on another analyst."[169] Two people will never understand the same instructions in quite the same way, which is why laboratory work always requires supervised hands-on training in addition to reading the manual.

Literacy, technical knowledge, space, financial resources, and reproducibility have been the basis of laboratory manuals since the time of al-Rāzī. They constitute the infrastructure necessary to carry out the procedures in the manual and are just as vital today as they were in the past. Over time, laboratories have expanded their applications and increased their economic integration with society, which ensures their survival and proliferation.

However, these conditions are not enough. To achieve reproducible results, laboratory procedures specify physical, operational, and verification standards, an explicit framework, which is also evident in the *Kitāb al-Asrār*. Physical requirements refer to materials, such as chemicals, equipment, and controlled heat that the laboratory needs to construct an artificial test environment. Operational requirements specify clear, practical, and safe methods for using these materials. Verification requirements set standards for ensuring repeatable results, such as timing, temperature, quantification, and endpoints.

PHYSICAL REQUIREMENTS: CHEMICALS AND EQUIPMENT

These are requirements that the procedures spell out because the person carrying out the process needs to implement them. For example, laboratory manuals explicitly specify the physical requirements, which include the material supplies that the procedures require: chemicals, equipment, and controlled heat. These elements are interdependent: the end purpose of the laboratory dictates the chemical requirements, and chemical reactions demand specific equipment for storage and heat. Today, laboratories purchase chemicals from commercial suppliers who must meet legal standards of purity, and even then accreditation agencies hold the laboratory responsible for observing the manufacturer's storage recommendations. Al-Rāzī, however, needed to prepare his students to evaluate the quality of raw chemicals for themselves. Al- Rāzī introduces his classification system in the First Section of the *Kitāb al-Asrār*, entitled "What one must know about Substances."[170] Although some of his procedures use organic matter such as plants, blood, bone, and hair, ninety percent of his 389 procedures are based on inorganic or mineral substances, which he divides into six groups: "spirits, metals, stones, vitriols, boraxes, and salts".[171] Living in the Persian city of Ray, gave al-Rāzī access to all of these chemicals. Caravans traversing the Silk Road filled Ray's bazaars with imported goods, while springs in the Elburz Mountains provided the city with an ample supply of pure water (Figure 4).

Figure 4. Caravans like this one traversed the Silk Road bringing imported goods to the markets in Ray. This caravan was photographed on the Old Shemran Road north of Tehran against the snow-covered Elburz Mountains. Photograph by Harry Marlow, 1954.

Not only was Ray a commercial crossroads, but the tenth century was also a time of expansion for the Persian mining industry. Islamic historian Alessandro Bausani writes: “Deposits of silver, iron, copper, tin, lead, sulphur (near Mount Demavend), lapis lazuli (Badakhshān and Azerbaijān), rubies (for which Badakhshān was famous), and turquoise (near Nīshāpur) were all mined.”[172] The many substances al-Rāzī uses in his procedures, including mined metals and precious stones, were readily available to the chemist who had only to select them carefully.

Al- Rāzī introduces the question of quality very early, in “Part Two: About Distinguishing the Good and the Bad Varieties.”[173] He gives five methods for selecting the best chemicals for the laboratory that require little or no equipment: color, texture, smell, point of origin, and testing for purity. Color and texture are the most frequently used. For example, the dense yellow sulfur is the most desirable, whereas the white and black varieties are “not suitable.”[174] The best kind of arsenic sulphide is “pure red and flakey.”[175] Smell helps to distinguish salts; for example, Chinese salt “smells like hard-boiled eggs.”[176] Al-Rāzī is particular about point of origin, which reveals a wide range of available sources: the best talc is from Yemen, the best iron oxide is from Istahr, the best red vitriol from Cyprus, the best borax from Zarawand, the best malachite from Kerman.[177] For mercury, the alchemist’s most critical ingredient, al-Rāzī recommends selecting some that is white and soft and then pressing it through a cloth to make sure no black residue is left behind.[178] In addition to purchased chemicals, his procedures assume that the alchemist has ready at hand basic substances such as wine vinegar, distilled vinegar, distilled water, honey, and eggs.

Today, few laboratories are individually owned, and the modern procedure manual focuses on providing convenient instructions rather than helping a chemist to organize a personal laboratory. The list of required chemicals now precedes each procedure, rather than first appearing in a master list at the beginning of the book. It is the overall outline of the *Kitāb al-Asrār* (reagents – equipment – procedures) that parallels the structure of individual procedures today. For example, a modern procedure for determining the fat content of milk specifies: Chemicals: Ammonium hydroxide, Ethanol, Petroleum ether. Equipment: Analytical balance, hot plate, Mojonnier apparatus (“with centrifuge, vacuum oven, and cooling desiccator”). Procedure: “Warm milk samples to room temperature and mix

well. . .” [179] The *Kitāb al-Asrār* defines the chemicals and equipment at the beginning of the book, followed by procedures that go right into action: “Take gold filings, mix red arsenic sulfide with them and pour them into a little bag, coat it with artist’s clay and roast it one night with a strong fire.”[180] Al-Rāzī’s structure indicates that he designed his manual as a fully integrated work, whereas laboratory manuals today are often organized in a binder, permitting the addition or replacement of procedures as needed.

Many procedures in the *Kitāb al-Asrār* provide series of three or four alternative procedures to the same end (“Another way . . .”).[181] For example, in the series of procedures on softening metals, there are three methods for softening for each metal followed by one procedure that uses the softened product of the other three.[182] These options may permit adapting to the availability of materials, time, or labor, since the alternative procedures vary in time, complexity, and value of final product, as measured by how many dirhams of metal it will transform into gold or silver.

In *Chemical Manipulations*, Faraday approaches the instruction of the new chemist differently. Rather than providing a comprehensive list of necessary chemicals and equipment, his procedures consist of teaching exercises, which offer the beginner experience in proper use of laboratory apparatus such as balances and crucibles. The aspiring chemist might select chemicals and equipment for the particular experiments he wants to try. However, many of these materials are the same as those named by al-Rāzī, such as copper, iron, borax, salt, and sal ammoniac. Faraday does not discuss the quality or country of origin of his reagents, indicating that by 1827 he had reliable sources of purchased chemicals.

Commercially available standardized chemicals facilitate replication of results, critical to establishing laboratory credibility. In discussing modern laboratories, science historian Theodore Porter states, “Not only have instruments been standardized; nature has too. Chemists buy purified reagents from catalogs – and they would be quite helpless if they had to extract them from the soil.”[183] Even in the tenth century, al-Rāzī did not dig up his own chemicals. He selected them in the marketplace. His concern with replication and predictability *within* his laboratory makes his testing space a controlled environment.

Once obtained, chemicals must be stored and combined within a suitable container that will not contaminate the chemical or enter into the

reaction. Glass containers were often the container of choice. “Glass vessels are used very frequently,” taught Boerhaave in the eighteenth century, “they do not alter, add to, or remove anything from the substances they contain.”[184] Equally concerned with the quality of the glass, Al-Rāzī states: “There are various kinds. . . The best of them is Syrian, white, pure, as clear as rock crystal.”[185] Since the art of glass blowing was invented in Syria in the first century B.C.,[186] al-Rāzī would have been able to obtain a variety of glass containers. He specifies using glass vessels for producing urine salts, combining iron filings and vinegar to produce iron rust, and for dissolving various substances.[187] In addition, three procedures require glass mortars and two specify glass funnels lined with cotton for filtration.[188] For one of the “sharp waters,” a series of strong solvents described in Part Seven, he specifies a particular container, a Chinese *barniyya*, because the prepared reagent will eat through glass and pottery.[189] All four chemists, al-Rāzī, Libavius, Boerhaave, and Faraday use small glass vials for some chemicals. All make clay and use it to repair containers, seal connections, and to coat glass flasks so that they resist breaking in intense heat. Laboratory equipment was purchased when possible and modified when necessary.

Until the widespread introduction of automated instruments and computers in the last quarter of the twentieth century, equipment remained a relatively stable part of the laboratory environment. Al-Rāzī, Libavius, Boerhaave, and Faraday would have understood each other’s laboratory apparatus. Because they shared common materials and processes with metal workers, they could use or adapt the furnaces, bellows, flasks, tongs, and crucibles used by the blacksmith or goldsmith. A self-ventilating oven, for example, was used to obtain a fire hot enough to smelt metals. Al-Rāzī describes it:

It stands on three feet and is placed on a saucer, whose walls have holes through them. In the middle of its base there is a hole, through which the ashes fall out. Coals are poured into its lowest part, and that which must be calcined is placed on

them and buried in the coals and covered over with coals. Place it where the wind blows through it. Its fire is exceedingly strong, it calcines the metals and combines them and smelts them.[190]

Libavius also describes a wind oven having three feet and a grate to separate the ash chamber from the coals. The metal is placed in a pan or kettle and surrounded or embedded in the glowing coals, and after a start with the bellows, an opening in the ash chamber is exposed to the wind, which maintains the coals at an intense heat.[191] The description is so similar to al-Rāzī's oven that the design apparently remained the same for over seven hundred years. Faraday, who often carried out projects involving analysis of metal alloys, also used coal-burning wind-ventilated furnaces for smelting them.[192] The need for controlled heat, recognized by the alchemist, is also of vital use in the laboratory today. For example, the hospital blood bank laboratory requires a stable room temperature incubator of about 22 degrees Celsius for preserving platelets, an incubator at 37 degrees (body temperature) to facilitate antigen-antibody reactions, and a high temperature heat block of 100 degrees to inactivate certain reactive components in the blood serum.

Controlled heat took many forms. Al-Rāzī used several kinds of furnaces in the *Kitāb al-Asrār* with dung or coal as fuel, and sometimes heated mixtures over a naphtha lamp. In 1827, Faraday reports using coal, charcoal, or coke in his furnaces, depending on the duration and intensity of heat required.[193] He also used alcohol lamps or oil lamps or even gas lamps as a quick economical source of heat, and water baths or sand baths to provide steady even heat. One of the most common media for long-term even heating used in early chemistry was manure.

Manure incubation provides a temperature that is universally constant and achievable without thermometers. Al-Rāzī uses it most often to dissolve solids that resist faster methods. "Bury it 40 days in dung, so that it becomes a pure water, purer than

tears,"[194] recommends a procedure for the sublimation of glass. A process for making sharp waters from vitriol reads, "bury it for three weeks in dung. It dissolves into yellow water without residue."[195] Both apothecaries and alchemists used manure at least through the sixteenth century to provide heat for the digestions, fermentations, and putrefactions required to make their medicines. An image from the *Thesaurus de Remediis Secretis* of sixteenth-century physician Conrad Geßner (1516-1565) shows a flask partially immersed in a manure pile in an apothecary's cellar.[196]

Manure was readily available, cheaper than other fuels, and virtually labor-free once it was shoveled into place. The heat from its natural bacterial activity generated a steady dependable heat. Faraday's nineteenth century contemporaries used manure for warming hothouse flowers. Gardeners mixed manure with vegetable matter such as leaves and the mixture was "allowed to warm to its maximum of around 100°F, and then permitted to cool to a more stable 90 to 92°F."[197] Like the apothecary's flask of earlier times, the partially immersed flowerpots stayed evenly warm at slightly below human body temperature for about one to three months before replacing the mix.[198]

This interval coincides with the incubation times given in the *Kitāb al-Asrār*. The procedure for transmutation using blood prescribes burying the calcified blood in dung for fifty or sixty days to dissolve it and then adding an equal amount of mercury and burying it for an additional forty days until it dissolves again.[199] The *Kitāb al-Asrār* includes about ten procedures using manure incubation, usually specifying horse manure mixed with radish or carrot juice. Almost seven hundred years later, *Alchemia* similarly prescribes a forty-day incubation for dissolving coagulated blood[200] and a month-long incubation with a vinegar compound for liquefying gems.[201] Faraday's chapter on dissolution through slow heat recommends sand baths, but his warnings about keeping the temperature low enough to avoid broken containers or boiling over suggest that this method had its disadvantages.[202] Manure incubation seems not only precise and easy to manage, but eminently practical, economical of both labor and fuel.

Although more than seven centuries separated the laboratories of al-Rāzī, Libavius, and Faraday, the physical requirements of chemicals, equipment, and controlled heat show their common functionality. Theories, financing, and technology change, but the conceptual testing space, the controlled environment that facilitates replication, remains in many ways constant. Another aspect of the laboratory that remained constant can be considered under the heading of operational processes.

OPERATIONAL REQUIREMENTS: CLEAR, REALISTIC, AND SAFE PROCEDURES

While physical requirements meet the material needs of the laboratory, operational requirements define how to carry out the procedures that utilize these supplies. Procedures that are clear, realistic, and safe are vital to successful and reproducible outcomes. The first of these, clarity helps insure that laboratory procedures will be understood and followed properly. "When no procedure is in place," asserts *Food and Drink Laboratory Accreditation*, a modern manual on regulatory requirements, "then a procedure must be written. Remember to keep it simple! . . . Staff will not follow complicated procedures."[203] Confusing instructions compromise reproducibility and waste precious materials and labor when the elements of a botched experiment have to be thrown away. Consider, the difficulties the alchemist faces in following this procedure attributed to Raymond Lull in *The New Pearl of Great Price* (c. 1330) by Petrus Bonus:

Take the black which is blacker than black and distil of it 18 parts in a silver vessel, and in the way suggested in my Testament. At the first distillation take only 1½ part and, distil it again, and then its 4th part, which also distil a third time; of this again take 2 parts for the fourth distillation, in which take a little more than the

whole; distil this 8 or 9 times.[204]

Clarity required communicated information to be sequential, in plain language, and appropriate to the intended audience.

The *Kitāb al-Asrār* achieved a wide readership in the Middle Ages directly and indirectly through its many copies, translations, and imitations. Although medieval alchemists frequently referred to al-Rāzī and quoted him, the accuracy of their source material and their understanding of his work varied. In his own time, however, al-Rāzī however, wrote for an audience he knew well. According to the *Fihrist of al-Nadīm*, a tenth-century compendium of literature, al-Rāzī taught medical students in his advanced years[205] and he apparently wrote the *Kitāb al-Asrār* for one or more of them. He states that he wrote it at the "request of a young man among my students, an honorable man named Muhammad ibn Yūnus, well-versed in mathematics, natural sciences, and logic."[206] The *Kitāb al-Asrār* appears, therefore, to address an educated reader with some basic experience who is interested in setting up a laboratory.

While many of the materials, containers, and processes sound strange today, the procedures are clearly written, step-by-step, with specific details about what to expect at different stages of the operation. The beauty of the *Kitāb al-Asrār* is that it sets up the series of alchemical processes logically and with an elegant simplicity, with no digressions. An outline precedes every section. For example, "The Chapter on Softening" begins: "There are four methods: Softening through spirits, softening through salts, softening through oils, and softening through borax."[207] The procedures follow the outline exactly.

Al-Rāzī's clear instructions include explicit warnings against conditions that put the experiment at risk: "One must watch, however, that the fire does not go out (E and the ashes do not get cold, before it has dissolved and solidified)."[208] "Then take black naphtha and add an equal amount of sal ammoniac and distill it; repeat the task with it

and watch that it does not ignite."[209] "Put it in hot ashes, but these must not be too hot so that the flask does not shatter."[210] These warnings, which have the sound of experience, help the beginner avoid disaster. The difficulty with replicating his procedures today would not lie as much in the clarity of the instructions as it would with duplicating the chemicals and equipment he used.

In contrast, some later alchemists disapproved of clear procedures, preferring to write in an esoteric manner in order to restrict knowledge to the initiated or to avoid detection. "If many know, the secret in no way will be kept, and that when it is divulged it will be repeated with error," warns the thirteen-century *Libellus de Alchimia* ascribed to Albertus Magnus.[211] In his prologue to *Compound of Alchemy* in 1591, George Ripley urges: "Our secrets to thee I will disclose. Keepe thou them secreate [*sic*] and for me pray."[212] However, other alchemists advocated openness and clarity. In *The New Pearl of Great Price* (c. 1330) Petrus Bonus made a plea for plain language: "The tropical expressions and equivocations, the allegories and metaphors, employed by the Sages, also create a most serious obstacle in the path of the Student."[213] Libavius, as an educator writing in 1597, had no patience with obscure writing: "For people who are not acquainted with the nature of the chemical discipline, everything one says sounds mysterious, even when it is presented in clear accurate terms that those modestly well-informed would understand."[214] He shared the concern for the student that both al-Rāzī and Petrus Bonus expressed. In time, clear writing predominated in chemistry texts.

Practicality, the second operational requirement, means feasibility. In order to be reproducible, a practical procedure must have reasonable expectations of the laboratory worker in regard to physical effort, number of repetitions, and duration. A procedure may be easy to understand, but if it is excessively demanding it is unlikely to be performed the same way twice. However, the definition of how much labor is reasonable in the laboratory reflects the surrounding culture. Al-Rāzī and Faraday show contrasting approaches to the manual labor required for successful results.

Al-Rāzī issues instructions in a straightforward manner, without reference to the tediousness of the operation. The most physically demanding processes in the *Kitāb al-Asrār* are digging pits for incubation and pulverizing solids to prepare them for dissolving or to blend them with other

chemicals. A typical instruction is found in the series of procedures for dissolving various solid substances in Part Three: “Dig a pit in wet earth on which the sun never shines, of a depth of two ells or more, and a width of one ell . . . then fill it up to one (E two) thirds with moistened clean sand.”[215] The numerous pulverizing processes, which reduce hard materials to a powder in order to dissolve or blend them, are long and onerous: “Grind it eight hours,” states a procedure for softening leads, and another requires sal ammoniac and mercury pulverized “for three days on a grindstone.”[216] Al-Rāzī’s procedures can be onerous but they are achievable. In contrast, alchemy historian E. J. Holmyard points out that some medieval alchemists recommended distilling and redistilling materials hundreds of times.[217] When a procedure has hundreds of repeated steps, reproducibility is virtually impossible.

The indoor laboratory of Michael Faraday no longer demanded digging pits, but strenuous physical work remained the only way to break down and combine solid substances. Faraday prefers the mortar and pestle to al-Rāzī’s grinding stone and he even gives ergonomic advice on the best way to conduct the tedious process of pulverizing: “The process is least fatiguing to the hand when the circles are up the side of the mortar,” he advises, and “The pestle may be held in both hands in succession, for relief of the wrists.”[218] He is familiar with al-Rāzi’s method of “grinding the body under a muller, upon a flat stone,” but judges that this is “so inferior to the use of the mortar in the laboratory, that it will be unnecessary to describe here.”[219] The degree of physical labor may have been less arduous in Faraday’s laboratory than in al-Rāzī’s, but both assumed that a manageable amount of physical labor was necessary.

Practical time intervals are also important to making sure a laboratory procedure is carried out correctly. When Petrus Bonus in *The Pearl of Great Price* (c.1330) states that: “The time required for the whole work is stated by Rhasis to be one year,”[220] he stipulates an unreasonable time interval for most laboratory processes. If al-Rāzī did make such a statement, it was not in the *Kitāb al-Asrār*. The longest time intervals involve incubations required to soften lapis lazuli, malachite, and turquoise with borax in “The Chapter on Softening Stones.” The dissolution requires a forty-day incubation, followed by another forty-day incubation, followed by seven days to solidify. The procedure then adds that the efficacy of the end product will be even better if it goes through another softening, dissolving, and a third

40-day incubation period, and then resolidifying.[221] These repeated incubations do not seem unduly difficult for the operator, since most of the time is hands-off.

Professor and physician Herman Boerhaave (1669-1738), was so fascinated by the lengthy medieval procedures for the transmutation of metals that he could not resist replicating them himself. Boerhaave's biographer, G. A. Lindeboom reports that the eighteenth-century chemist kept mercury at a steady heat above 100 degrees F. for fifteen and a half years.[222] A laboratory assistant, at one point, spilled the contents of a pot of lead that Boerhaave had been heating for twenty years, showing the risks of overly long heating periods.[223] The experiment and the accident illustrate how the priorities of contemporary society changed the laboratory's standards for timing and safety. Long testing periods may still be required in some areas of research and development, but in the ordinary laboratory that tests medical specimens, forensic evidence, food, or drugs, the public expects fast results at a low price with perfect accuracy and no toxic exposure to anyone. No wonder accreditation experts Wilson and Weir proclaim: "Labs contain largely unsung heroes."[224]

Safety, the third operational requirement of the laboratory manual, is just as important as clarity and practicality. Like labor, safety is relative to the expectations of society as a whole. Today the mercury, lead, and arsenic compounds so casually handled by al-Rāzī, Libavius, Boerhaave, Faraday, and many chemists since, are highly regulated by state and federal agencies. Testing laboratories measure acceptable levels for lead in candy for children and mercury in seafood in parts per million.[225] Although by today's standards one might conclude that early laboratory investigators held no regard for safety at all, their manuals often demonstrate a genuine concern both for their own welfare and for their students.

There are seven specific references to safety in the *Kitāb al-Asrār*. In the procedure for initial treatment of sulfur and arsenic sulfide, found in Part One, al-Rāzī instructs the alchemist to heat the substances in a remote outdoor area and not to return them to the laboratory until after the smoke turns white, because at that point, ". . . it will not harm you."[226] In addition to keeping the toxic fumes out of the workplace, the instruction appears to show concern for protecting the public as well, by requiring the procedure to be carried out in "a desert . . . or a place free from inhabitants."[227] The

instructions for purifying sulfur and arsenic sulphide caution the alchemist to "protect your hand and your nose, because it is a poison."[228] The procedure for softening iron using borax goes a step further, advising the alchemist to plug his nostrils with cotton soaked in oil of violets and to avoid touching it because the poison acts in one hour.[229] The same precaution is advised in Part Three for working with "sharp waters," (strong solvents), recommending the addition of either rose oil or violet oil to the cotton. A different procedure for making "sharp water" from sal ammoniac, copper acetate, lime, and arsenic sulfide advises strict caution because it "exerts a powerful effect on you."[230] The emphasis is on protecting the worker from immediate harm. Al-Rāzī gives no precautions for working with lead or mercury, which are relatively slow-acting toxins.

Later alchemists, however, did show some awareness of these poisons. In *The New Pearl of Great Price* (c. 1330), Petrus Bonus specifically warns of the dangers from mercury: "be careful to shut your mouth and nose, because the fumes are destructive to the teeth."[231] At the end of the same work, an extract from Arnold de Villa Nova (1235-1311)[232], advises labeling as a safety precaution: "Keep each element carefully sealed up in a well-stoppered jar, write upon each its own name, and a record of its properties, for it would be fatal to mistake one for the other."[233]

Faraday, writing in 1827, recommends labeling not only for safety, but for convenience. "All products, educts, precipitates, or solutions, that are set aside for some time, should be labeled . . ."[234] Faraday's main concern with mercury exposure is to avoid contaminating the mercury itself: "Even a touch of the finger is sufficient to communicate so much impurity as to render the mercury inapplicable in the construction of accurate instruments."[235] Although he recommends using face and eye protection when handling explosive substances in glass containers,[236] in general his references to laboratory safety are sparse by today's standards. This does not mean that Faraday was careless or unaware of the hazards around him. Safety expectations in any workplace were simply not as all-encompassing in 1827 as they are today.

Safety is probably the area in which laboratories have attained the most impact on society as a whole. As testing methods gained increased ability to detect the minute and the invisible, the public correspondingly narrowed the limits of acceptable risk thereby increased the need for

laboratory testing. Latour demonstrated how Pasteur's demonstration of bacteria as a cause of disease coincided with the agenda of the hygienic movement in *The Pasteurization of France*, illustrating how powerful achievements in the laboratory can become when they merge with political, social, and economic goals in the outside world. The laboratory produced a new enemy, invisible microbes, giving a focus and mobilizing support for the hygienists' campaign to implement public health measures by cleaning up water supplies, air quality, housing, and working conditions.[237] Of this powerful union Latour states, "there is no outside to laboratories,"[238] because the laboratory's findings merge into the community's reality.

This external impact is visible today in international commerce and diplomacy as the laboratory's ability to measure lead and mercury in parts per million is applied to painted toys imported from China, candy from Mexico, and fish from Japan. While testing introduced an unprecedented expectation of safety into the outside world, safety precautions inside the laboratory have intensified as well. When laboratory testing justifies increasing public regulation of cleanliness, waste disposal, or safety, the inner world of the laboratory is swept up in the forces it helped to create. Laboratories have forged a reciprocal relationship with the volatile forces of public activism.

VERIFICATION REQUIREMENTS: THE KEY TO REPRODUCIBILITY

The earlier section on general assumptions addressed general factors affecting reproducibility, which are outside the scope of the written procedure, such as humidity or human behavior. Most important to achieving a repeatable outcome, however, are verification requirements, which are specified in the procedures, such as defined time and temperature, quantifiable weights and measures, and clear-cut endpoints, which are the indicators of successful completion. Verification standards stabilize the testing conditions so that the results of the process are the same every time it is performed. This reproducibility is fundamental to the concept of the laboratory. Biologist Edward Wilson made it the primary defining property of real science: "The diagnostic features of science that distinguish it from

pseudoscience are first, repeatability . . .”[239]

Standard systems of measurement are the foundation of repeatability. However, like defining standards for labor or safety, acceptable quantification in the laboratory is relative to the expectations of the society around it. The level of standardization in industrialized societies today did not just happen because it seemed logical. Science historian Theodore Porter points out that enforcing standard weights and measures requires more than an accepted reference point, it requires changing how of millions of humans manipulate materials, calibrate instruments, and standardize record-keeping. [240] A standard system of measurement, like a national language or public education requires a centralized government with a bureaucracy that defines, prioritizes, and enforces uniformity. The Abbasid Caliphate needed standardized weight for commerce and tax collection more than it needed precise calibration of time and temperature.

TIME AND TEMPERATURE

The shortest time interval specified in the *Kitāb al-Asrār* is one hour, occurring in many procedures such as: “take it out every hour and examine (E what adheres to it)” and “grind it while roasting a good hour.”[241] These hours would have been approximate, possibly based on the pre-Islamic tradition of dividing the day and night each into twelve equal hours.[242] It is significant that al-Rāzī uses the hour only to describe the length of time to perform a particular process, such as grinding, roasting, shaking, or soaking, where the exact duration is not critical, but he does not use time alone to define when a procedure is complete. That is, instead of stipulating simply: “pound it with mustard for several hours,” he adds the words “until it turns black,” so that the alchemist can tell when he has pounded the mercury long enough.[243]

Timekeeping is grounded in astronomy and observable natural phenomena such as sunrise, sunset, moon cycles, and seasons. In the time of al-Rāzī an administrative calendar coordinated tax collection with the harvest and established the timing of religious observances. Daily timekeeping determined the five daily prayers of Islam. When al-Rāzī uses time to specify the frequency of a process, rather than its duration, he specifies the three most

obvious times of day, as in: “every day for three hours, one hour at the beginning, one in the middle, and one at the end,” or “every day, morning, noon, and evening.”[244] He does not use other frequencies, such as four, five, or six times a day. Occasionally he specifies a long duration, such as “apply heat under the aludel twelve hours for each ratl” or “light a gentle fire under the lamp for ten hours.”[245] These may have been estimated as the length of one day or night. Both shadow-measuring techniques and water clocks were used in tenth-century Persia for measuring time intervals,[246] but the *Kitāb al-Asrār* does not specify instruments for determining time intervals or duration. Nevertheless, timing is a prominent part of the procedures, indicating that it was considered important to a successful outcome.

Al-Rāzī also specifies time spans of days, weeks, and months. These are probably not approximations. Notes contained in his medical writings demonstrate that, as a physician, he documented the precise timing when symptoms appeared or subsided and the frequency of treatments. For example, in the case of a woman suffering from residual fever after smallpox, he records the results of a regimen of “dried apricots at day-break and barley-water at noon during a fortnight. The maturation of urine appeared after forty days, and her recovery was complete at the end of fifty days.”[247] As he was an experienced and renowned physician for a number of years before writing the *Kitāb al-Asrār*, it seems logical to conclude from the systematic recording of time intervals in his medical writings that he observed the forty, fifty, or sixty-day intervals in his alchemical procedures with equal care.

Like time, temperature measurements are based on natural phenomena. Body temperature, freezing and boiling water, and the melting points of metals are dependable reference points. Al-Rāzī, Libavius, Boerhaave, and Faraday all understood that uncontrolled temperatures could introduce unacceptable variables into their test system, yet none of them had a perfect solution. It is not surprising that, in 920, al-Rāzī described temperature relative to his surroundings. A mild warmth, in the procedure for calcination of lapis lazuli, calls for a “gentle fire, like a bird incubator,” hot ashes provide a medium heat, and the most powerful fire is the “fire of the oven for casting iron.”[248] Not all heating required a fire. As discussed earlier, manure provided a dependable gentle heat for long incubations. The sun also provided heat: “Put it in the sun in the most heat possible,” reads one procedure.[249] When fire is the heat source, the *Kitāb al-Asrār* describes its

relative intensity with adjectives like “a gentle fire,” “a medium fire,” and “a strong fire.”[250] Many procedures specify the fire’s distribution, on all sides for some purposes, and from below for others.[251] The manual also states general principals, such as, “the fire for roasting for solidifying dissolved substances is a strong fire, whereas the fire for roasting for melting is a gentle fire.”[252] Al-Rāzī understood how to control heat and he specified levels of heat in terms that could be interpreted by a student with a good eye for the flame and some experience in melting metals.

In 1597, Libavius similarly described four increasingly intense levels of heat, beginning with the mild heat of a bath or manure in which one can hold one’s finger comfortably, or the warmth of a brooding hen. The second level is the warmth of ashes, the third is hot enough to cause iron filings to glow, and the highest level is among the flames of the metallurgist’s reverberating furnace.[253] Almost 150 years later, Boerhaave participated in the development of thermometers as a laboratory tool in active correspondence with Daniel Gabriel Fahrenheit. In *Elementia Chemiae*, Boerhaave records how an alcohol and a mercury thermometer, which Fahrenheit made for him, failed to agree in laboratory conditions. Investigating this report, Fahrenheit concluded that he needed to use a standard source of glass because the expansion properties of glass varied depending on where the glass was manufactured.[254] Boerhaave not only incorporated temperature measurements into his experiments, but also was an early advocate of using the thermometer clinically to evaluate fevers.[255] Like al-Rāzī, Boerhaave applied his laboratory techniques to medicine.

Faraday used standard commercial alcohol and mercury thermometers with caution in 1827. He advises calibrating the readings against crushed ice and then against boiling water, and then verifying that the gradations between those points are evenly spaced. Even so, he points out the inaccuracy inherent in measuring very high temperatures, because of the lack of an “unexceptionable and natural standard point by which they can be corrected.”[256] Faraday estimates high levels of heat visually, observing that the flame of an alcohol lamp is hot enough make a small glass retort glow red.[257] Measurement of very high temperatures had not changed substantially since the time of al-Rāzī.

Alchemists understood time and temperature as functional concepts in the Middle Ages, but standardization and calibration of both remained elusive

into the nineteenth century. Quantification of weights, on the other hand, had a long history of commercial use wherever regional trade predominated. The measurement of weight, the second tool of verification, remained the most consistent and accurate type of quantification in the laboratory.

WEIGHTS AND MEASURES

Tenth-century Ray was a city of over a hundred thousand residents, a center of trade on the Silk Road, and a commercial hub of a prosperous empire.[258] Weights, measurements, and currency were in use throughout the Abassid Caliphate, with values consistent enough to facilitate business transactions and tax collection. There are three methods of quantification for weight and volume in the *Kitāb al-Asrār*: the quantitative weights and measures of the market place, proportional quantities, and semi-quantitative estimates. The most common unit of measurement is the *ratl*, both a unit of weight or of volume (as can the English ounce). According to Ruska, the word *ratl*, is equivalent to 360 grams of weight or between one and two liters of liquid. The currants, cane sugar and dates that Persia sent to the treasury in Baghdad were measured in ratls.[259] The ratl is divided into twelve *uqia* or ounces, so that one ounce is three grams, or about the weight of three paper clips.[260]

A typical quantitative procedure from the *Kitāb al-Asrār* reads: “Then take vitriol, copper acetate, cinnabar, and sal ammoniac, one uqia of each, pour a ratl of distilled vinegar on it and bury it in manure.”[261] Al-Rāzī does not mention a balance specifically, but he almost certainly had one, because fifty of his procedures start with weighed materials and three require reweighing materials during a process to monitor a weight change. Al-Rāzī also uses the *dirham* and the *mithqal*, which Ruska puts at four grams and six grams respectively, to quantify metals.[262] The silver dirham was a coin used as a rate of exchange. For example, according to Italian historian Alessandro Bausani, in tenth-century Persia, “one *dirham* or drachma would purchase between 11 and 18 lbs of meat or honey, or up to 50 cakes of barley.”[263] Al-Rāzī used the measurements of the marketplace.

However, almost eighty percent of al-Rāzī’s procedures use proportions rather than weights. In this method, all quantities are relative to

the first one. This type of procedure reads: “Take what you will of copper filings, amalgamate them with three times as much mercury, add an equal amount of alum as copper and half as much sal ammoniac as alum.”[264] This approach may not sound as precise as a procedure that specifies absolute weights, but in fact it would successfully keep all components in proportion. This method enables the practitioner to adjust the amounts to the availability of materials without recalculating the weight of each ingredient.

Proportions also enabled alchemists to repeat each other’s procedures in the absence of standard weights and measures (Table 3). In 1789 Antoine Laurent Lavoisier (1743-1794) used this reasoning to advocate the use of proportional measurements among chemists in his work *Elements of Chemistry*. He suggested that each chemist use their local standard weight as a unit and use decimals for fractions. “By this means the chemists of all countries will be thoroughly understood by each other, as, although the absolute weights of the ingredients and products cannot be known, they will readily, and without calculation, be able to determine the relative proportions of these with utmost accuracy; so that in this way we shall be possessed of an universal language for this part of chemistry.”[265] The distinguished French chemist was promoting a convention long known to alchemy.

Table 3. Use of actual weight compared to proportions in the *Kitāb al-Asrār*

Type of Procedure	Purpose	# times in *Kitāb*	% with proportion	% with weights	% none stated
Primary	Produces a substance that transforms metals into gold or silver	175	80	18	2
Intermediate	Prepares materials required for primary procedures	127	95	5	0
Reagent	Produces a chemical used in other procedures	51	75	24	2
Preparation	Instructions for a method used in other procedures (dissolving, softening)	36	14	3	83
Total		389	78 %	13%	9%

Table 3 compares the use of absolute weights to the use of proportions in the procedures by type. For example, intermediate procedures, which prepare material for another procedure, almost always specify quantities by proportion, which makes it easy to prepare the amount that is needed without calculations.

Semi-quantitative estimates, the third method of measurement al-Rāzī uses, work well for manipulations that do not involve mixing chemicals. These procedures often specify a familiar object on which the laboratory investigator can base an estimate. “On the lowest portion of the open beaker is a hole; so big that the little finger passes through it,” specifies the Chapter on Sublimation.[266] Other semi-quantitative measurements describe making a hole that a needle can pass through or sprinkling an entire surface with oil “until there is no place that is free of oil.”[267] Some semi-quantitative methods are still used today for non-automated procedures. For example, the Centers for Disease Control web site has a procedure for preparing malarial blood smears which reads, “Using the corner of a clean slide, spread the drop of blood in a circle the size of a dime (diameter 1-2 cm). Do not make the smear too thick or it will fall off the slide. (You should be able to read newsprint through it.)”[268] In this procedure, the size of the blood drop, how much time one can take, and the thickness of the smear are all approximate. Any method of measurement requires hands-on training and practice under supervision in the laboratory, but none more than semi-quantitative methods, which may sound easy, but in reality depend on judgment informed by experience.

Faraday’s quantification resources are remarkably different. He is very precise about measurements, using phrases like: “A cubic inch of water at 62 º, it will be remembered, weighs 252.458 grains.”[269] Even so, duplication of this measurement by any other laboratory requires external standards and calibration enforcement. Al-Rāzī’s methods would have enabled replication within his laboratory, if he consistently used the same measuring containers or weights and if they weren’t altered over time by wear or residue buildup. Faraday specifically warns against these risks of usage.[270] Al-Rāzī does not address accuracy directly, but he would have recognized these pitfalls that were common to the goldsmith, the metal worker, and the marketplace. To ensure success, his ultimate requirement was the achievement of a specified end point.

END POINTS

The end point is the most important verification requirement in

laboratory procedures. In the laboratory, a detectable end point indicates when a process is complete or when it is time to proceed to the next step. It shows that the required conditions have been met, an assurance of repeatability. An end point in chemistry can be defined as "a point marking the completion of a process or stage of a process."[271] When Faraday refers to carrying out a process until the flame turns blue or the litmus paper turns red, [272] he is using color as an end point, one of the most common indicators still in use today even in automated testing. Forensic laboratories regularly start a bomb investigation with a color test, such as the diphenylamine test, which turns blue to indicate the presence of certain explosives.[273] A standard clinical laboratory procedure of the mid-twentieth century ends a titration for ammonia: "Endpoint is a blue-gray or a dirty blue."[274] A chemist either looks for a visible change produced by the chemical reaction itself or monitors the results with an indicator that was not a part of the reaction, but that undergoes a visible change it comes in contact with the reaction product. Al-Rāzī used both of these methods.

Color change is the most common end point in the *Kitāb al-Asrār*. Most procedures conclude with a phrase such as: "until it is black," "until it [the smoke] begins to come out white," "red as liver," "red as blood," or "white as snow."[275] Al-Rāzī also frequently uses changes in consistency: "until it is like foam," "like honey," "as thick as tar," and most often, "an impalpable fine white powder," a description also used by Faraday.[276] Carrying out a heating process until the mixture starts to smoke or ceases to smoke is another common visual end point in the *Kitāb al-Asrār*.[277] Occasionally the procedure calls for the chemist to place the powder on the tip of his tongue to test solubility, again, a test Faraday employed in the nineteenth century.[278]

Flammability is another important end point, used four times in the *Kitāb al-Asrār*. When distilling oils, the procedure stipulates: "Do this with it several times, until it ignites no fire"[279] The distillation of naphtha instructs: "Make naphtha into a paste with an equal amount of sal ammoniac and distill it. Do this with it, until it distills like water and absolutely does not ignite a fire."[280] The use of flammability as an end point shows that al-Rāzī recognized it as a chemical property, along with color, smell, consistency, and solubility.

Two more complex end point methodologies in the *Kitāb al-Asrār* use test tablets or weight change to detect the success of the desired reaction. The

test tablet is a flat surface of a known metal such as copper or silver to which a sample of the test substance is applied.[281] A test for whitened stable sulfur free of black residue states: “the indicator for that is that is you sprinkle some of it on to a heated silver test tablet, it does not blacken the tablet and flows over it and does not smoke.”[282] Less common is the use of weight change, which is used to detect loss of moisture in three procedures. One instruction reads: “grind it and weigh it and repeat the procedure until it remains unaltered at one weight that does not diminish.”[283] A procedure for distilling a solution made with hair states: “Then weigh the remaining water, so that you know what has been taken from it.”[284] Faraday uses the same concept, more quantitatively, in a teaching exercise that requires weighing out sixty grains of crystallized muriate of baryta, heating it to drive off moisture, and then weighing it again: “When cold, re-weigh it and ascertain the diminution occasioned by the dissipation of water. It should equal 8.71 grains.”[285] When modern histories of alchemy and chemistry refer to the *Kitāb al-Asrār*, they comment on al-Rāzī’s classification of chemicals or his description of equipment, but almost never on the methodology used in his procedures. Yet these procedures display a remarkable consistency, not the least of which is that ninety-five per cent of them have a defined end point.

The similarities between Faraday and al-Rāzī’s use of end points are not coincidental. Both are keen observers who describe how to detect matter’s altered states, and one might conclude that their observations correspond because the behavior of matter has not changed. Yet there is much more to this similarity than the ability to interpret the manifestations of chemical transformations that occur through natural processes as substances become wetter or drier, combine, rot, evaporate or burn. Both scientists created an artificial environment, the laboratory, for the purpose of developing processes that do *not* occur in nature. They combined substances in predetermined proportions in a specific container so that only the materials they selected participated in the reaction. They subjected these mixtures to extreme or mild heat for a controlled time period. Faraday and al-Rāzī were usually not surprised by the results of their procedures. They knew exactly what to expect. That is why they were able to predict the end points.

CONCLUSION

My book encompasses three subjects: the knowledge of substances, the knowledge of equipment, and the knowledge of procedures.[286]

Al-Razi, Book of Secrets.

The history of the laboratory is not a linear series of great discoveries, but a scattered array of connections and dead ends, through which our species pursues its tireless propensity to test in an environment it can manipulate and control. The *Kitāb al-Asrār* is but one thread of many that brought the modern laboratory into being, but al-Rāzī's book was by no means a dead end. The *Kitāb al-Asrār* put laboratory testing into a systematic structure that alchemists alternatively copied, discarded, and modified throughout the Middle Ages. Its author held the unique advantage of being renowned for his medical volumes, which may have contributed to the wide distribution of the *Kitāb al-Asrār*. Yet copies of the text persisted through translations and adaptations even when its author was unknown. "Who is the author of this little book?"[287] mused archivist Hartwig Derenbourg, in his 1884 catalogue description of MS Arabe 700, the Escorial manuscript of the *Kitāb al-Asrār*, a handbook-sized manual carefully preserved to this day even though it does not bear its author's name. The content of the *Kitāb al-Asrār* speaks for itself.

The text of the *Kitāb al-Asrār* shares the same unwritten assumptions of

the modern laboratory manual: literacy, technical knowledge, dedicated space, financial resources, and reproducibility. It assembles a pattern of strategies for reproducibility by addressing the physical requirements of equipment, fuel, and chemicals, as well as operational requirements of clarity, practicality, and safety. Most significant of all, the procedures in the *Kitāb al-Asrār* specify verification criteria: time, temperature, weights, proportions, and endpoints. These components do not come together by chance. They occur, as a set combination, in laboratory manuals up to the present day. They prove that the author of this laboratory manual intended the procedures to work, and intended them to work more than once.

In comparing the *Kitāb al-Asrār* to later laboratory manuals, I do not mean to suggest that chemistry did not change. Al-Rāzī wrote procedures for transforming metals and precious stones into gold. Libavius brought together a wide range of procedures for making medicines, dyes, oils, as well as transforming metals, gathering them all under the chemistry umbrella. Faraday wrote about the properties of matter and the expansion of gases. After the publication of *Chemical Manipulations*, he broke new ground in his work with investigations of electrical conductivity and magnetism. The boundaries of chemistry shifted and adjusted, and by the mid-nineteenth century chemistry staked out its own dominion, a delimited space, separate from physics, pharmacy, and medicine, but never quite on uncontested territory.

The transmutation of metals lost its theoretical bearings and the meaning of the word *alchemy* shriveled into an outdated term for a futile process. Having captivated top intellects from Albertus Magnus (c.1193- 1280) to Isaac Newton (1643-1727), alchemy was thoroughly discredited by Enlightenment chemists. Pierre Joseph Macquer (1718-84) stated: “The alchemical mania was (a) leprosy that disfigured chemistry and opposed its progress.”[288] This total disassociation of alchemy from chemistry persisted into the twentieth century. In 1954, historian A. Rupert Hall echoed Macquer almost word for word, claiming “. . . its persistence (transmutation of metals) was the greatest obstacle to the development of a rational chemistry.”[289] Modern authors exhibit less condemnation. In 1992, William H. Brock wrote cautiously: “To the extent that it undoubtedly stimulated empirical research, alchemy can be said to have made a positive contribution to the development of chemistry.”[290] French social theorist Bruno Latour uses the concept of a “black box” to encompass the artificial and inscrutable environment in which

modern laboratories construct reality.[291] To marginalize medieval alchemy into the annals of superstition is to put a thousand years of laboratory history into a "black box."

Recent historians, however, are finding more ways to integrate both alchemy and the laboratory into the history of science. William Newman and Lawrence Principe, for example, incorporated the laboratory notebooks of English chemist/alchemist Robert Boyle and American alchemist George Starkey into an historical analysis of the shifting definitions of alchemy and chemistry in the sixteenth through eighteenth centuries. David Gooding scrutinized Faraday's notebooks in order to learn how scientists use the laboratory to produce knowledge, and Owen Hannaway compared the laboratory designs and floor plans of Libavius and Danish astronomer Tycho Brahe. Historian Marcos Martinón-Torres examined archeological findings to study physical evidence left by laboratories of the early modern period.[292] Taking the study of the early modern and medieval laboratory back to the tenth century may help uncover key connections linking the history of science and medicine with politics, economics, and technology.

One line of research would be to analyze the relationship of quantification inside and outside the laboratory to compare the concept of time, temperature, and weights in science, medicine, religion, and the marketplace. Another approach might look at the laboratory's interdependence with the larger society. Pamela Smith's *The Business of Alchemy: Science and Culture in the Holy Roman Empire* demonstrates how the need for patronage brought laboratories into engagement and sometimes conflict with economic, political, and social agendas.[293] In the nineteenth century, scientists like Pasteur and Liebig promoted the economically significant laboratory and the same era saw the development of the first laboratory accreditation programs.[294] These events have roots in the historical balance of power, dependence, and trust between medieval rulers, alchemists, pharmacists, and their laboratories. For thousands of years, civilizations prospered without laboratories, and yet today they are so integrated into our economy and way of life that shutting them down would invite catastrophe. In 1992, *The Laboratory Revolution in Medicine*, edited by Andrew Cunningham and Perry Williams, posed the question: "Why should the laboratory have become so dominant in modern medicine?"[295] One might well ask: "Why should the laboratory have become dominant at

all?" The history of alchemy and the laboratory holds the key to this question.

It seems, in the end, remarkable that the *Kitāb al-Asrār*, written so long ago, has any connection with the sophisticated computerized laboratories of today. Nevertheless, alchemy asks the historian to look beyond the immediate goals and theories of science, which are, with apologies to Kurt Vonnegut, stuck in time,[296] and recognize that the book embodies the very reason for the laboratory's existence – to deliver reproducible results. Leafing through the laboratory procedures from a modern medical diagnostic laboratory, the headings still repeat: "Reagents," "Equipment," "Procedures." [297] In *The Structure of Scientific Revolutions*, Thomas Kuhn points out that when the boundaries of research shift and the efforts of previous investigations are abandoned, "part of that achievement always proves to be permanent." The lasting achievement of the transmutation of metals may be the concept of the laboratory itself, embodied in a book.[298]

THE TRANSLATION OF THE *KITĀB AL-ASRĀR*

Seventy years ago, science historian and language scholar Julius Ruska translated the *Kitāb al-Asrār* into German using three Arabic manuscripts, from Göttingen, Leipzig, and photographs of a manuscript in the Escorial. On a recent visit to the Real Biblioteca del Monasterio at the Escorial in Spain, I was able to see the Escorial manuscript, catalogued as MS Arabe 700, and hold the book in my hand (Figure 5). It consists of 91 pages bound in a brown cover, measuring 13 by 17 centimeters (smaller than a folded sheet of ordinary paper) and sits easily in one hand. The pages are flexible paper, not brittle, and the writing is a clear and even black script, sixteen lines per page, having one to five words in red on each page, possibly section headings. It shows no signs of wear or damage, so it was probably not actively used in a laboratory, and yet even in the fifteenth or sixteenth century someone thought it important enough to make a very careful copy.

By rendering Ruska's scholarly German translation into English, I hope to make the content of this book accessible to English-language readers. Since Ruska's translation is based on three Arabic manuscripts, he is careful to note where they differ, and, because these are manuscripts, an occasional sentence is incomplete or illegible in all three sources. I have followed Ruska's conventions, including his parenthetical phrases, his italicized phrases, the use of the letters G, L or E to indicate differences in the manuscripts, the insertion of the symbol * to show parts missing in the Leipzig manuscript, and the consecutive bracketed numbers ([G1], [G2]) which indicate the corresponding pages of the Göttingen manuscript.

Figure 5. The *Kitāb al-Asṭār* may have been among the 4,000 Arabic manuscripts acquired by the Escorial library during the reign of Phillip III of Spain (1598-1621). (Photograph by author, 2007)

I have parted from Ruska in my choice of chemical terms. I chose to use familiar names for chemicals and containers as much as possible, even when Ruska chose to retain the Arabic name. His commentary points out that many of these chemicals were not available in the standardized form we know them today. However, using the term *arsenic sulfide* in place of *zarnich*, for example, not only makes it easier to follow the flow of the procedure, but also clearly shows that the procedure concerns handling a poisonous substance. In deciding which English language terms to use, I referred to Ruska's commentary and to the English translations used by Holmyard and Stapleton, both of whom knew Arabic. Of course, all errors are my own.

The *Kitāb al-Asrār* offers a view into the chemistry and procedure organization of the tenth-century Islamic world. Yet a careful reading yields even more than that. As a laboratory manual, it gives intriguing clues into Persian culture under the Abbasid caliphate: the relationship of teacher and student; attitudes toward safety, labor, and quantification; tools and logical problem solving; commerce and the availability of luxury goods; and the value of the written word. This is the *Kitāb al-Asrār*.

KITĀB AL-ASRĀR: OUTLINE

THE BOOK SECRET OF SECRETS

In the name of God the All-merciful God bless our Lord Muhammad, the Pure, the Noble [G[299]] Thus says Abūbakr Muhammad Ibn Zakarīyā al-Rāzī: Glory be to God, a glory that is worthy of his grace and in accordance with his beneficence. God bless our Lord Muhammad and his family and his companions. Let there be glory to him and peace!

What led me to write this book was the request of a young man among my students, an honorable man named Muhammad ibn Yūnus, well-versed in mathematics, natural sciences, and logic, one of those whose readiness to serve me is great and who has a right to my service in return. He asked me – after I was finished with the twelve books about the Art and with the refutation of al-Kindī and of Muhammad ibn al-Sinnī al-Rasā'ilī[300] – if I would like to put together something about the workings of the art of secrets, that would be a guide that he could follow and a model to which he could turn. So I have written this my book for him and with it given him something that I have never once given any king or prince. I have explained to him that which is indispensable in the science of the chemical arts from all my other books on this subject and compiled one compact, concise book on this subject for him, the title of which is *The Book of the Secret of Secrets.* Using it, the (status of) metals committed to its processes will be elevated, and (the elevated metals) broken down again and returned to their original state. Therefore I describe these procedures. God guides us to righteousness, the longing to fulfill that which we have described is directed towards him; he is the dispenser of mercy.

In the book are (also) chapters that the adept and the scholars have not seen. If I did not know that my days are numbered, and that my death is near, and if it were not for my concern that this service that I want to render out of friendship might be prevented by my death, I would not have brought all [G2] this together in my book and I would not have tried to bring it to such a

state of perfection.

My book encompasses three subjects: the knowledge of substances, the knowledge of equipment, and the knowledge of procedures.

* * *

Section One: What one must know about Substances

Part one: Substances Required for the Chemical Art

1. Concerning substances, there are three classes: animal, vegetable, and mineral. But the minerals fall into six groups: spirits, metals, stones, vitriols,[301] boraxes,[302] and salts.

2. Of spirits, there are four: mercury, sal ammoniac[303], sulfur, and arsenic sulfide[304].
3. Of metals, there are seven: gold, silver, iron, copper, tin, black lead, and Chinese iron.[305]
4. Of stones, there are thirteen: marcasite,[306] magnesia,[307] iron ore,[308] tutia,[309] lapis lazuli,[310] malachite,[311] turquoise, hematite, white arsenic,[312] kohl,[313] talc,[314] gypsum,[315] and glass.
5. Of vitriols, there are five: black vitriol, white vitriol, yellow vitriol, red vitriol, and green vitriol.
6. Of boraxes, there are six: borax of bread,[316] natron,[317] borax of goldsmiths, tinkar[318], borax from Zarāwand,[319] and borax of willow.
7. Of salts are there eleven: good salt, bitter salt, mountain salt,[320] Andarānī salt,[321] naphtha salt, Indian salt, soda,[322] urine salt, salt of ashes, salt of lime[323], and salt of egg.

* * *

Part Two: About Distinguishing the Good and Bad Varieties

1. The types of spirits

8. Mercury. The best must be white and soft. When it is pressed through a cloth, no residue resembling kohl (eye powder) must

remain behind.

9. Sal ammoniac. There are two kinds. One of them is mineral, white, fissile, hot, salty, pungent; (G it is brought from Khorasan and Samarkand), and there is (also) a yellow kind, which is of no use in the Art. [G3] The other kind is (L artificial imitation) sal ammoniac from hair. (G E We will mention this sort in the procedures with animal stones, as God wills.)
10. Arsenic sulfide.[324] There are various kinds. Among them is a greenish kind, mixed with earthy rocks; this is the most worthless of the arsenics. Then one that is yellow and impure, mixed with earth; this is used in baths. Then a saturated yellow, flakey, gold-colored one; this suits us and is excellent. Then a yellow one, mixed with red; this is (L likewise) excellent for our work. Another, that has gray flecks, is not useful to us. A red one, pure red and flakey is especially excellent for our work.
11. Sulfur. There are various kinds. The red is unknown. A yellow variety is dense, (glassy) like sandarac,[325] very pure. Another yellow one is grainy, pure and a saturated yellow. One variety is as white as ivory and one is white mixed with dust; this is not suitable for us. One is black and not suitable (L and all the others are suitable.)

2. The metals

12. Concerning metals, we do not need their description (L since they are so well-known), apart from Chinese iron (G E but this shines like a mirror), only that it is even (smoother); it is unknown.

3. The types of stones

13. Marcasite. There are various kinds (colors). Among these are a silvery white variety, a red copper variety, a black iron variety, and a yellow gold variety.
14. Magnesia. There are various kinds (colors). Among them is a black earthy one, with sparkling eyes. Then there is also a hard iron type, which is male. There is a red variety with a crust,

which is female; this one has glittering eyes and it is the best of its kind.

15. Iron oxide.[326] There are two kinds, the one from Istahr and the one from Iraq, and the best of them is from Istahr.[327] It is the water of iron.
16. Tutia. There are various kinds (colors). There is a green one, in pieces; then a yellow and red, with a bark resembling cane. Then white one with a thin bark, the Indian variety; then a yellow stemlike one, the mahmudish; finally there is a red (E green), from Kerman.[328]
17. Lapis lazuli. There is only one kind. It is a dark blue stone, which has a little red in it, and has eyes that sparkle like gold.
18. [G4] Malachite. There is a green stone with veins; Official seals and amulets are fashioned from it. There are new and old, from Egypt, Kerman, and Khorassan; the old Kerman stone is the best kind.
19. Turquoise. There is only one kind. (E It is a green stone) and grease enhances its shine (E beauty).
20. Hematite. There are two kinds. It is a red stone; one of the two is the color of lentils, the other is a yellow-red. The lentil-colored is the best.
21. Concerning the malachite, lapis lazuli, turquoise, and hematite, they are all oily stones (E like gold), (E and all make gold red and color it, because they possess the same substance as copper.)
22. White arsenic. There are two kinds, one yellow and one white. It is brought out of silver mines (G E and is the smoke of silver.)
23. Kohl. There are two kinds. One of them is dense, breaks like glass, and comes from (G Isfahan and) Ray. The other is grainy and (also comes) from Isfahan. (G E It does not belong to the stone-like (actual) stones), but instead is the stone of lead.) (G I mean, in its fundamental substance.)
24. Talc. There are various kinds. To this group belong one from Yemen and a sea-talc and a mountain-talc. They break into flakes when crushed, and have a glittering appearance; the best kind is from Yemen.
25. Gypsum. There is only one kind and it belongs to the mountain stones.

26. Glass. There are various kinds. It is produced from sand (E and soda). The best of them is Syrian, white, pure, as clear as rock crystal.[329]

4. The kinds of Vitriol

27. The vitriols. There are various kinds. Among them is a yellow, dense, hard kind. Then there is a yellow one, with golden eyes, which the goldsmiths use. In addition, there is a green variety, which is mixed with dust, and is used by shoemakers and dyers.

28. Alum. There are various kinds. Among them is the kind from Yemen, white (G fibrous, fissile); in addition, the Syrian, white, mixed with clay and rocks; then the Minğānī, the color of which resembles green, then the yellow Egyptian and the white, stable kind.

29. The qalqadīs is white vitriol, the qalqant is green vitriol and the sūrīn is red vitriol, the qalqatār is yellow vitriol.[330] [G5] These four are strong, and the sūrīn is the strongest. It finds an application in the chapter on reddening. It is brought from the mines on Cyprus. Its origin is vitriol; it is washed up with the spring waters and with it comes to

the depths of the mountain mines. Learned men make a substitute for it and this works more effectively, as God wills.

[L] Third part. About the knowledge of artificially producing of the afore-mentioned substances.

30. Production of white vitriol: Take pure white alum, dissolve and clean it, then distill vitriol and copper acetate[331], mix them with the liquid of the cleaned alum and let it solidify in a beaker, and thus it will become the best white vitriol that there is.

31. Production of green vitriol. Take vitriol and dissolve it in water, purify it, drop in some copper filings and boil it until it turns green. Then purify it, put it in a copper kettle and cook it, after you have added a half dirham[332] sal ammoniac to every ten dirhams, (and let it stand) until it has solidified, as God wills.

31a. [E] Even better, when you dissolve and purify the vitriol, and put it in a copper kettle and dissolve it, after you have added a half dirham sal

ammoniac to its ten dirhams, until it solidifies.

32. Another way. You take yellow vitriol, cook it and then purify it, add to it just as much copper acetate as vitriol and let it stand for several days, until it dissolves and turns green. Then purify it and let it solidify, as God wills.

33. [E] Another way. You take vitriol, dissolve it and purify it, add an equal amount of ferric oxide to it, cook it vigorously and purify it, so that it comes out red. It sometimes takes the place of red vitriol.

34. The production of yellow vitriol. You take vitriol, purify it, add the liquid of a distilled egg yolk in the amount of a quarter of the vitriol and let it solidify.

35. Production of red vitriol. You take dissolved and purified vitriol, saturate it with the liquid from copper acetate and roast it until it turns red.

36. [G E] These are the vitriols, which the learned prepare; they are more effective than the mineral ones. So pay attention to their production and use them as needed, as God wills.

5. The Kinds of Borax

37. [G6] There are different kinds, among them the borax of bread and the borax of the goldsmiths. The borax of bread consists of small white and large hard pieces. Natron also belongs to these; this is better than the borax of bread. Concerning the borax of goldsmiths, it is white and resembles the efflorescence that forms at the base of a wall. The borax from Zarāwand also belongs to these; its color (E is like dust and) pounds into red, and is the best of the boraxes. Out of these tinkar can be made, that is the artificially made borax.[333] The following is the description of its production.[334]

38. [E] This is how to make tinkar. Take one part salt of soda, the choice white kind, and three parts white purified borax and pour buffalo milk on it, so that it covers them; boil it together until it solidifies; form little balls out of it, dry them and protect them from dust and use them.

39. [E] Better yet, you take one part white salt of white soda and three parts natron; boil it with cow milk and buffalo milk, poured it over three times, form little balls out of it, and dry it and hang it in the sun,

until it sweats, and pound it and use it as needed, as God wills.

40. Description of the production of tinkar. Take white salt of soda, that you have made clean, and natron, and purified borax, Andarānī salt, urine salt, and sal ammoniac, one part of each, and pulverize them all with cow milk or with buffalo milk in a measure that equals its volume. Then place it in the sun forty days, until its oil is sweated out and it shines within like rock crystal, as God wills.

To these belongs also the borax of willows. It comes from the willow tree (and is) white.

6. The Kinds of Salt

41. (To these belong) good salt and table salt and bitter salt and that which the goldsmiths use; (furthermore) the Tabarzand, that is a white, pure salt with (E without hard pieces) luster (E and Andarānī salt), two kinds, one of which is white, pure, without luster and the other red, large pieces; from that one the crucibles and *sawani*[335] are turned. In addition, the naphtha salt, hard black pieces without luster, with a smell of oil, then the Indian salt, black, fissile, with very little luster, and the Chinese salt; of which it is only known that it is white and hard and that the smell of boiled eggs clings to it.

And concerning the soda-salt and the urine salt and the quicklime and the ash salt, these four salts are made artificially.

(G the production of soda salt has already been covered.

42. [E L] The preparation of soda salt. Take a half-ratl piece of white (L pure) soda, grind it up, pour seven times as much water over it and let it stand seven days. Then put it in a kettle and boil it until it is reduced by half, and let it settle. Then strain it ten times and put it in thin-walled jars and hang them in the beaker. And what crystallizes at first, grind it and mix it back in. And what drops out of the beaker, protect from dust, and what crystallizes on the jars the second and third time, grind it and save it until you have obtained all of it as a salt, as God wills.

It is even better, when you want to achieve the utmost purity, that you put it in a bottle that is sealed with clay; secure its plug and lay it in hot ashes

until the salt has solidified like mountain salt, as God wills.

43. Description of the production of ash-salt. Take white ashes of oak,[336] in which no coal is mixed and that has no smell, strain it through silk and proceed with it as with soda-salt, and a white salt will result.

44. Nura-salt: Take quicklime and handle it like the soda-salt.

45. Concerning the preparation of urine salt, take ten liters urine and bring it in a bottle (decanter) into the sun or (G in a glass bottle) forty days long in the most heat possible, so that it solidifies and turns to salt; if not, (E G put it in a glass bottle, cover it with clay and) let it become solid in hot ashes (E G ashes of a fire); (E G and each time when the ash becomes cold, replace them) until it solidifies into (L pure) white salt as God wills.

46. * Another way. Take from it as much as you want and let it age for a month. Then you distill it, put into each liter of the distillate four uqia of soda-salt and let it solidify for three days in hot ashes, and it will solidify in this time as God wills.

47. * Another way. You take from it as much as you want, let it age one month and distill it. Then calcine its residue until it becomes white,[337] then put in each liter of that which you distilled, three uqia of the hardened residue, two uqia soda-salt and one uqia egg shell calx and let the salt solidify over (hot) ashes (E thus it will become solid like crystal.)

7. About the Other Substances

48. The substances break down into two groups, into natural matter and non-natural matter. Natural matter includes egg, hair, metallic and simple stone-like matter. Artificially-made matter includes copper acetate, ferric oxide,[338] *Iqlīmiyā* of gold,[339] silver slag, lead oxide (smooth lead),[340] the saqmūniyā, the usrunğ (red lead), the zarqūn, the isfīdāğ (white lead) and the rūsahtağ.[341] I will describe which ones apply to our work, as soon as we need them. [G8]

49. Concerning plant substances, apart from those that the understanding of the learned is small, and they make little use of them, the best of those that are useful are the trees with the long seeds.

50. Concerning the animal substances. From these, the adept

prepare their elixirs and refer to them and point them out and for them they use secret names. There are ten stones, namely hair, skulls, brains, bile, blood, [eyes], milk, urine, mussels, horns, and egg. The strongest of them is hair, then brains, (E then bile), then eggs, then skulls, then

blood. We will describe (the most important) of their elixirs, when I come to that place, where it is necessary that I describe them in this our book.

* * *

Section Two: What one must know about Equipment

Part One: About Equipment for Smelting[342] Metals

1. We have (E in another place) already stated in our book that there are two groups of equipment: one for smelting metal, the other for working with substances.

2. The equipment for smelting is well-known; it is the following: smelting oven, bellows, crucible, hammer, firetongs, double crucible, plate shears, and crusher.[343] They are found at the goldsmiths, with the exception of the double crucible which is not found at the goldsmiths.[344]

3. The double crucible consists of a crucible below and another on top that has (E one or) two or three holes (E in the lowest) in the bottom. You put that which you wish to melt down in it, made into a paste with natron and olive oil. (E the crucible is placed in

the smelting oven), (E covered and) pounded down with coal and blow on it with bellows[345] as with (the smelting oven for) copper, or if it (E the substance to be melted) is iron or something like it, or (with) talc three times . . . (?)[346]

4. * *The secret of smelting* is that the bellows bag must be large and its blowpipe as wide as the eye of the bellows and the mouth of its pipe should be as wide as a farthing[347] and the wood at the back end of the bag should be shaped and made tight with light leather thongs.

(E description of the smelting oven). Furthermore, it is necessary that

the smelting oven has a well-fitting lid and a well-fitting openwork grating [G9] that is placed inside the oven, and that you surround the crucible by coal on all sides; (E and it is especially necessary that) coal is arranged (E firmly under the crucible), if you smelt refractory metals, especially iron and iron ore and steel; because these must be smelted in a large oven and with coal from the coppersmiths (E or with cane coal).

5. (E About smelting iron. And the procedure with which iron is smelted by fire consists of this, that the iron) is heated (G roasted) with a fourth part of red arsenic sulfide or a half part of yellow arsenic sulfide in clay-coated cloths in an oven (tannūr)[348]

that is heated up with a powerful fire. (Then it is) washed repeatedly with water and salt, dried, and made into a paste with olive oil, after you have mixed it with a sixth part (E red) natron. Then smelt it and let it flow to the middle of the double crucible.

6. * And if you want it to turn white, then mix it with equal parts white Syrian glass and the best crystal-like sal ammoniac made into a paste with olive oil, and pour it on the ground each time into a dry mold. You do this until it is white and soft; then grind it with an equal amount of tin, then it is as fire resistant as silver. We will reach our purpose for it when we come to the main chapters.

* * *

Part Two: The Equipment for Handling Nonmetals

7. Concerning the equipment for handling nonmetals, it includes the curcurbit[349] and the alembic[350] with the beak and the receiver, vessels and blind alembics[351], the aludel,[352]

the stove, beakers, flasks and vials, grinding plates[353] and the graters, the oven, braziers,[354] the self-ventilating oven,[355] containers and round molds and others like these, that one needs.

8. The curcurbit, the alembic with the beak and the receivers are

suitable for distilling liquids. *The secret of this is*, that the vessel must be large and thick-walled, without fissures in the bottom, and that there must be no blisters in the walls, and the alembic must fit on it tightly. The kettle, in which the alembic is placed, should be shaped like a cooking pot, and the vessel must be immersed in the water (of the kettle) up to the highest level of the material that it contains. Furthermore, a large cauldron of boiling water must be ready on the stove to fill the kettle (L the waterbath) when [its water level] is reduced. And watch out lest the vessel touch cold water and secure the vessel so that it cannot move, and that its bottom does not touch the bottom of the kettle, or it will break.

9. Sublimation[356] can also take place in clay vessels that are placed on the stove in a saucer of potter's clay. It is heated with a gentle fire and when the stove is hot and it

begins to distill fast, stop the heat until it (the contents of the vessel) comes to rest and the distilling has ceased.

The vessels can also be placed in a kettle with (L K sifted) ashes and heated from beneath. That is the best method for beginners.

One can also place a large brick on the bottom of the stove where the bottom of the kettle stands, and put ashes on it and stand the kettle on it and pack sifted ashes around the sides of the kettle. Then heat it; however it is necessary for you to secure the end of the tube and the mouth of the receiver (make it tight) so that the smoke of the fire does not enter it and the air pollute the contents.

10. * There are four kinds of alembics: one alembic with a very wide spout, for distilling the blackness from calcined substances and suited for sublimation of sal ammoniac; then one alembic without an especially wide spout, this is for distillation of essences (K and impurities and colors) and suited for sublimation; then an alembic (with a spout) that is still narrower; it is suited for distilling stones at the beginning of the work; finally an alembic with a very narrow spout, it is suited to evaporate liquids and purify them.

11. The cucurbit[357] with the blind alembic is suitable for dissolving spirits and softened metals. [G10] It is an alembic with a gutter and without a spout. You place that which you wish to dissolve

into the gutter, and one of the sharp waters[358] into the cucurbit. Then the alembic is set on top of it and the connection is sealed and the whole thing is placed in a kettle of water. This apparatus is suitable for nothing other than dissolving, and (the kettle) is the bath which is mentioned.

12. The blind is a fitted beaker, set on top of a cucurbit, in which things to be dissolved are placed. It is hung in a fitted oven and a burning lamp or coal or hot ashes are placed under it. One must watch, however, that the fire does not go out (E and the ashes do not get cold, before it has dissolved and solidified.)

13. * The equipment is made out of glass and potter's clay and stone[359] and iron and crucible clay; with none of them however can one do without the artist's clay (E to coat with clay).

14. To make artist's clay. You take pure red or white viscous clay, free from stones, spread it in a clean place and sprinkle water on it several times, until it is (sufficiently) saturated and dissolved and its grains so (fluid) that the hand no longer feels them. Let it

stand there until it is dry (again), then pulverize it (E K as the jar makers do, and sift it through a flour sieve and grind it with a mortar) and sift it through silk (E K or through a hair sieve or a flour sieve); then saturate it with water, in which rice bran, from which flour is made, was softened. Then knead (the clay) thoroughly and let the dough soften a day and a night. You then take clean rice[360] and sift it (E through a large hair sieve, so that all the dust falls out of it; then sift it with a fine sieve), and after you have pounded it (again?),[361] mix it with an equal amount of the softened potter's clay, adding to each pound (*ratl*) the weight of ten dirhams of table salt, and the same amount of rice, and a third pound of ground and silk-sifted pot shards, and a hand full of animal hair, cut up as fine as possible. Let it stand three days and use it, for it is the best artist's clay that there is. And the success comes from God.

15. [G11] The chapter on the production of the aludel[362]. You take a vessel in the shape of a large pot[363] one ell long and two fists wide. Then lay it on a flat surface and scatter (one and a half fists) sifted ashes all around it. Then remove it again and place a cover (E made of artist's clay) on the sifted ashes around the kettle, let it dry, and lift it

(out of the mold). Then you coat the outer surface and smooth it over with (a mixture of) white lead and egg white, and coat it a second time and make a gutter around its edge and leave a place in it open, so that the sublimated substances can be collected.

You now let it dry, then you turn the upper part of the aludel with the opening beneath and coat evenly it with clay, (E K from medium grain, E not too big and not too fine). Then set the cover on the kettle and seal the joint with clay on both (E on all) sides. Also make a continuous wing under the cover, so that the fire does not come in contact with what is on the cover, and perhaps scorch and ruin it, and set the lid on it. *There is a secret about this*, which we will mention, when we come to the description of the sublimated substances.

16. * Concerning the mustauqid (oven), it is a small oven (tannūr) about the size of an aludel. The bottom of the aludel is made to exactly fit within the interior wall of the oven, so that the fire does not touch the sides of the kettle (E except only the lowest part of the aludel and nothing else). In the lowest part is a cavity into which coal can be placed. Its upper end is narrower than its bottom – I mean the oven – and opposite the door of the oven is a hole bored under the winged rim, through which the smoke escapes, as God wills.

17. The aludel is for sublimation of dry matter and the alembic with the beak is for distilling waters.[364]

18. The vials however are used to constrict[365] the sublimates. * Indeed sometimes the wise want to constrict any of the sublimated things. So they place it in vials and force it upwards, it rises into the neck and constricts in its upper section [like lead and tin] purer than before. And if it is a sublimated thing, that they want to constrict, they knead it with any oil and put it in the vial so that it becomes a pure substance within. [there is a wing, as we have mentioned.]

*The vials are spread with a paste of (ground) iron slag and egg white. They are left to dry and coated over with artist's clay, so that the fire cannot actually come into contact with it (directly against the glass). If there is (E no oily matter in it, seal the top after coating [the vial], and if there is) oily matter in it, then swab its top with clean white wool. Each time that it is saturated, take it away, press it out, and set another in its place, and when that

one is saturated, take it away again and set the pressed one in its place (and continue with this) until no more moisture remains in the vial at all [E and you burn one of the two wool swabs.] Its top is then sealed (plugged) with (E roasted) salt and clay, indeed one must use hot water for the paste made of salt and clay so that the vial and its contents do not get cold. *And this is the secret* of coating the tops of the vials with clay.

19. One needs the beakers only for roasting substances. * The alchemists often soak their substances with waters and put them (G dissolve them) between two clay-coated beakers and make a tight bond between them with laces (and a paste) smeared on a cloth, or with salt and barley flour in the same way with the mallow herb[366] smeared on a cloth, or with lime, that has been kneaded into a paste with egg white. Then spread clay over them also and roast them over a dung fire or in an oven (tannūr), as long as necessary.

20. Concerning the grindstones and the grater, one needs both to grind substances.

21. The atūn is similar to a small kiln. It is used to calcine metals, until they turn to white calx.

22. The tābistān is an oven similar to the oven of the metal molders. [G13] [E They heat drachmas until the fire transforms them.] They put into it that which the fire should contact on its upper surface, and on which the oil should be burnt, or that which the chemists want to heat and roast.

23. The self-ventilator is an oven (*tannūr*) which has its lower part narrower than its upper part. It stands on three feet and is placed on a saucer, whose walls have holes through them. In the middle of its base there is a hole, through which the ashes fall out. Coals are poured into its lowest part, and that which must be calcined is placed on them and buried in the coals and covered over with coals. Place it where the wind blows

through it. Its fire is exceedingly strong, it calcines the metals and combines them and melts them.

24. The clay box[367] is made of clay and serves to purify. One places in it that which is to be purified, namely a sheet of metal, a layer

of the medium and a layer of the metal sheet. One sheet is brought to the other, the bond of the container and lid is secured and then heated.

25. Metal filings are handled with a round mold. One mixes them with the medium, with which the powder of the metal is to be treated; it is tied up in a sturdy cloth and spread with clay, similar to a ball, and it is roasted to the desired level.

With that, the description of the equipment is ended. Now we begin to describe the chemical processes, which we discussed at the beginning of the book, so that this can be a guide to those who look within.

* * *

Third Section: About the Individual Parts of the Procedures

1. The procedures are divided into seven parts:

The first part is the purification of spirits and the calcination[368] of metals, stones, eggshells, mussels, and residues.

The second part is the softening of spirits, lime, salts, and such.

The third part is the dissolving of spirits and the softened lime and the salts and boraxes.

The fourth part is the blending of dissolved substances.

The fifth part is solidification, in order to take the process to its final state of perfection. [G14]

The sixth part is the sublimation of metals and stones, in order to transform lead, and such to full perfection.

The seventh part is the creation of red-coloring waters.

* * *

Part One: Handling Spirits and the Chapters on Calcination

A. Procedures for Spirits

2. Let us begin with the procedures for spirits. These are the coloring and the volatile, and in other than these there is no coloring

(coloring power). (G E Spirits are mercury, sal ammoniac, arsenic sulfide, and sulfur.) Mercury and sal ammoniac are volatile, and do not burn, arsenic sulfide and sulfur are volatile and flammable.

3. That which is desired from mercury is the absorption and elimination of moisture (wateriness), that which is desired from sal ammoniac is the purification and release from earthiness, that which is desired from arsenic sulfide and sulfur is the whitening and the elimination of oiliness and flammability.

4. Mercury, sal ammoniac, red arsenic sulfide, and sulfur are changed by reddening and whitening together, the yellow arsenic sulfide by itself (L especially) by whitening.

5. The treatment of mercury is carried out by solidification, sublimation, and amalgamation.[369] Sal ammoniac is treated by sublimation and amalgamation. Arsenic sulfide and sulfur are treated by sublimation, washing, and roasting (E and boiling).

* * *

I. The Chapter of Mercury

First Chapter. About the Solidification of Mercury

6. The beginning of its solidification is, that you take as much of it as you wish, and pound it with mustard for several hours, until it turns black. Then boil it with vinegar and salt, until it is clean, then place it in a pit in the ground and sprinkle oil over it, so that there is no part of its surface remaining that the oil has not touched. Then strew it with a light layer of ashes, which should be white sifted ashes, and pour melted black lead or tin on it. [G15] You melt it repeatedly and pour it on, until it is solid, as God wills. (E and pour . . . enough tin on it to cover it a finger deep. You do this until the whole amount is solidified like stone; I mean, melt the lead repeatedly and pour them on the mercury.)

7. Another way. You melt both leads in an iron spoon and then take them off the fire. And when they are almost congealed, submerge some mercury in them, for this, the

mercury which you have with you is placed in a woolen cloth (E

moistened with oil). Now you lay it in the middle and keep it there until it is as solid as a stone.

8.9.10 [G] And from this another. You wash it (read: sprinkle it) with white marcasite for whitening and with tin for whitening and with lead for reddening. And you

strew ashes on it by hand and then roasted alum for whitening, and red vitriol for reddening. And it is also changed (fed) with yellow sulfur, and for whitening sprinkle yellow arsenic sulfide on it and for reddening, red arsenic sulfide.

8. [E] And it is even better, when you sprinkle white marcasite on it instead of ashes, in case you want to whiten the mercury, and if you want to redden it, gold marcasite. Or pour tin on it for whitening and for reddening, lead.

9. [E] And it is still better if you use what was named in the first chapter on the mercury, for whiteness sprinkle roasted alum on it and for redness red vitriol.

10. [E] And another is, if you use the previously mentioned yellow arsenic sulfide for whiteness and red arsenic sulfide for redness, or for redness use yellow sulfur and for whiteness use sal ammoniac.

11. * However, concerning the pure solidification, that purifies mercury to permanent gold or to permanent silver, you will only find it takes place through the mineral, plant, and animal elixir combined. We will mention these when we have finished with the basic principles, or even earlier, as God wills.

Second Chapter. On the Sublimation of Mercury

12. Concerning the sublimation of mercury, there are two methods. (E one of them for reddening, the other for whitening; and *in its sublimation are two secrets.*) One takes place on removing its moisture (wateriness), the other serves to generate its dryness, so that it becomes completely dry.

Regarding removal of its moisture, this takes place through two processes (operations), after you have pulverized it that with which you wish to sublimate it; (indeed) while you roast it in a clay-coated flask on a gentle fire, take it off and pulverize it and roast it (again). Do this seven times, until

it is completely dead. Then sublimate (L or soften it, E pulverize it) with that with which you wish to refine it and roast it on a light roasting fire, and place it in an aludel.

13. And the aludel is an alembic of clay or glass, with a wide spout. (E L You use it to distill everything that has moisture in it. You set a bowl on top of it, or set a well-fitting lid) on top of a kettle. There is a hole in the lid of the size that the head of a strong needle can pass through. You place a woolen wick in this and hang the end of the wick in a clay bowl, until all the moisture in it has dried out. Then take it off (of the fire) and, in place of the wick, place a lid on it that goes over (G on all sides of) the entire cover, and seal them firmly as God wills.

14. [E] And better than these is a hole in the lid of the aludel so large that your little finger can pass through it. (Heat) until the mercury is turned into a white dust; as soon as the moisture has left it, plug it with (a small rod of) glass or wood wrapped in a cloth, so that the moisture will be removed. When the powder that was white has turned black,

know by this that the moisture has been completely driven out. Now seal the opening, I mean, plug the hole with wood, around which a fitted cloth is wrapped.

15. And that which the mercury is refined is alum, vitriol, salt, sulfur, lime, brick, glass, ashes of gall,[370] ashes of oak, and marcasite; with waters except vinegar, water of vitriol, water of sal ammoniac, water of alum, water of lime, and water of sulfur.

Third Chapter. The Sublimation of Mercury for Whiteness

16. Take solidified mercury, as much as you wish, and grind it with an equal amount of sal ammoniac (E white alum) or (E and) an equal amount of salt or (E and) ashes. Sprinkle vinegar over it, after you have placed it on a grindstone, and grind it carefully (E for three hours, one) at the break of day and (E one hour) at midday, and (E one hour) at the day’s end. Then place it in a clay-coated flask, secure its lid (plug) and put it on hot ashes in a baking oven, which has just been used for baking. Leave it in there one night and in the morning take it out again

and put it in the vessel of the aludel, after you have ground (the lot) with an additive of (E roasted) ground salt, and place it in the alembic that we previously mentioned and remove its moisture. Then pick up the alembic and set the cover in its place. Take care to get a tight seal and heat it from below, until you have driven away the moisture with a gentle fire. After that, build up (strengthen) the fire, until you have brought it to medium heat, and apply heat under the aludel twelve hours for

each ratl.[371] Each time, when the covering and the lid become hot, take it off the fire, so that that which is on the covering does not get ruined and burnt before it is all sublimated. Then place the top underneath and pulverize it and sublimate it. Do this three times, then take burned bones, like one takes out of the oven, and grind them carefully, and pulverize the sublimated matter with an equal amount of these (E burned) bones for one (E good) hour. Then repeat this three times, [G17] each time renewing the bones, so that it becomes (E completely dry) white and dead (L on the third time).

There is also a hole on the rim of the lid, big enough to insert a large needle wrapped in cotton. Take this out every hour (during the process) and observe it for anything you find on it from the sublimation. When you have taken it out and you see nothing more on it from the sublimation, take it off the fire and let the aludel cool. Then collect what is on the cover (G E after you have carefully loosened the seal), and gather it together, knead it with castor oil and put it in a clay-coated flask. Set it in a pot with ashes and plug the flask with wool, light a fire under the pot and drive off the moisture. When the moisture is completely gone (w.:cut off) plug the opening and pile ashes on it and over the ashes, small coals. Light the fire over it, so that what is in the flask solidifies (G E similar to a Chinese mirror).[372] Then it becomes solid and, if not, repeat the

procedure. When it is accomplished, cast one part of it (L dirham) on to 20 of copper, (E press it into these and) thus it achieves a perfect effect (L thus it turns them to white).

17. * Another way: You take a ratl of solidified mercury and an equal amount of vitriol, and roasted salt equal to the entire amount. Pulverize it with wine vinegar, until it becomes like slush, dry it, pulverize it (again) and sublimate it three times in an aludel to drive off

the moisture (E as was already described). After that, let it sublimate with bone lime, until it comes out dead and pure. Then saturate it with enough "virgin's milk,"[373] so that you can knead it, and grind it a half-day long and place it in a [G gentle] dung fire throughout one night. When it is dry and morning comes, take it out and let it get cold. Take what is in it, pulverize it and saturate it as well, until it is stable and runs on the test tablet and does not smoke. (E Cast one part of it on 25 parts copper, and you will find what you desire. [G18] And if you soak it with water from whitened sulfur, in which (G no dryness and) no black is, it will solidify to perfection. One dirham of it will color 30 dirhams of whatever metal you wish; (E you will find it like silver in all its qualities in the utmost purity.)

18. Another way. Take mercury and grind it with half as much tin or black lead and grind it with an equal amount of vitriol and an equal amount brick, and with roasted salt equal to the entire amount. Pulverize it all carefully on a grindstone, sprinkle water (G on the rim: the acid) of lemon on it, pulverize it (again) carefully and roast it in a clay-coated flask with a tight lid on a gentle fire. Then pulverize it a second day with the same, and

after that roast it in a gentle fire. Do this with it seven times and use a dung fire for roasting. After that sublimate it three times and mix with it an equal amount calx[374] of tin or of black lead or of silver and knead it with hair sal ammoniac, that is dissolved in distilled water, and roast it, so that it solidifies. Cast one dirham of it on to 30 of copper, and it will color it (E with a most excellent color) as God wills.

19. Another way. Take living mercury and kill it with an equal weight of marcasite and with as much as roasted salt as the entire amount. Pulverize it with sublimated wine vinegar one day long and roast it through one night and remove its moisture. Then set the lid on the aludel and let it sublimate three times. Each time, set the top beneath, until it become white; after that saturate it with water from egg white, that has calx from egg shells, sal ammoniac, and alum dissolved in it, for each ratl egg white one ūqia[375] of each individually. You pulverize it in the daytime and roast it at night. (E until it is solidified and runs off the test tablet. For its dirham, it colors 25 dirhams of copper with the best

coloring.

20. [E] Another way. You take a ratl of solidified mercury and a ratl of vitriol and an equal amount of glass, and as much roasted salt as the entire amount, and grind it with wine vinegar on a grindstone for one day, then roast it over night and in fact do this three

times with a light fire, and place it in an aludel and take the moisture away and let it sublimate three times, until the whole is sublimated white and dead. Then soak it with water of tin or of black lead and of silver, that is dissolved as well, and roast it seven times, and when it is improved until it is stable, runs off the test table, and does not smoke [G19], then cast one dirham on 50 dirhams of copper and change it into white silver as God wills.

21. Another way. When you take one part of it and one part sublimated arsenic sulfide, that no more black adheres to, and you soften it with water of tin or of silver or of black lead, dissolved with sal ammoniac in seven softenings, and dissolve it and let it become solid, then one dihram of it will color one ratl of copper (E it emerges in perfect purity). And when you dissolve each of the two by itself and mix them and lay them 3 weeks long in manure until they have dissolved, and you then solidify them, one dirham of them will color two ratls of copper. However, if you soften the solidified matter with them and saturate them with an equal weight of mercury, that was dissolved four times, and you then dissolve (E soften) and solidify it, then one dirham will color 1200 (E 2200) of copper.

* And if you replace sublimated arsenic sulfide with whitened sulfur saturated with water from egg white, in which calcined alum (E and sal ammoniac) is dissolved, until it is stable, then one dihram of it enriches 1000 dirhams of mercury. If you finally cast a dirham of it on 300 dirhams of mercury, this solidifies to an elixir, one dirham of

which colors 100 of any metal that you wish. And the effort will show you something in this chapter that will bring you joy as God wills.

* This is the end of the chapter on sublimating mercury to whiten, and now we begin with God’s help to explain its sublimation to red.

Fourth chapter. The Sublimation of Mercury for reddening.

22. For this, you take a ratl from the mercury solidified (G L to

redden), and pulverize it with a equal amount of vitriol and soak it with the water from quicklime and sulfur, that is known as *zād al-rağwa*.[376] Pulverize it, until no visible trace remains, then dry it and crush it, and place it in a aludel and take its wetness away. Let it sublimate three times, each time move the top to the bottom, soak it with *zād al-rağwa* and roast it seven times on a light fire; on the seventh time let it sublimate [G20] in a vial with a short neck, so it sublimates like rock crystal and it colors (G like garnet) with a good color.

And when you pulverize it and saturate the dissolved copper with water and roast (G L and pulverize it during the day and roast it all night seven times, until it is stable and flows on a silver test tablet), then one dirham of it will color 40 (E 30) dirhams silver to unrefined gold. And when you mix the ten (L the silver) with two mīthqāl of red gold, it comes out as excellent refined gold, as God wills.

23. * Another way. You take one ratl of mercury that has been solidified by covering it with sulfur (for redness) and an equal amount of vitriol, and half as much yellow sulfur as vitriol, grind it with the best wine vinegar a good hour, cast as much roasted salt as vitriol on it and, after its moisture is driven away, let it rise seven times. On the eighth time let it rise with half its amount of green vitriol and an equal amount of copper acetate and constrict it in a vial; then it increases to red (G becomes red) as garnet. Then soak it with water of copper, that was burnt (E calcined) with sulfur, that is saturated with the water of dissolved vitriol, and roast it. Do this with it again, until it is stable and does not smoke (any more), and one dirham of it will color 70 mithqāl silver (E with a perfect color). And if you fully complete this process, you will not need to grind it, as God wills.

24. Another way. You take one ratl of mercury that is solidified with (E sprinkled with) gold marcasite, and an equal amount vitriol, and half as much yellow sulfur as vitriol, and the same amount of Andarānī salt as sulfur and pulverize the whole amount with water from softened oak ashes for four hour long, until there is no visible trace. You then roast it with a light roasting, pulverize it, and roast it (again). Do this with it (E fourteen times) and do not soak it except for the first time. After that, let it rise in the aludel seven times, so that it turns rose-

colored or red; however if it comes out white, then it is not good. Now saturate it with water from dissolved sal ammoniac, to which vitriol and green vitriol were added, [G21] from each one as much as a quarter of the water, and roast it, until it becomes as red as liver. Now saturate it and roast it, then it

dissolves, after you have let it flow on a silver test tablet, until it no longer smokes and flows, then dissolve it at once. After that soak it with calcined gold, that is mentioned at the end of the chapter on copper acetate, and bury it in manure, so it dissolves into red water. If you let it solidify, one dirham of it will color 40 (E 200) mithqāl of silver (E to unrefined gold). And if you cast half as much red from hair or egg yolk or blood into the dissolved material [made] from the solidified material, one dirham will color 200 mithqāl from whichever metal you wish to the finest.

25. Another way. Take one ratl mercury solidified to red and an equal amount vitriol and let it sublimate until it becomes white, and elevated to dead and dry. Then saturate it with distilled vinegar, in which you have placed one quarter as much vitriol, purify it and add soda-salt over night; purify it (on the following day) and add ferric oxide to it over night, purify it again and add copper acetate to it over night; purify and pulverize with this water by day and roast it by night, until it becomes like blood. After that take whitened stable sulfur, in which there is no blackness; the indicator for that is, that if you sprinkle some of it on to a heated silver test tablet, it does not blacken the tablet and flows over it and does not smoke. Then saturate it with the (E prepared) vinegar, with which you saturated the sublimated mercury[377], and roast it ever so carefully, until it has turned red from the roasting. Then take the calx of gold (E of tin,

powdery, white), which was calcined with mercury [or, he says, with tin] [378], then saturate it with this vinegar (E and roast it), until it has turned red as well. (E Then take calx of eggshell and saturate it with this vinegar and roast it, until it has turned red; then take the calx of gold, that was calcined with mercury, and that was exposed to the smoke of sulfur during roasting, and saturate it with this vinegar and roast it until it has turned red.) Then take one part of the roasted mercury that was set aside and two parts ferric oxide, one

part calx [G22] of the gold that was made red, one part cinnabar from tin, one part cinnabar of sulfur, and one part cinnabar of eggshells. Then saturate all the ingredients of the mixture with sal ammoniac, sublimated with dissolved vitriol, to which a quarter portion of green vitriol was added, which was prepared from vitriol and ferric oxide in equal parts, set in the sun, purified by pulverizing (E an entire day, until it is softened. Then soften it like wax; do this twelve times, then knead it thoroughly and dissolve it). And whatever of it is not dissolved, saturate that and soften it and knead and dissolve it, until all has dissolved; and when it is dissolved, put a fifth part of the color of egg yolk in it and bury it until it is pure; then take it out and let it solidify, then will one dirham of it color 1300 of silver to refined gold. And when a dirham of it is added to 1000 of any metal you wish, it will come out perfectly pure.

[E He rejoices in the mention of this significant chapter (the author to the reader)]

27. * Another way, excellent. The mercury will solidify to a pure red. You take a ratl of it, purified with mustard, then you put it in a clay-coated beaker and pour a ratl of oil on it, cast five dirhams yellow powdered sulfur in it and a equal amount of yellow vitriol, submerge the beaker up to its middle in a dung fire and let (the contents) become solid; each time when the oil is reduced, add more, and take care that the fire does not make it too hot. Do this with it one day and one night, then take it out and wash it with water and salt. Then take a clay-coated kettle and stand a clay lamp in the middle of it, and over its top something like a small clay bowl. Put the boiled mercury in the lamp and around the lamp in the kettle place a ratl of yellow pulverized sulfur and layer it also on top; seal the connection and light a gentle fire under the lamp, for ten hours, until you know that the sulfur has made everything red. After that, [G23] let it get cold and open it, and you will find the mercury as a red (E crushed) powder.[379] When it is like that (erg.: then it is good), and if not, then repeat the procedure, until you find the mercury like that.

28. * *And the secret of this procedure* is that you perceive when the smoke (E from the steam) of the sulfur ceases, then discontinue the heat. The procedure for that is, that you bore a hole in the lowest brim of the kettle with your finger, so that the head of a large needle passes through it. You take a wood splinter and wind cotton around it, insert it through the hole and take it out every hour and examine (E what adheres to it) continuing, until you see

no smoke upon taking it out. At this indicator point stop the heat and let the kettle become cold and take it out. When you cast one part of this mercury on to ten of silver and grind the ten (E with five), thus it comes out like (E excellent) gold as God wills.

* And when you cast its half part of burnt copper on it and an equal amount of hematite and an equal amount of gold marcasite, and saturate it with water from dissolved vitriol and water from sal ammoniac, that was sublimated with the same amount of dissolved vitriol, and when you throw in equal parts iron saffron and copper acetate and the redness of blood and pulverize it and soften it, until it becomes a salt, that melts in moisture, then dissolve it, you will find it like a red water. Solidify it (E in a blind alembic) with a small fire, so that it becomes as solid as garnet; one part of it will color 100 of silver (E to gold as God wills).

* It is the end of the solidifying of mercury and it sublimation to whiteness and redness (E and we begin now with the list of sublimations of sal ammoniac), and praise be to God.

* * *

II. The Chapter of the Sublimation of Sal ammoniac.

29. Take sal ammoniac, as much as you wish, pulverize it carefully and combine it with half as much table salt. Let it sublimate three times with the salt, and renew the salt each time, so that you find it on the lid like salt (E like snow) as God wills.

30. Another way. (L to whiten). Take sal ammoniac and mix it [G24] with Andarānī-salt and pulverize them together, and place it in the aludel and let it (E according to the work of salts) sublimate three times, so it rises up clean (E with a brilliant white color) like salt as God wills.

31. * Another way, to redden. Take sal ammoniac and pulverize it with an equal amount of vitriol and let it (E according to the work of salts) sublimate three times and renew the vitriol each time so that it rises up a brilliant red.

32. * Another way, to redden. Take sal ammoniac and pulverize it with an equal amount of vitriol and green vitriol, and make a paste of it with egg yolk and let it sublimate, so it rises up red.

33. * Another way, to redden. Take sal ammoniac and pulverize

three times it with an equal amount of vitriol and an equal amount of copper acetate and as much ferric oxide as the whole amount (E according to the work of salts). Place the top underneath the bottom, then take vinegar, in which is (dissolved) its quarter amount of vitriol and ferric oxide and copper acetate and green vitriol and yellow vitriol in equal parts, and set it in the sun for a week. Dissolve it then continually until it has become red and the best cinnabar, then one dirham of it will color 30 dirhams of silver. Grind 10 dirhams with three mithqals, and if you soften it in seven softenings and dissolve it, and cast in as much as a quarter of mercury's calx of gold and bury it, so will it dissolve in 40 days to a water as red as blood. (E Let it then become solid, and one dirham will color 40 mithqals to excellent gold. And if you dissolve it a second time and solidify it, it will color) 80 mithqals of silver to (E excellent) gold. And when you saturate it with half as much water of lead oxide[380] (lead ore) and of red arsenic sulfide, and roast it, then one dirham will color a ratl of silver as God wills.

34. * Description of water of lead oxide. Take two uqia of foliated lead oxide[381] and three uqia arsenic sulfide and boil it with two ratl distilled wine vinegar, until it has been reduced to one ratl, and purify it and put [G25] some purified vitriol in it and saturate it with the elixir until it is saturated with red.

(G The sublimation of sal ammoniac for whiteness and redness is at an end with praise to God and with his help.

III. The Chapter on the Procedures of Sulfur and Arsenic Sulfide

35. * Let us begin with the procedures for sulfur and arsenic sulfide. (E Every procedure with sulfur that is successful, is even more effective and successful with arsenic sulfide.) The procedures that apply to them are roasting, washing, boiling, sublimation, and making the essence visible.

36. The substances that sulfur and arsenic sulfide are treated with are copper acetate, quicklime, lime, iron filings, copper, tin and black lead, vitriol, salt, white lead, lead oxide, glass, soda, talc and sea foam, [382] burnt copper, mashaqūiniyā,[383] white brick, the ash of gall nuts, of oak, and of carob. One of these is mixed together with another and (the sulfur and arsenic sulfide) are treated with them. Also waters can be

added to them, and with them simple and compound medicines are ground.[384] These [waters] are vinegar, salt water, alum water, vitriol water, urine, sal ammoniac water, sour milk, and the acid pressed from lemons, soda water, lime water, and such.

37. *The secret of treating sulfur and arsenic sulfide* is, however, that you put as much of their powder as you wish into a kettle and set the lid (L coated with clay) on top and seal the connection, after you have made a hole in the lid. Then go with it to a place where no one will notice the smell, in the desert or elsewhere (L or a place free from inhabitants), and dig a pit for it in the earth and light a medium fire in it, set the kettle on the fire and observe the smoke that comes out. You leave the kettle on the fire, as long as the smoke comes out black and yellow; however, when it begins to come out white, close the hole and take the kettle from the fire, so that it can get cold. Take the contents out [G26], grind it fine, and sublimate it in a house or in your dwelling or where you will, because it will not harm you (now).

And the secret of the sublimation is that you test the sulfur and arsenic sulfide, by spreading them on a heated silver test tablet, until they no longer blacken it.

First Chapter. About the Sublimation of Arsenic Sulfide and Sulfur

38. Take one ratl of whichever of the two you wish and grind it with an equal amount of roasted salt or bitter salt or Andarānī salt and with half its amount of copper acetate. Grind it with wine vinegar or soda water or saltwater or urine from boys; grind it carefully and roast it one night on a medium (E small) fire, after that grind it with these waters and roast it. Do this three times and sublimate it in an aludel; after you have removed its moisture, until (E it turns white, and when you test it) it does not blacken silver. (E Put the top underneath the bottom, and if you add more salt to it each time, it is very good. After that, take a ratl of it, of anzarūt water,[385] and of incense, both boiled as much as one can boil them (E to make a paste); you place it in a flask and purify it in a kettle with ashes and plug the flask with wool). Take away the moisture (E after you have heated it from beneath), then plug the top with (a paste of) roasted salt and barley flour and cover it over with clay, pack ashes over it and put small coals over the ashes, light a

fire in it – its fire would be from underneath and on top and the coal on top – and leave it alone for the rest of the day. Follow this procedure through with it three times, until it has become solid and stable and then add one part of it to 30 of copper, and it will leave it behind as (L E gray) silver as God wills.

39. * Another way. Take one ratl of whichever of the two you wish and an equal amount of unquenched quicklime; grind it with saltwater and soda water and roast it one night on a (E gentle) medium fire; sublimate it to remove its moisture and add more quicklime, until it is white and no (longer) black. After that saturate it with virgin's milk and roast it, according to what I have explained (E seven times), so that it is solidified. Thereupon soften it several times with water of sal ammoniac and dissolved it and with it saturate mercury that has been sublimated to whiteness, and roast it on a light fire. Do this with it until it (E is stable and) flows on a copper test tablet and loses itself in it. Then add one dirham to 50 of copper, so it is stable as God wills. (E so it changes this to silver).

40. [E] Description of virgin's milk.[386] [outside of this manuscript][387]. He says: Take the urine of twelve children, boys and girls; collected in a carafe and set in the sun for one week with the top sealed, then a white salt congeals and collects on the bottom. Gather the whole amount in a glass vessel; it is not necessary that it fills over half the vessel. Now seal the closure between the vessel and the alembic, the receiver and the spout, and when all that is in there is evaporated, a salt remains on the bottom. This is now taken and sublimated and used for the treatment of all that you wish to purify. Then take the distilled water and repeat its distilling seven times, until it is clean, and becomes useful. That is the *philosopher's vinegar* and *virgin's milk* and the *noble water.*

41. * Another way. Take one ratl from whichever you will, from such that is just roasted and whose smoke, blackness, and stench is driven off. Then take one ratl of it and grind it with an equal amount of calx of bone, saturate it three days with saltwater and grind it on a grindstone (E in the day and roast it by night with a gentle fire, and let it arise in the aludel to take away its moisture), until it has become white; add more calx and saltwater, and sublimate it each time, until you see that it has become white and no blackness remains in it. Saturate it with alum, ground with soap, (E until both are dissolved together) and roast

it; you do that until it stays and no longer smokes. After that, cast one dirham of it, if it is sulfur, on 30 of mercury in a crucible with a lid, make the closure secure and let it become hot, then blow on it, and it will solidify to excellent silver. If it is arsenic sulfide, cast it on 30 of copper, and it comes out as (E thus it changes into) gray silver as God wills.

42. *Another way. Take one ratl from either of the two that you will, and add to it an equal amount of salt and half as much iron filings. Now grind the whole amount carefully with wine vinegar on three (E consecutive) days (E each day three times for three hours, one hour at the beginning, one in the middle, and one at the end) and roast it on a medium fire: then take it out, grind it, saturate it with vinegar and roast it. Do this with it three times, after that sublimate it to remove its moisture, so that it ascends the first (E time white with some yellow in it; then resume mixing it, having taken as long as the first time) until no more residue remains behind (E and all is sublimated). Repeat this now (E do this with it) until silver, when you test it, is no longer blackened. Then grind it with half as much pulverized burnt copper and constrict it until it comes out like crystal. Now take it and saturate it with mercury that is dissolved with the calx of tin, and roast it, until it is stable, and flows, and does not smoke. Then let one dirham of it fall on 80 of copper or 50 of tin and mercury and let it return to (E white) silver (E that has returned to purity) as God wills.

43. Another way. Take one ratl of whichever of the two you wish and one ratl copper filings and one ratl bitter salt; grind it (G and saturate it) with soda water, (G grind it well and) roast it one night on a medium fire, crush it finely and saturate it with soda water and roast it. Do this with it three times, then sublimate it, until all the white is sublimated (E and replenish the mixture each time; then knead it with oil) without burning, and distill it and soften it until it is stable and does not smoke. Cast one dirham of it on 30 of copper, and if it is sulfur, with 30 of mercury or tin; it turns it into (E gray) silver (E that returns to purity).

44. *Another way. Take one ratl from whichever of the two you wish and one ratl bitter salt or Andarānī salt; grind it and saturate it with purest water, roast it, sublimate it and renew the salt in it each time, until all of it is sublimated, white as snow and the salt stays beneath and there

is no blackness is in it. Now soften it with water of sal ammoniac seven times, until it melts into wetness, (G even if this is the first of 30 times). After that, take an equal amount calcined tin and soften it with water of sal ammoniac, until it melts into wetness even if this is the first of 30 times. After that take an equal amount of mercury sublimated to whiteness and soften it with water of sal ammoniac, as you have softened both its companions; combine all of them on a grindstone in equal parts and saturate it with sharp water of lime, that is called *crushing water*[388] and roast it, so that it becomes white powder (E silver) after five softenings (E roastings). Let one dirham of it fall on one ratl of whichever metal you will; but if it is arsenic sulfide, then cast it on copper, it leaves it all behind as (E white) silver (E that returns to purity) as God wills.

45. *Another way. Take one ratl of whichever of the two you wish and an equal amount white lead oxide (G and an equal amount Andarānī salt). Grind the whole amount with vinegar one night (E and roast it on a light fire several times); do this with it seven times, then sublimate it and replenish the mixture [G29] each time, until it (E white) has ascended and there is no blackness in it. Then make a paste with (E distilled) naphtha that does not ignite, and constrict it. Let one dirham fall onto 20 of copper, purified with boiled egg white, that is kneaded into a dough with sal ammoniac; it leaves it behind as gray silver as God wills.

46. [G] Another way. Take one ratl of whichever of the two you wish and an equal amount white lead of tin; grind it with vinegar, roast it with a weak fire seven times and replenish the white lead each time, until it sublimates white, without blackening silver. After that replenish the white lead, grind it and saturate it with water of lead oxide and purify it, so that it come out as silver; one dirham of it colors 20 dirhams gray.

47. * Another way. Take one ratl of whichever of the two you wish, an equal amount burnt copper and as much roasted soda salt as both together; grind the whole carefully (E without moisture) and roast it, let it sublimate, until it becomes white and replenish the mixture each time without moisture. After that, stifle it with an equal amount of burnt copper, so that it comes out purer than rock crystal. Now grind it now and soften it with water of sal ammoniac, until it becomes a salt that melts in moisture; then dissolve it and put it aside. After that take

mercury sublimated(E to whiteness) (E grind it and) soften it with water of sal ammoniac, dissolve it and (E set it aside. Then take calx of silver and soften it with water of sal ammoniac, until it becomes a salt that melts in moisture, and dissolve it) and combine them (E the three waters). Now set as much as a quarter of the entire water of dissolved sal ammoniac aside and bury it, until it dissolves (E to a water) and no residue remains, then let it become solid with the blind alembic on hot ashes. Let one dirham of it fall on 600 (E dirham) of whichever metal you wish and it leaves it behind as white silver that in stable in its purity. And if you solidify it a second time and dissolve it, it colors 1000 for you, and if you dissolve it a third time and solidify it , it produces for you what you wish (E it shows you something to delight your eye) as God wills.

48. *Another way (E to redness). Take one ratl from whichever of the two you wish [G30] and three ratls of copper filings; saturate it with soda water and roast it, then let it sublimate and replenish the copper, and pay attention to the copper that remains beneath until all rises up white without blackness. Saturate it now with water of green vitriol and of vitriol and roast it, until it turns red and is stable, then set it aside. After that, take an equal amount mercury sublimated to redness, and soften it and set it aside, then take an equal amount of green vitriol as the (E to redness) sublimated mercury and an equal amount of ferric oxide, combine it all by grinding on a grindstone, saturate it with water of sal ammoniac, that is sublimated with vitriol, after you have dissolved vitriol and green vitriol in it, and soften it, until it becomes a salt, that melts (G in moisture). After that, dissolve it, add half as much oil of egg yolk to it and bury it, until it dissolves and becomes a pure water; this takes 50 days. Then solidify it, then it will solidify as a red ruby; one dirham of it colors two ratls of whichever metal you wish to (G excellent) gold as God wills.

49. * Another way. Take one ratl of whichever of the two you wish and an equal amount of talc, and saturate it with soda water and grind it and roast it one night. Do this three times, then let it sublimate and replenish the mixture (E each time) until it arises white, without blackness in it. After that,set a quarter of pure soda salt in it, soften it with water of sal ammoniac, until it becomes a salt, which melts (G in moisture), then let it solidify. One dirham of it colors 100 of copper to

gray silver and if it is sulfur, then (it colors) whichever metal you wish.

This is the end of the description of sublimation of arsenic sulfide and sulfur. So now let us begin with the description of roasting, boiling, and washing (these substances) and the success is from God.

Second Chapter. Excellent Washing.

50. Take one ratl of whichever of the two you will and grind it with an equal amount of soda with the purest water [G31] for one day in the sun; then wash it (E on a filter without a beaker and shake it until the saltiness goes out of it; E L then dry it and repeat the process) until it becomes a white lead. Sprinkle it on a heated test tablet (E of silver) until it no longer blackens it (E and does not burn it) and even this is the first of 50 times. [E: Description of virgin's milk.[389]] Then take some whitened lead oxide and boil it with four times as much vinegar, (G E until it reduces to half, and purify it. Then take soda, calcine it and boil it with the fourfold amount of water, until it is reduced to half, and purify it (E and take the pure part of it, then take one part water of lead oxide and one part water from soda; then combine the two and beat it hard, and let it stand until it has become clear; take the clear portion away from the upper flask, so that a white substance remains beneath. Now dry it and cast a quarter of its amount calx of egg shells on it, and as much as the calx (E L sublimated sal ammoniac, and grind it vigorously and let it steam between two beakers several times, until it agglomerates), after that dissolve it (E thus dissolve it by suspending it in the moisture and in manure and in vinegar). Combine it with that which you have filtered, and saturate the washed arsenic sulfide and sulfur with it and grind it (E L with it) and roast it gently until it is stable and does not smoke, and then one dirham of it colors 20 of copper, it turns to gray silver. And be careful to close the lid of the flask, before the moisture has dried out; then seal the lid and pile sifted ashes over the kettle and cover the ashes with burning coals, and close the oven door tight, so that it solidifies in (E L six) hours and becomes stable and changes copper into silver as God wills.

51. Another way. Take one ratl of whichever of the two you will, put it in a green *barniyya*[390] and pour saltwater over it and let it stand in there three days; shake it several times each day, purify (filter) it with a

strainer and wash it with sweet water, until you find no more saltiness in it. After that, dry it and put it back in the *barniyya*, pour saltwater over it and shake it several times and let it stand in there three days. Then purify (filter) it and wash it (G and again repeat the task with it) until, when you test it on the test tablet, it no longer blackens it (E and flows off it white). Then dry it [G32] and grind it and put it aside. Then saturate an equal amount of dissolved lead ten times and roast it with each saturation (E and grind it and roast it), until it is stable. Cast a dirham of it on 50 of copper, and it will change it into gray silver (E G and if it is sulfur, so will it change any) metal that you wish.

52. Another way. Take from whichever of the two you will, grind it with an equal amount of (G E bitter) salt and roast it (G E in a clay vessel and when it smokes, set it aside. Do this with it 15 times, after that wash it and purify it with the strainer), until the saltiness leaves it. Then pour (L E saltwater, after you have placed it in a green clay flask, and let it stand three days, then purify and wash it the same way and put it back in the flask. Do this with it until its appearance and its efficacy pleases you. Then take equal amounts of soda and quicklime and pour four times the amount of water over it, and let it stand three days and purify it. Then put in it) a fourth part soda and quicklime and let it stand three days. Then purify it several times, until it is very pure, and be careful to protect your hand and your nose, because it is a poison. Then to each ratl of it add an uqia of calx of shells and calx of mussels and let it stand three days and purify it. After that, cast one uqia burnt alum and (E burnt) sea foam on each ratl of it. Let it stand one day, purify it and with it, saturate the arsenic sulfide or sulfur that you treated; grind it together, put it in a flask (instead E L: gather it into a ball) and place it in a clay-coated kettle. Place roasted alum under and over the sulfur, pack salt over it and leave it no air and seal the top of the kettle. Do this with it several times, until it is stable and does not smoke, then one dirham of it colors 50 dirhams of copper as God wills.

53. * Another way. Take (E one ratl) of whichever of the two you wish, grind it with an equal amount of salt and roast it strongly, until it turns white (E: turns to a powder) and melts. Then pour water of quicklime on it and sun it until it becomes good (E red), then filter it and wash it with the filter, until its saltiness goes away. Place an equal amount of salt on it, grind it vigorously [G33] and roast it, until it melts.

Then take it out, pour water of quicklime on it and sun it until it turns red. Then filter it and wash it, and repeat the process in which you put an equal amount of salt on it, until it (E until its effect on silver) pleases you; then set it aside (G after you have tested it on a test tablet). After that, take distilled vinegar and for each ratl of it, add one uqia alum and Andarānī salt and soda salt and bread borax and an equal amount calx of eggshells. Let it stand then several days and shake it every day, morning, noon, and evening, indeed vigorously for a good hour long, thus dissolving its potency and what is in it. After that, purify it and saturate it with that which you treated and roast it as was previously explained, until it is stable; then one dirham of it colors (E one dirham of it falls on) 30 of copper (G and leaves it behind as gray silver) as God wills.

54. Another way. Take from whichever of the two you wish and grind it with the best pure wine vinegar, which contains a quarter of roasted sea foam. Do this with it a full day until night, until it becomes like fluid clay, and make a cake of it and cook it an entire day with this vinegar. Filter the vinegar from it and replenish it with the cooking and the vinegar, until its color and efficacy please you, then set it aside. Then take a ratl of wine vinegar, add to it a ratl soda, that was burned in a tābistān oven (E like powder), add to it a half ratl whitened lead oxide (E and two uqia roasted alum, two uqia burnt soda) and two uqia quicklime, leave it three days and shake it hard every day for two hours long, each at the end of the day. After that, purify it and add a quarter of its amount of the mixture as we have mentioned. Do this four times, after that, purify it even better and with it saturate what you had treated and set aside (E and roast it), until it is stable, then one dirham of it colors 40 of (E pure) copper so that it comes out as the best silver as God wills.

55. * Another way. Take whichever of the two you wish [G34], then grind it with wine vinegar, in which is a quarter of soda salt and roast it one night in a gentle fire, if it is sulfur, but if it is arsenic sulfide, on a medium fire; the process is similar to the previously discussed (G procedures). (G I mean about the sulfur and the arsenic sulfide). Then grind it and wash it with sweet water and dry it and repeat the procedure until you see that its color and efficacy satisfy you. Then that which you wish of it is the removal of its blackness and smoke (E: the elimination of blackness and burning and combustibility and volatility), until both

have reached an extreme degree of whiteness; then set it aside. [*Superscription* E: Distill the oil so that it does not ignite]. Then take oil and boil it (G several times) with an equal amount of water and some white clay several times, until its color has changed. Then purify it (G and dissolve it) and put it in a vessel, sprinkle (G water of) quicklime and bitter salts in two portions on it, until it becomes like a soup, then set the alembic on it and distill it. Do that several times, until (some) drips over, so that the fire will not light, then make it into a paste with that which you have treated (E set aside) and dissolve it several times until it is stable. Then soften it with water of sal ammoniac several times, until it becomes a salt, that melts, and dissolve it (through softening), until it dissolves into a flowing water; and if a residue remains, repeat the process and soften it with water of sal ammoniac and dissolve it over again, until no more remains of it and all is dissolved. Let it solidify in a flask and in an ash kettle, and seal the flask on the top so that it becomes white powder. When one dirham of it falls on 60 dirhams of copper, you find it is as white silver as God wills.

56. * Another way. Take from whichever of the two you wish, then grind it well, make a paste of it with distilled salt and roast it one night. Then take it out, grind it, wash the saltiness from it and dry it. Then pour saltwater on it and use the procedure with the repeated grinding and roasting, until its color and its efficacy please you. (E and it uses this procedure, after its odor has been eliminated by roasting, *as we have explained as a secret with this procedure*); then dry it and set it aside. Then take a fourth ratl sublimated sal ammoniac and three uqia whitened lead oxide, and also add calx from eggshells, calx [G35] from mussels and calcined soda, one uqia of each. Bury it for two weeks, purify it and saturate it with that which you wish to treat and have set aside (E and roast it) until it is stable. Cast one dirham of it on 30 of copper, thus it comes out as (E excellent) silver as God wills.

57. *Another way. Grind whichever of the two you will with water of soda and quicklime, boil it with them and filter the water off of it. Repeat the procedure with it and do this until it has become white and its effect pleases you. Then make a paste of it with white honey (E and roast it; do this) three times (E or more), until it is stable, and cast a dirham on (E 10 of copper) 20 and more as God wills.

58. * Another way. Take a roasted portion of whichever of the two

you will, grind it with saltwater (E and soda) and roast it, then grind and roast it (E grind it in the daytime and roast it at night), until it comes out white and wash it five times (E each day) and purify it with the filter, until it becomes white powder, whose color and effect please you. Then soften it with water of sal ammoniac (E to whiteness until it becomes a salt that melts in moisture. Then take mercury sublimated to whiteness and soften it with water of sal ammoniac, until it becomes a salt, that melts in moisture and set it aside. Then take calx of tin and soften it with water of sal ammoniac, until it becomes a salt that melts in moisture.) Then combine all of it by roasting and softening ten times (E in ten softenings) and dissolve it all (E and was still remains behind, that soften more times and dissolve it, until all becomes a water.) Then solidify it, so a dirham of it colors 300 dirhams (E it returns back to purity). [G] And if you dissolve it once more and let it solidify, thus it colors 1000 for you as God wills.

59. [E] Another, even better than these. Dissolve each of these elements by itself, then mix them together and crush them, until they are combined with each other and their mixture has become beautiful. Then let it solidify, thus one dirham of it colors 400 dirhams of any metal that you wish; then if you grind that which has become solid and saturate it with a quarter of its amount dissolved (fluid) mercury and roast it, one dirham colors 600 dirhams and if you dissolve it and again let it solidify, then it colors 1000.

Third Chapter. Explanation of washing, boiling, and roasting

60. Take from whichever the two that you wish and grind it well with an equal amount of salt and roast it. Then wash it through the filter and repeat with salt on it (E the procedure of salt) and roasting three times; after that spray saltwater on it and let it sublimate in an aludel, until its color and effect are satisfactory. [*Superscription* E: Description of distilling black naphtha, so that it does not ignite] Then take black naphtha and add an equal amount of sal ammoniac and distill it; repeat the task with it and watch that it does not ignite. Then saturate it with that which you have prepared (E and set aside) and roast it, until it is stable. Then cast one dirham of it on 50 dirhams (E 30) of copper, thus will it change this into excellent silver as God wills the success.

61. Another way. Take from whichever of the two you wish and grind it with an equal amount of tin filings. [G36] with saltwater and wine vinegar one day and roast it one night. Then (E grind it with saltwater) wash it, saturate and roast it; do this seven times, then let it sublimate, take the sublimated matter and mix with it an equal amount of iron filings and bitter salt. Grind it carefully one day long and roast it by excellent roasting, grind it, and let it sublimate three times, while you place the uppermost underneath each time (L once each day) until its color and effect please you. Then (E set it aside and) take both arsenic sulfides and calcine each separately in a clay-coated jug, after you have sprinkled (the arsenic sulfide) with water and salt) and set it in the oven until it turns to white powder. After that, combine both, mix with it an amount of sublimated mercury equal to the entirety and saturate it with the *crushing water*.[391] We will explain this in the chapter on sharp waters [found] in the chapter on dissolving so God wills the success.

62. Saturate (E soften) it now with it seven times, then pour a stream on it (E after you have placed it) in a lamp and seal it inside a large kettle in which there is water. There should be a margin of space between it [the lamp] and the water; coat with clay and make the connection tight. On one side of the lid there must be a hole, corresponding to the amount of water that was poured in the kettle. When it is reduced, add hot water to it (G by means of a funnel with a long tube, so that it does not touch the lamp. Seal the hole) until all is dissolved. And what is not dissolved, dry it and soften it and roast it and dissolve it following the roasting and the softening yet again, (E until you have saturated it three times with an amount equal to its weight), so that it is stable and does not smoke. Cast a dirham on one ratl of whatever metal you wish (G thus will it change it into silver) so God wills the success.

63. * Another way. Take (E take again) one ratl of whichever of the two you wish and four ratls of iron filings and grind it with a grindstone with vinegar and (E bitter) salt on three consecutive days. Then roast it and grind it (G three more days, then roast it and crush it; put it) with vinegar and salt (E and boil it with a stream of vinegar; until it is dry, and roast it. Do this thus) three times [G37] (E then let it sublimate) and place the top part underneath (E three times) and set the lowermost (G the residue) aside. And take an equal amount of copper

filings and Andarānī salt, grind both and let them sublimate and put the top part underneath, until its color pleases you (G and its effect, and set it aside). Then take the iron and the copper that were sublimated, and let it melt down, separately, after you have washed it with water and salt, and make a paste of it with oil and natron, until it has turned white. Then combine the two, (G I mean the copper and the iron, E and smelt) and add it to tin, that is purified with sal ammoniac, thus it will change on the fire to gray silver. And if you wish to apply its effect, mix any of them with one (G 100) dirhams mercury, then will its effect (E its color) please you. (E and if you wish the fullest accomplishment of its effect, then add any 100 dirhams of it to one dirham sublimated mercury, thus will its color please you. Then take that which was set aside and grind it with vinegar to which a quarter of its amount of alum has been added. Leave it three nights in water, then will the water be filtered from it, then will it be replenished and anzarūt (*sarcocolla*[392]) and hiltit (*Asa foetida*[393]) cast in it and left in it three days. Then filter it (L sublimate it) and grind it with this water (E and saturate it one day and do that until it is stable, then saturate it with boiled water of lead oxide) and roast it, so it becomes white powder. Its dirham colors 60 of copper so that it comes out as silver as God wills.

64. * Another way. Take one ratl of whichever of the two you wish, grind it with an equal amount of vitriol and salt for one day with purest water, and roast it one night on a strong fire, if it is arsenic sulfide, but if it is sulfur, on a gentle fire. Then crush it and wash it with the filter until its saltiness is gone out, then replenish the salt (E water) and the grinding and the roasting. Do this with it three times (E and let it sublimate three times), until its color and its effect please you. Take the residue from it and calcine it, saturate it with soda water and natron, then roast it, until it becomes a melting (metal) and smelt it several times. Then grind it and combine it with an equal amount of sublimated mercury and an equal amount of arsenic sulfide that you have treated. Saturate it with sea water and soften it in seven softenings, dissolve it and let it again solidify, (G until it satisfies you), then cast one (E dirham) on 100 of whichever metal you will, thus it will change it to white silver. And if you dissolve it three times and solidify it again, then it works on 500 of any metal that you will and the success comes from God.

This is the end of the chapter about the procedures; so let us begin now with the production of essence of arsenic sulfide and sulfur.

Fourth chapter. The Drawing out of the essence of arsenic sulfide and sulfur.

65. Take whichever of the two you will and put it in a pouring spoon of iron and pour and pound purified kidney fat into it. When it is burned and its blackness is removed from it, then wash it with water and salt, and repeat the task with it, until its color and effect satisfy you (G and its stability). Its dirham colors 30 dirhams of copper so that it comes out as gray silver as God wills.

66. Another way. Take whichever of the two you will and boil it with oil, and as soon as the oil turns black, replenish the oil until it stays white and is finished. [E Another way. Take whichever of the two you will and] sprinkle it now with melted wax and roast it in a hot oven (tannūr). Do this repeatedly, until it turns to powder; then wash it with water of soda several times, and repeat the roasting (G until it becomes powder; then repeat the washing with the soda water and roasting), until it becomes white powder. Cast one dirham on 20 dirhams of copper, so it leaves this as white (L gray) silver.

67. * Another way. Take whichever of the two you will and crush it and sift it (E and put it in a clay-coated beaker and set it on a coal fire) and pour a stream of sesame oil on it and blow on it carefully one time after another until it boils and the oil turns black. Now pour the oil off of it and wash it with (E hot) soda water – but it must be hot – then it dissolves therein. Repeat the process with it seven times, until it becomes white (G a white metal). Add its dirham to twenty-five [G39] dirhams of whichever metal you will (E it turns to true silver).

68. Another way. (E take of it what you will and) make a paste of it with white wax and roast it one night; then grind it and make a paste of it and roast it; do this three times, then make it into a paste with egg white (E and roast it, then make it again into a paste with egg white) and put it in a kettle, in which are ashes (E in a flask and plug it with wool and dry the moisture. Then seal the lid of the kettle) and pack ashes over it and small coals over the ashes, and light the fire and burn a medium fire under it for three days and nights; each time, if there is plenty of coal in the oven, take it out and put it over the kettle, so that it is on all

sides of it. Then let it cool and take it out and crush it, thus you find it as white powder similar to silver. Grind it then with an equal amount of dissolved calx of hair and roast it. Do this with it three times and roast it each time until it becomes white powder like rock crystal. Its dirham colors one ratl copper (E to silver, G L it comes out as white silver) as God wills.

* * *

B. The Calcination of Metals

1. Calcination takes place with metals and stones and salts and with shells and mussels. It is the decomposition of substances and burning up the sulfur and oil that is contained in them. Calcination changes them into white powder, so that they become imperceptibly fine. Among the fusible metals there are three methods: one way is calcination through burning, one way is calcination through letting it rust, and one way is calcination through amalgamation. For (metals) other than these, calcination occurs exclusively through burning. [G40].

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I. The Chapter on the Calcination of Gold

First Chapter. The Calcination of Gold through Burning.

2. Take gold filings, mix red arsenic sulfide with them and pour them into a little bag, coat it with the artist's clay and roast it one night with a strong fire. Then take it out, grind it (E L and wash it) with water and salt and add an equal amount of salt to it. Put it in a clay-coated jug and set it in an oven (atūn), then after five times it becomes a white calx as fine as dust as God wills.

3. Another way. Take as much gold as you will, melt it and transfer ten parts from it with one dirham lead or lead oxide,[394] so that it crumbles these. Then grind it with salt water and put it in an oven in a clay-coated jug. Do this repeatedly until it has become a fine powder (G is calcined) as God wills.

4. Another way. Melt it in a crucible, in which lead or lead oxide

has been melted, so that the gold calcines from its vapor. And if the lowest part of the crucible is coated with lead oxide and the gold is melted in it, and then this is sprinkled with water and ground salt, then put it repeatedly in a potter's oven, then it becomes finely powdered imperceptible calx as God wills.

5. Another way. Take gold filings and grind them with distilled water and salt and water of sal ammoniac one day, and calcine it in an oven (G atūn, L and, E or tābistān), until it turns to weightless dust. Rinse it out every day, once with salt and sal ammoniac, then (E replenish of these) and take yellow vitriol, dissolve it with water and boil them together, filter it and put a quarter portion of ferric oxide (L calx of iron) in it.

6. Saturate it with, whichever calx you wish, and roast it until it leaves a red powder of dust behind. Then take mercury sublimated to redness (G soften it with sal ammoniac, that was sublimated with dissolved vitriol), add as much a quarter of its quantity (G with vinegar) distilled copper acetate in it, soften it with ten softenings, dissolve it and saturate these calxes with it , until it has absorbed an equal amount. Then add its dirham to 70 (E L 30) mithqal silver, thus it colors these; [G41] and mix (grind) the ten with two, thus it comes out as refined gold as God wills.

7. Another way. Take dissolved vitriol and cast as much as its quarter lead oxide into it, let it stand three days, purify it, (E cast so much as its quarter yellow arsenic sulfide into it and let it stand three days; purify it and cast as much as its quarter amount of gold marcasite in it and let it stand three days; purify it) and strain it each time. Then purify it again and cast as much as the whole oil of egg yolks in it and roast (E L and saturate it with gold filings, grind it with them and roast) continuously until it becomes a powdery dust as red as blood. Then set it aside and combine both with an equal amount sublimated (E and constricted) mercury and soften it with water of sal ammoniac that was sublimated with vitriol, in ten softenings. After that, dissolve it and let it solidify again, so it colors 50 mithqal for you. And if you bring it together with whitened sulfur, in which there is no blackness, saturated with water of vitriol and green vitriol and yellow vitriol and redness of blood, until it is red as blood, and you soften it in fifteen softenings and dissolve and let it solidify, G then it colors 1000 of any metal that you

will (E L then its dirham colors 200 mithqal of any metal you will; E it turns back into purity E L to pure gold). (E And if you soften each one separately and dissolve it and combine it all together and bury it for three weeks and let it become solid, so it colors 600 with its one part; and if you dissolve it three times and let it become solid, so its one part colors 1000 of whichever metal you will.)

Second Chapter. The Calcination of Gold through letting it rust (p.128)

8. Take gold filings (L E as much as you will) and grind it with an equal amount sal ammoniac with distilled wine vinegar on a grindstone, until it has become a weightless dust, even if it takes 30 days.

9. * Another way. Grind it with an equal amount of sal ammoniac, distilled with wine vinegar three days, then let it sublimate (E place the top underneath and grind it with vinegar and let it sublimate) and continue this until it has become an impalpable weightless dust. Then take vitriol, copper acetate, cinnabar, and sal ammoniac, one uqia of each separately, pour a ratl of distilled vinegar on it and bury it in manure, so that it dissolves in one (E two) weeks. Then use it to saturate the calx that was set aside, and dissolve it until it becomes a red dust powder. Cast its one on ten and grind (E mix) it with its third, so it comes out as gold as God wills.

If however you combine (E grind) it with an equal amount of red mercury and make a paste of it with egg yolk and roast it, and cast one mithqal of it on 30 silver, and grind it with a third of it, then it comes out (E excellent), just as you wish it. And if you (E take and) dissolve the whole amount and saturate it with roasted sulfur and roast it [G42], thus its part colors 50 (E silver to gold) and it comes out in the purest state. If you then dissolve it for the second time and again let it solidify, that way its one part colors 100 dirham (E mithqal silver); and if you dissolve it (G and let it solidify), saturate it with ferric oxide and again roast it, until it has absorbed an equal amount (G and even if it takes) ten times, then its dirham colors one ratl (E copper or) tin to refined gold as God wills.

Third Chapter. The Calcination of Gold through Amalgamation

10. Take filings of it, as much as you wish, amalgamate it with

three times as much mercury and grind it carefully; then roast it between vitriol and sulfur (E seven times, until it becomes a red dusty powder, of which one part colors ten, so that it comes out as an excellent metal). Grind it with three (E two mithqal), and then it becomes refined gold as God wills.

11. Another way. Take five dirhams lead, amalgamate it with 30 dirhams mercury, grind it and wash it with water and salt and press it out. Then take the expressed matter and amalgamate it with the gold filings; grind it and roast it in a flask with sulfur inside, until it becomes an impalpable powder. Saturate it now with oil from egg yolk and roast it until it has absorbed an equal amount and turns red as blood. Cast its dirham on 15 mithqal (E 10) silver and grind the ten with two mithqal, so that it comes out red (E as refined gold) [better than it] as God wills.

12. * Another way. Take (E amalgamate) one part gold filings with three times as much mercury and grind it with half as much vitriol as gold and with half as much sulfur as vitriol; saturate it with water of quicklime and roast it seven times, until it becomes a red dust powder. Then sublimate the mercury from it and saturate (the residue) with water of vitriol, of copper acetate, of sal ammoniac, of quicklime, and of sulfur, and roast it, until it becomes red, then soften it seven times with water of sal ammoniac alone. Now dissolve it and saturate it with the mercury that was sublimated from it and roast it, until it turns red; then distill it, take its water and its [G43] oil and concentrate the oil in a blind alembic in the sun or on hot ashes, pour a stream of “white water” on it, until it turns red, and pour (E filter) the water out of it. Repeat the process with it until you have taken all its color, then saturate an equal amount of reddened mercury with it three times and roast it, when you have saturated it and filter it, until its effect and color please you (E until its color is saturated). Then cast its dirham on one ratl silver, thus it comes out as red gold as God wills.

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II. The Chapter on the Calcination of Silver

First Chapter. The Calcination of Silver through Burning.

13. Take silver and add ten (dirhams) of it to the weight of one half

dirham yellow, melted sulfur, then pour it on a grindstone and grind it (E well and saturate it) with saltwater one hour long (E and grind it) until it is dry. Then place it in a clay-coated jar and put it in the oven (atūn). Then take it out, when it has become cold (E and take out that which is in it) and grind (E and wash) it. Repeat the procedure (G and the work) with it until it (G pleases you and) has become an impalpable fine white powder.

14. Another way. (G L Take the silver and) add ten (E of it) to one part of tin, so it becomes a powder. Put it in the tābistān, sprinkle saltwater on it and shake it until it turns white and becomes an impalpable dust (E until it becomes like quicklime).

15. [E] Another way. Take what you will of it and add it to kohl (antimony) until it crumbles and becomes a weightless dust. Then saturate it with saltwater and put it in the oven (atūn), until it is calcined and becomes a weightless dust.

16. Another way. (E and better than all these is,) that you soften the (G white) marcasite with water of sal ammoniac in ten softenings; then let it sublimate in a aludel (L in a vessel), until it (L E: until most of it) is sublimated. After that, take silver test tablets, and moisten them with water of alum, after you have sprinkled them with the sublimate. Now put the marcasite in a clay-coated clay mold, put a lid on it, seal the connection and roast it one night; then take it out, grind and wash it and repeat the process with it, until it is calcined, then saturate it with dissolved mercury and roast it. Do this with it, until it has absorbed just as much and has solidified to white powder. One dirham of it colors 60 (L: 70, E: its 50 to 7) of copper, and when you saturate these with an equal amount water of hair, to ten (dirham) of which two dirham white calx has been added [G44] and you roast it, then one dirham of it colors 100 (E one of it 80 of copper). And if you soften the calx before the treatment, until it becomes a salt that melts, and you dissolve G L: and you grind with water of hair and roast it, thus it colors and its quality increases. (E . . .: and saturate it with the amalgam[395] and roast it three times, so will its one [color] 120 of copper.

17. (Another way). And if you take a ratl of both arsenic sulfides and saturate it with soda water and vinegar (E and with sal ammoniac), and then pulverize it and roast (G and saturate it during its roasting) until it becomes white and stable and no longer becomes black and does not

smoke, then take one part silver calcined with marcasite and one part of this arsenic sulfide, and soften it with mercury dissolved in sal ammoniac ten times (E in five softenings), until it has absorbed an equal amount. Now pour an equal amount (E water of lead) on it, until it is absorbed and bury it, until it is completely dissolved, then let it solidify. Its dirham colors 600 (E 300) of copper to white, fine silver (E it returns to purity).

18. Another way. Melt tin and pour it into water ten times; (E then melt silver and pour it in this water ten times). And in each ratl of the water place one dirham yellow sulfur (E: after you have placed . . .), thus this calcines it (the silver) black. Treat (w.: heal) it with now with water and salt, until it is whitened as God wills. (E and becomes as weightless dust).

19. * Another way. If you boil sulfur with soda water and sharp quicklime, then pour the melted silver on it several times, then it burns, and its parts separate from each other. Then saturate it with saltwater and put it in the oven (atūn), then in three times, it becomes a white calx (like quicklime). If you mix an equal amount of sublimated mercury with it and soften it in ten softenings and dissolve and again let it solidify, and then its dirham is deposited on one ratl of copper as God wills. (E so that its one colors 100 of copper; and if you dissolve it a second time and let it solidify, then its dirham treats one ratl copper, as God wills.)

Second Chapter. The Calcination of Silver through Letting it Rust

20. Take as much silver filings as you will and (L grind it with) an equal amount sal ammoniac, sprinkle both with water and shake them several times each day, and whenever it is dry, then add more water, until it has turned to impalpable dust. Then wash it and saturate it with water and salt and roast it, until it has become as quicklime [G45] as God wills.

21. * Another way. Take of silver filings as much as you will and just as much sal ammoniac, and grind it while roasting a good hour. Place it between two beakers, coat the lower one with clay and set it on a coal fire and every time it smokes, lift it off and let it cool. Do this with it ten times, then open it, take (the mixture) out, grind it and put it back in the two beakers, and treat it, until it has become a white lump.

Then sublimate it on a gentle fire, until the sal ammoniac is driven off and the calx remains below; and place the top one underneath and do not cease to sublimate it, until it has become white powder as God wills.

22. Another way. Take of silver filings as much as you will, and grind them with distilled saltwater, in which there is a quarter as much sal ammoniac, on a grindstone continually every day for three hours, one hour at the beginning, one in the middle and one at the end (E and spread it on its grindstone and sprinkle wine vinegar on it, distilled with sal ammoniac), and let it stand one night. Do this with it five times (E 15 days), until it has become a dust (E zinğār); then cleanse it through the filter, saturate it with saltwater (E and grind it three days), until it is white and impalpable so God wills the success.

23. [E] Another way. Take the distilled vinegar and put an equal amount sublimated dissolved sal ammoniac in it, an equal amount of distilled copper acetate and an equal amount dissolved distilled alum, and let it stand three days. Then, with it, saturate silver filings in a flask with a wide mouth, the size you would use for a soup, and let it stand one month and shake it every day for three separate hours, like the first time, according to what we have said. Shake it thoroughly, and every time that it is reduced, replenish it, until it has become a powder. Then let it stand several days, so it becomes an white lead, and then dissolve it, then it will dissolve swiftly. Then take whitened arsenic sulfide, in which there is no blackness, and soften it in ten softenings with sal ammoniac water, until it becomes a salt, which melts. Dissolve it and distill it, and if any of it remains, then soften it and dissolve it, until all is distilled. Then combine all of it and let it solidify in a blind ambiq on hot coals, and then it will solidify in three days. One part of it colors one ratl of whichever metal you will; it becomes silver that returns to purity. And if you saturate sublimated silver with it or let it sweat and dissolve and solidify, then will one dirham of it color 200 dirhams of whichever metal you will. And if you dissolve it and let it solidify a second time, then it will color 400 dirhams. And if you dissolve it and let it solidify a third time, then will its one [dirham] color 800 dirhams of which metal you will. And if you saturate it with an equal amount of water of hair and roast it, after so much as a quarter of water calx of hair is cast in, then its dirham colors 100 of all metals more perfect than that which comes out of the mines.[396]

Third chapter. The Calcination of Silver through Amalgamation.

24. [E] Take silver filings and amalgamate them with three times as much mercury; grind it to the finest and sublimate it, after you have added half its amount of salt, and set the top underneath, after you have washed it and replenished the salt, until it becomes a white impalpable powder.

25. Another way. Take silver filings and amalgamate them with three (L four) of their amount of mercury and grind it with water and salt and wash it, until it (G L is clean and) becomes like foam. Then roast it between (E burnt) alum (G and salt) (G L and soda, until you leave it behind impalpable) (E and grind it and make a paste with water of sal ammoniac and roast it between alum, until it becomes an impalpable dust, then it is reduced to dust as God wills.).

26. Another way. Grind it with four equal parts of mercury, carefully with (E water of) dissolved sal ammoniac, (E and roast it between two crucibles) until it becomes an impalpable (E weightless dust).

27. Another way. Take the silver (L the filings) and melt it and add an equal amount of tin to it and grind and wash it constantly with water and salt, until it becomes as white as salt. Then amalgamate it with four times its amount of mercury and grind it [G46] and wash it, until it becomes like foam, and let both sublimate with salt (E and replenish the salt) and set the topmost on the bottom (GL and wash it each time) and replenish the salt each time with the same (weight), until the lower one (L until it) becomes white like quicklime. Then take the uppermost, let it sublimate two times with as much (L with an equal amount) sal ammoniac and dissolve it. After that, take one part of (E white) sulfur and from this calx one part, and saturate both with that which was dissolved in equal weight, and roast both with each soaking. Do this, until it becomes white powder; its dirham colors (E drop its one on) 150 dirhams. (G E and if you dissolve it and again let it solidify for the second time, then its dirham colors 300 of whichever metal you will.)

28. * Another way. Amalgamate one part tin with four parts mercury and grind it thoroughly. Then add three more dirhams mercury, without washing it, then grind it one additional day, press it out and amalgamate the silver with that which was pressed out of it, three for

one, and grind and roast it, until it has become a white calx. Add to it three times its weight dissolved mercury, let it solidify and add one dirham of it to tin amalgamated with iron (E 100 pure), then you will find it as pure silver as God wills.

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III. The Chapter on Calcination of Copper.
First Chapter. The Calcination of Copper through Burning.

29. Take copper filings, mix them with a quarter the amount of yellow arsenic sulfide, place it in a clay-coated jar and roast it one night in the oven (tannūr). Then take it out, grind it and wash it several times with water and salt, until it is clean; then sprinkle it with distilled water and salt, and place it (again) in a clay-coated jar and put it in the oven. Then take it out, when it is cooled, wash and dry it, knead it with water and salt to a paste, (E place it in a clay-coated jar,) and take it back to the oven, until it has become a white calx (E and a powder) as God wills.

30. Another way. Take as many copper filings as you will and mix them with half (E: a quarter) the amount yellow arsenic sulfide, coat it with clay (in a jar) and roast it one night in a hot oven (tannūr). Then take it out (E if it has cooled), wash it with water and salt and dry it and with it repeat [G47] the (procedure with) water and salt and dry it; mix it with a sixth part of natron, make a paste with oil in proportion, as it amalgamates its part, and let it melt down using a double crucible, then melt it as a perfect metal like Chinese iron. Grind it and make a paste of it with water and salt, place it in a clay-coated jar, set it in the oven (atūn) and take it out, when it has cooled; grind it (once again) and wash it with water and salt, dry it and repeat the procedure with it, until it has become a white calx as God wills.

31. Another way. Melt the copper and mix it with yellow sulfur, until it it burnt; then grind it and wash it with water and salt and roast it in an oven according to what was done previously, until it becomes white. Then saturate it with water of green vitriol and white vitriol and yellow vitriol dissolved in vinegar, a quarter ratl of each, and roast it, until it has become a red powder. Its dirham colors 10, and you add

them each one by one as God wills.

32. Another way. Burn the copper with sulfur, then take it out and saturate it with water of vitriol and copper acetate and sal ammoniac and roast it, until it has become a red powder. Its dirham colors 20 of silver and is ground with 5 (E of gold made into filings). If you combine it with dissolved red mercury and bury it, until it has dissolved, and it is solidified, then one colors 50 of silver; you grind (E you mix) the 10 with one (E so that it comes out red).

Second Chapter. The Calcination of Copper through Letting it Rust.

33. This consists of making it into copper acetate.[397] You take copper sheets and dip them in sweet milk and lay them on a cane strainer in a clay vessel, which contains wine vinegar, until it has changed into copper acetate. (E Each time, when it has changed into copper acetate,) scrape it off and repeat the procedure with it, until it is all left behind as copper acetate and to God is the success.

34. Another way. Take copper filings, to each ratl of them add one uqia sal ammoniac, pour wine vinegar on it, cover it and shake it several times a day until it has become copper acetate, (E and each time, when it is dry) [G48] add vinegar to it again (E moisten it with vinegar) until it has all changed to copper acetate. (L It is excellent to use as God wills.)

35. Another way. Take one ratl burnt copper (E crushed) and grind it thoroughly, place one uqia sal ammoniac on it and let it stand one night; then take two ratl (E of the best) wine vinegar, place it in a (E another) uqia (E sal ammoniac) and let it stand overnight. Clean and pulverize (thus!) the burnt copper that was ground on a grindstone, (E grind it by day and spread it out in the night) and moisten it each time with vinegar, if it has become dry, until it has all changed to copper acetate.

36. * Another way. Take copper filings, as many as you will; if you have taken an uqia, then take an equal amount of sal ammoniac, pour as much water (vinegar?)[398] over it, until it is just covered and shake it several times every day. Each time it becomes dry, add some water to it, in which there is a little sal ammoniac, until it has become copper acetate. If you soften this and add it to a dirham of silver, three times, then it will take effect on it. As God wills.

37. * Another way. Take burnt copper [in sheets], grind it and put an equal amount of sal ammoniac on it, pour wine vinegar on it, in which is a quarter volume sal ammoniac, and shake it, until it has changed to copper acetate. Each time when it is dry, moisten it with the vinegar, until all has changed to excellent copper acetate, it is good to use.

38. Another way. Take the aforementioned copper acetate, then grind it with wine vinegar, in which a quarter amount of vitriol is (dissolved), roast it and do this with it 9 (L E: 7) times, until it has become (L E red and) colored. One part of this colors ten of silver; if it is mixed with an equal amount of (gold), then it will come out red, as God wills.

39. Another way. Take the aforementioned copper acetate, grind and soak it with wine vinegar, combined with a quarter part of vitriol and as much as half of the vitriol is yellow sulfur and alum. Let it stand three nights, filter the residue out of the vinegar and roast it, until it has become a more perfect cinnabar. Cast one dirham on ten of silver and grind it with three (L with an equal amount gold), then it will come out as refined gold as God wills.

40. Another way. Take the red copper acetate and saturate it with *zād al raǧwa*,[399] grind it by day and roast it in the night, do this seven times (E and saturate it with wine vinegar, in which there is a quarter as much vitriol;) add a dirham of it to 15 of silver and grind the ten with three, then it will come out perfect as God wills.

41. [G L] Another way. Take one part of the red copper acetate and as much as a quarter of it of yellow vitriol, make a paste of it with oil of egg yolks in proportion with that which you have combined, and roast it on a gentle fire; do this with it until it has become a cinnabar. Its dirham works on 20; grind the 10 with 3, then it will come out perfect, as God wills.

42. Another way. Saturate the copper acetate described previously with vitriol dissolved in moisture, in which there is as much as its quarter of yellow marcasite (gold marcasite) and ferric oxide and oil from egg yolk. Do not stop roasting it until it has absorbed an equal amount of the mixture and has become excellent cinnabar as God wills. (G E Its dirham colors 30, and if you grind ten with two mithqal; it comes out good as God wills.

43. * Another way. (E Soak it with this water, and that is, that) you take one part roasted, clean, excellent soda salt, dissolve it in its moisture, and then sublimate it no less than to redness, then pour constricted mercury, to which a quarter as much dissolved, filtered, purified vitriol has been added, then it dissolves in it. (G Then it is mixed with that, which you treated with marcasite previously in this chapter.)[400] Grind it by day and roast it by night, until it has absorbed an equal amount and has become cinnabar powder. Cast one part on 40 of silver, then it comes out as perfect gold. And if you take vitriol and dissolve it, roast, and purify it and add in a quarter as much red arsenic sulfide and gold marcasite in equal amounts, let it stand three nights and then purify it, and if you saturate gold filings with it, and roast it continuously, until it has become a red powder, and then, grind with it a quarter of what is already prepared, and soften the whole with sal ammoniac that has been sublimated in vitriol, in seven softenings, then one dirham of it will color 100 dirhams as God wills. [G50]. And if you dissolve it and solidify it again, it will color one ratl, and if you dissolve it a second time and add distilled water from egg yolk equal to half of the whole amount and a quarter part oil and let it solidify, then will its one part color 600 mithqal to refined gold (E it returns to purity) as God wills.

Third chapter. The Calcination of Copper through Amalgamation.

44. Take as much of copper filings as you wish, amalgamate them with three times as much mercury, add an equal amount of alum as copper and half as much sal ammoniac as alum; grind it thoroughly (E one day) and wash it with water and salt, then roast it several times with alum, made into a paste with egg white, until it becomes a white impalpable powder. And if you grind it with an equal amount of silver, then it will come out perfect (E as silver) as God wills.

45. * Another way. Take from the filings what you wish and amalgamate it with five equal parts mercury, grind them well together and cook it three times with oil, until it boils, then wash it with water and salt, let it sublimate in an aludel and place the topmost underneath, until it becomes like powder, as God wills.

46. Another way. (G Take as much copper filings as you wish,)

amalgamate it with three (L five) equal parts of mercury, (L grind it well) and cook it three times with oil; then place it in a clay-coated flask with vitriol and sulfur (and roast it), until it becomes a cinnabar. Then soak it with water of sal ammoniac, that was sublimated with vitriol, ten times (E and soften it in ten softenings), then dissolve it, saturate it with whitened sulfur and roast it, until it becomes a cinnabar.[401] Then soak it with vinegar, in which there is a quarter amount of vitriol and just as much ferric oxide and redness from the oil of horns. Roast it and do this with it until it has absorbed an equal amount of vinegar, then grind it with just as much constricted red mercury, saturate it with (E the vinegar of) redness of hair, (E dissolved with its whiteness) and roast it. Then cast a dirham of it on 600 (E 300) of silver, [G51] (E thus it returns to purity).

* And when you have dissolved it and have distilled all of it (E and have taken its residue and dissolved and distilled it with sal ammoniac that that was sublimated with vitriol) and then solidified it in a blind alembic, then will its dirham color 2000 mithqal silver, it returns it to purity.

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The Chapter on the Calcination of Iron
First Chapter. The Calcination of Iron through Burning.

47. Take iron filings and grind them with an equal amount (E red) arsenic sulfide; put it in a clay-coated jar and put it in the oven (atūn); then take it out, wash it and dry it and make a paste of it with water and salt and repeat the procedure, until it becomes powder. (E: . . . salt and put it in the oven, then take it out, grind it and dry it with water and salt and put it in the oven; then take it out and grind it in the same way and wash it and dry it, so that it becomes white powder.) If you then soften (E this calx) seven times with sal ammoniac water sublimated with salt, and dissolve it and then soak the sublimated mercury with it and roast it seven times with a small fire (E then soften and dissolve and let it solidify), then it will solidify in an excellent manner. One dirham of it colors 100 of copper and tin and changes it to excellent silver as God wills.

48. Another way. Take iron filings, as many as you will, grind them with just as much yellow arsenic sulfide and place it in a clay-coated jar. Roast it in the oven and let it melt down, after you have ground it with a sixth as much natron, and sprinkle it with as much oil as combines with it, then it melts down to a metal similar to Chinese iron. Then grind it with together with water and salt, wash it several times and dry it (E then combine it with Andarānī-salt and put it in the oven. Take it out, when it has cooled, and wash it, after you have ground it, and dry it), and repeat the process and the procedure with it until it has become white powder. Then soak it with mercury, dissolve it with sal ammoniac, and roast it, until it has absorbed three times its amount. Then cast one dirham on 100 of whatever metal you will, then it will come out as (E L excellent) silver as God wills.

Second Chapter. The Calcination of Iron through Letting it Rust (L E: so that it becomes saffron).

49. Take the best iron filings and wash them (E and dry and filter them) and pour them in a bag and leave them in a wet place three days. (G L Then take it out, crush it and wash it.) Repeat the procedure with it in the same manner and place it [G52] in a wet place three days. Then take it out (L crush it) and grind it and repeat the procedure with it the same way, until it has become ferric oxide as God wills.

50. [L E] Another way. Take iron, that is not roasted (E iron filings are best) and wash it with water and salt, until its dirt is gone. Then place it in a wide glass beaker, pour wine vinegar over it and shake several times daily; each time that it becomes dry, add new vinegar to it, until it has become saffron as God wills.

51. Another way. Take iron filings, as many as you will, and mix them with a quarter of their amount red arsenic sulfide, place it in a clay-coated jar and roast it one night in a very hot oven. Take it out, when it is cooled, and wash it with water and salt, until it is clean. Grind it with one-sixth part natron, make a paste of it with oil and let it melt down several times, then grind it and soak it for three nights long with wine vinegar, in which is a fourth part [G purified?] vitriol. Saturate it and soften (E grind) it by day and roast it by night until it has become a red (unsurpassable) powder. And when saffron of hair is combined with it,

then it . . .) Add its one part to 6 of silver and add one to one, so it appears as gold (L is perfect) as God wills.

52. Another way. (It consists of) that you saturate this saffron with vinegar, which contains a quarter part purified vitriol and a quarter part copper acetate; grind it by day and roast it by night, until it becomes (red) as liver. Cast one dirham on ten and add one to one.

53. Another way (It consists of), that you soak this purified iron (G saffron), after you have ground it, with vinegar which contains a quarter part green vitriol and sal ammoniac, and as much as half the amount of sal ammoniac is sulfur. Let it stand in them three nights, then clean it, grind it (E soak it) by day and roast it by night, until it has become excellent saffron. One dirham colors 20 (L silver), and you grind ten with five, (E L so that it comes out red as God wills).

54. Another way. Take this purified iron, let it melt down with a sixth part (L half) sal ammoniac, then with a sixth part bat dung, then with a sixth part vitriol; (E do this with it) three times, then soak it with vinegar, which contains a quarter of dissolved vitriol and copper acetate and sulfur and sal ammoniac [G and ferric oxide] in equal parts. [G53] Grind it with them by day and roast it by night, so that it comes out as a red powder. Its one part colors 30 of silver and it acts on tin with a moderate effect. Grind ten of silver with three (Gold), then it comes out red as God wills.

55. Another way. (It consists of) that you saturate this (iron) with redness of hair, solidify it and dissolve it with its water with four times its amount. You grind it, soak, and roast it, until it becomes powder, red as liver. Its dirham colors 100 (E 30) silver and 50 tin as God wills.

56. Another way. Take from this chapter that which (has been mentioned), whereby its dirham colors 30 of silver, and grind it with an equal amount mercury, that has been sublimated to redness and constricted with *Zād al-rağwa*.

* [G We will mention this at the end of this chapter so God wills.] Soften it with water of sal ammoniac, sublimated seven times with vitriol and egg yolk, and dissolve it; add two dirham oil from egg yolk to it, moisten it and bury it, until they have both mixed well with each other and it has dissolved and become a coloring water, then let it solidify. Its one part colors (E its dirham) one ratl of silver (G and leaves it behind) as refined gold as

God wills.

57. *And if you desire the full accomplishment (E the perfection), then before it solidifies, place calx of gold in it, that we referred to at the end of the chapter of copper acetate, as much as the red mercury, and lead burnt with vitriol, as much as a quarter the amount of mercury, and whitened stable sulfur, as much as half the amount of mercury, and bury it in dung, until it is dissolved. Then add an amount of redness of hair equal to the whole and let it solidify in a blind alembic in a small fire (E a naphtha lamp), and then it will solidify in seven days. Its dirham colors 1000 of whatever metal you will and transforms it into refined gold. If you dissolve it a second time and let it solidify, it colors 2000, and if you dissolve it and let it solidify a third time, then it spreads throughout the metal like snake venom in the bodies of beasts, and one part of it colors [G54] 3000 (E 4000) of whatever metal you will as God wills.

58. Description of *Zād al-rağwa*. Take two parts unslaked lime and one part yellow sulfur and boil it with four times as much water until it turns red. Filter it and repeat the procedure, until it turns red, then combine the waters and boil them until they have evaporated to half, and use them (E Allah knows best).[402]

Third Chapter. The Calcination of Iron through Amalgamation.

59. Take iron filings (G L that were polished for one hour long), boil them with alum and sal ammoniac and pour four times as much dissolved mercury on them and roast it seven times in a small fire, until the mercury flies away from it and white impalpable powder remains behind. Then soften it with the dissolved mercury in seven softenings and pour a stream of it thereon and bury it in dung, until it has dissolved. Then let it solidify in a blind alembic on a coal fire, so that it solidifies in three days, then grind it with a quarter of its amount of calx of egg white [G or, he says, calx of shells] and grind it with dissolved mercury. Bury it, until it has dissolved, and put as much as a quarter of its amount dissolved egg white in it, and let it solidify, so that it becomes white powder. Its dirham transforms 100 of whichever metal you will, and if you dissolve it and let it solidify a second time, then it colors more than this for you (E 200 dirham) as God wills.

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V. The Chapter of Calcination of Both Leads.
First Chapter. The Calcination of Both Leads through Burning.

60. Take whichever of the two you wish and burn it with sulfur, one part for every ten of sulfur, until it becomes a dust. Then grind it with water and salt, then put it in a clay-covered jar and put it in the oven (atūn); then take it out, when it has cooled, (L E grind it,) wash and dry it and repeat the procedure with it (L until it has become like a dust). After that put it in the tābistān and heat it underneath, and continually spray water and salt on it and shake it, until it has become a white powder (G L and even if it takes ten days).

61. [E] Another way. Take whichever of the two you wish and burn it with a quarter part of sulfur, until it becomes a dust. Then put it in a tābistān and light a fire over it and spray it continually with water and salt and shake it, until it has become white powder, and even if it takes ten days.

62. Another way. Burn whichever of the two you will with salt, then put it in the oven, after it has been washed and dried [G55] and sprinkle it with distilled water and salt, in which there is a quarter of the amount of sal ammoniac. Put it in the oven in a clay-coated jar, take it out (E when it has cooled) and wash it (G with grinding) and dry it. Repeat this process, until you have left all of it as white impalpable powder as God wills.

63. * Another way. Burn whichever of the two you will in a tābistān, thereby the lead turns to a yellow powder and the tin to a white powder; then let the tin melt down, it comes out of the oven as a noble metal. Then grind 100 parts with three of (E just as much) pretreated iron ore and one dirham silver, that is solidified with mercury, then it turns to a elixir [*ra's*] (beginning, precursor) that it replaces for you.[403] Soak the lead with water and salt and put it in the tābistān again, until turns white and impalpable, then use it.

64. Another way. Take sheets of whichever of the two you wish, dip them in water of sal ammoniac and put them in the tābistān, after you have taken out the fire and the coal. Then heat them in it with careful heating and take them out and wipe off what is on them. Repeat

the procedure until it (E L can be crushed between the fingers and) has become white (G crumbly) powder. Then heat it in the tābistān and spray water of sal ammoniac on it, shake it, and heat it over that, until you get a white impalpable calx. Then wash the sal ammoniac out (G E with the filter), and dry it, put it back in the tābistān and burn it one day long with the dissolved sal ammoniac, but be careful with its burning (E and turning to dust). Then soak it with whitened dissolved sulfur and roast it three times, then its dirham colors 30 of whichever metal you wish. And if you soften it in ten softenings and dissolve it and distill it, (E and likewise soften the residue which is left behind, and dissolve it and distill it until all is distilled) and you mix it with an equal amount dissolved distilled mercury and a quarter of its amount dissolved talc and again let it solidify, then one dirham colors 500 (E 100) of any metal, that you will (E it returns to purity).

Second Chapter. The Calcination of Both Leads through letting them Rust.

65. Take whichever of the two you wish [G56] in sheets and put them over an open bowl of vinegar and scrape the rust off of it, as soon as it rusts, and repeat the process, until you have removed all the rust.

66. Another way. Take filings from whichever of the two you wish and put them in vinegar, in which its quarter amount of sal ammoniac is dissolved, until it rusts, and every time it dries, again add vinegar to it, until you have removed all its rust (L until it rusts as God wills).

67. [E] Another way. Take filings from whichever of the two you wish, drop them in this sharp water, and this is, that you take distilled vinegar and add its quarter amount of sal ammoniac and alum and copper acetate in the same amount. Let it stand one week and purify it, after you have shaken it several times a day, then replenish the mixture three times and let it stand again for one week. Do this several times, then grind the filings from whichever of the two you wish with this water, so that it dissolves therein and precipitates to the bottom.

68. Another way. Take distilled vinegar and add to it a quarter as much copper acetate, sal ammoniac, and alum in equal parts and let it stand one week (E and purify it, after you have shaken it several times every day. Then repeat the three mixtures and let it stand overnight.) Do

this three times, then grind it with filings from whichever of the two that you will, then it dissolves therein and crumbles. Then saturate it with saltwater and roast it, until it turns to rust.

69. Another way. Take (G L from it and) one part calcined vitriol (L glass, E lead) and ten parts mercury dissolved with sal ammoniac, place it in a flask and bury it (G in dung) , so that in 40 days it dissolves without residue. Let it solidify in a blind alembic, then it solidifies to powder. One dirham transforms one ratl of whichever metal you will into white silver as God wills. And if you grind it and soften it a second time and dissolve it and distill it, until it is entirely distilled, and you let it solidify in a blind alembic, then it comes out as powder, purer than crystal. One dirham colors 1000 of whichever metal you will, it returns to purity. (L God is the helper, there is no other than him.)

Third Chapter. The Calcination of Both Leads through Amalgamation.

70. Take from whichever you will, amalgamate it with three times as much mercury and grind it with water and salt, until it is pure, then roast it with alum. Do this with it five times (G and grind it) and soak it with water and salt and roast it in a clay-coated jar in a glassmaker's oven[404] one day and one night. Do this with it, until it has become a white impalpable calx.

71. Another way. Take from whichever of the two you wish, amalgamate it with three times as much mercury, grind it and wash it with water and salt, until it is pure; soak it with sal ammoniac and alum [G57] and roast it in a clay-coated flask with a gentle dung fire. Do this with it three times, (E at the beginning of the night, and in the middle, and at the end of the night; soak it after the drying) then let it sublimate in an aludel and place the topmost below, until it (E the lowermost) has become white powder. Take that which sublimated from it, purify it, and soak it with water of sal ammoniac and soften it, until it becomes a salt, which melts. Then dissolve it (E and put it in a dung fire) and soak it with the lowermost (L with mercury) and roast it. Do this until it flows over a copper tablet and (disappears) in it. Cast one on copper, then it colors this to excellent silver as God wills.

And if you soften the calx once again and roast it and dissolve it mix it

with both waters and then let it solidify again, then its dirham colors 60 dirhams copper. And if you soften the residue once again and dissolve and distill, until it is completely distilled, and you mix half as much whitened, dissolved, distilled sulfur and solidify it, then its dirham colors 400 dirhams copper and transforms 200 dirham tin and lead as God wills. And if you dissolve it a second time and let it solidify, then its dirham colors 700 of whichever metal you will.

Now we are at the end of the chapter on the calcination of metals; so we will now describe the calcination of stones as God wills.

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C. The Calcination of Stones

There is no calcination for stones other than through burning.

I. The Calcination of Marcasite.

1. Grind it with water and salt, then wash it, until it is clean, and sprinkle it with distilled saltwater. Then place it in a clay-coated jar, put it in an oven (atūn) and take it out when the oven has cooled. Do this until it has become white powder.

2. Another way. Take from it what you will, heat it on a (E long-handled) iron roasting pan in a tābistān and cast it in soda water. Do this with it seven times, then sprinkle it with distilled saltwater and put it in the oven in a clay-coated jar. Take it out, when it is cooled, wash it and repeat the procedure [G58] with it, until it has become white powder. Then soften it in seven softenings with sal ammoniac water and dissolve it and set it aside. Then take amalgamate of silver six to one, and place it in a clay-coated flask and pour the water that was set aside on it, from both of these waters, enough to just cover it, and seal the connection. Roast it on hot coals one night and repeat the process with it, until it has absorbed its weight of the water, and it has solidified and does not smoke, therefore nothing escapes from it, then its dirham colors 30 of whatever metal you will.

(E: . . . six, and of red arsenic sulfide as much as a quarter of it, until it has absorbed its weight of water, and has solidified and does not smoke. Its

one part colors and so on.)

* * *

II. The Calcination of Magnesia.

3. Grind it well, mix with it as much as its half part of yellow arsenic sulfide and roast it one night in a strong fire. Then take it out and wash it with water and salt and dry it and mix an equal amount of salt with it and place it in a clay-coated jar in an oven with a roaring fire. Take it out when it has cooled, and wash it and repeat the procedure with it and replenish the salt, until it (G in its state) has reached white powder.

4. Another way. Burn it, after being ground with an equal amount white sulfur, in a clay-coated jar with a strong fire, take it out, wash it and mix an equal amount of salt with it and put it in the oven. Do this (as often) until it pleases you, then mix it with an equal amount whitened sulfur and grind it with dissolved mercury, until it has become dry, then roast it. Do this until it has absorbed an equal amount of sulfur, then pour a stream over it and bury it (L E three weeks long. Then take it out and distill it and take the residue and soften it with dissolved mercury and bury it, E so that it dissolves, and distill it. Do this with it, until all is distilled, then solidify it in a blind alembic,) then it solidifies like crystal. Its dirham transforms 200 of lead or tin (L of both leads) and mercury. It makes it permanently into white silver (E G it returns to purity as God wills.)

* * *

III. The Calcination of Iron Ore

5. Take iron ore, heat it well and quench it several times in wine vinegar and salt, so that it crumbles; (E but if it offers resistance), then break it up and crush it with a steel mortar,[405] so that it turns to powder. Mix it with red arsenic sulfide and roast it one night in [G59] a hot oven (tannūr) with a very strong fire, then take it out, wash it and let it melt down, after you have ground it with a sixth part of natron. Mix it several

times with oil, then grind it with an equal amount of salt, put it in the oven (atūn) and replenish the salt. Do this with it several times, until its color (G calcination) pleases as God wills.

6. Another way. Take it and heat it well and cast it repeatedly in water and salt, until it crumbles. Then grind it well and mix with it half as much yellow arsenic sulfide, put it in a clay-coated jar and burn it in a strong fire throughout one night. Then take it out, grind it and wash it and let it melt down, after you have ground it with a sixth part natron, and sprinkle it repeatedly with oil, E so it melts down as a white metal.) Grind it and sprinkle it with saltwater (E vinegar), put it in the oven (atūn), take it out, when it has cooled, and repeat the procedure with it, until it has become a white calx. Then mix it with its third part calx of silver and soften it seven times with dissolved mercury, until it has absorbed seven times its equal, then pour just as much as that on it and bury it 60 days, until it has become a white water. Then solidify it with the blind alembic, then it turns to white powder. Its dirham transforms 100 lead and mercury into silver as God wills. (E and if you dissolve it over again and let it solidify, then one part of it transforms four ratl of whatever metal you wish.)

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IV. The Calcination of Tutia. [zinc vitriol]

7. Take it [already] ground and sprinkle it with oil, put it in a clay-coated jar and place it in a very hot oven (tannūr), then take it out; its fire, however, must be very strong. Then grind it and wash it several times with water of soda, then sprinkle it (with oil?) and place it in the oven (atūn). Do this with it, until it becomes white powder, as God wills.

8. Another way. Take the tutia and grind it with a sixth of its amount of red arsenic sulfide, put it in a clay-coated jar and place it in a [G60] very hot oven (tannūr) and leave it there until it is half (G L and immerse it) one day and one night. Then take it out (E when it has become cold,) grind it and wash it several times with water and salt, then several times with sweet water, then sprinkle it with water of sal ammoniac and alum, both boiled with ten times as much water, until a third of it has gone away (evaporated). Purify it and put it in a clay-

coated jar and place it in an oven (atūn) three times according to this procedure, wash it each time, when you take it out of the oven, and grind it, then it becomes white as quicklime (powder). Then soak it with vinegar, in which there is a fourth part of dissolved sal ammoniac and half as much dissolved vitriol, and roast it, until it has become a zunğufr (cinnabar), and put it away. Then take as much gold as you will and amalgamate it with five times as much (E mercury and roast it in a clay-coated flask between vitriol and sulfur, until it has become a zunğufr (cinnabar), then grind it with vitriol and sulfur and add half of it to the already prepared tutia and as much as the whole) dissolved mercury sublimated for redness in it and bury it three weeks, then it entirely dissolves in three weeks. Then let it solidify, grind it and soak it with vitriol and green vitriol and yellow vitriol, dissolved with the dryness four days, until it has absorbed four times as much in seven times. And roast it (E each time) until it has become red, as you have seen (L and its color and effect please you). Then throw its dirham on 70 of silver, then after you have mixed the ten with one mithqal gold, it is returned to excellent gold as God wills.

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V. The Calcination of Lapis Lazuli

9. Take of it what you will, then grind it and soak it with wine vinegar, which contains vitriol and alum (E salt) and sal ammoniac in an amount equal to a quarter of it, and roast it strongly, until it has become a white powder. Then soak it with wine vinegar, which contains vitriol, sal ammoniac, and yellow sulfur (E in an amount equal to a quarter of it), and boil it (G and grind it) until it has absorbed a quarter of its amount and turns red like cinnabar. Then put it aside, take mercury, sublimated to redness, and just as much ferric oxide and half as much green vitriol [G61] and grind it well and soak it with the vinegar, in which the vitriol, the sal ammoniac, and the yellow sulfur were dissolved, and roast it in a gentle fire like a bird incubator – I mean the hot ashes – until it turns red. Its dirham colors 30 dirhams of silver, and you grind the ten with three as God wills.

10. Another way. (It consists of) that you soften this lapis lazuli in

ten softenings and dissolve it and then let it solidify. Its dirham colors 50 dirhams of silver and you grind it ten with two. And if you soften it and soak it with distilled water of egg white and dissolve it, until it has absorbed as much as half its amount, then its dirham colors 70 and it transforms it into excellent gold; it stays permanently with its ra’s (elixir).

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VI. The Calcination of Malachite.

11. Take it and grind it and soak it with water of copper acetate, of vitriol, and of sal ammoniac, but be careful with it, and roast it with hot ashes, until it becomes zunğufr (cinnabar). Then grind it with just as much whitened stable sulfur, soak it with water of copper acetate, of vitriol, and of sal ammoniac and roast it, until it has become red powder. Its dirham colors 10 of silver, and you grind ten with five, then it comes out red as God wills.

12. Another way. Take from it what you will, grind it and soak it with water of sal ammoniac, that is sublimated with vitriol, dissolved with moisture, roast it. Do this with it constantly, until it has become a dust, then grind it with vitriol, dissolved with water from distilled egg yolk, [until it has turned red] and roast it on a gentle fire, until it has become red. Its dirham colors 10 silver, and you grind ten with five, then it comes out perfect as God wills.

13. Another way. (L E This is a precursor. Take from this one part and one part whitened sulfur and one part mercury sublimated to redness; soften it with water of sal ammoniac, sublimated seven times with vitriol, then dissolve it [G62] and let it solidify, so its dirham colors 30 and it is stable with its first stage.) And if you will, then soak it before you soften it, seven times with water of green vitriol and of vitriol and of water of sulfur and of quicklime, that is called *Zād al-ragwa*.[406] (E Roast it one night on a gentle fire, with each soaking, then soften it) and dissolve it and let it solidify, then its dirham colors 100 of whatever metal you will.

And if you, before you let it solidify, add to it half as much water of egg

yolk and just as much oil of egg yolk and keep it dissolving 14 days long, then take it out and let it solidify, then its dirham colors 200 mithqal silver and 100 mithqal mercury; it is stable in its purity. And if you distill it, before you (E have mixed it with the water of egg yolk and its oil, and you have added a tenth part of calx from egg yolk and) have mixed it with water of egg yolk and its oil and let it solidify, then its dirham colors 700 of whichever metal you will to excellent gold (E that is stable in its purity) as God wills.

14. Another way. Take one part of it and grind it and mix a quarter part red arsenic sulfide with it and roast it in an oven (tannūr) in a strong fire, then wash it and grind it after its drying, grind it with water of dissolved green vitriol and yellow vitriol and red vitriol and roast it. Do this until it turns red and becomes a powder. Then take (E one part from it and just as much calx of turquoise and) just as much calx of gold, grind it and soften it in seven softenings with water of vitriol and of sal ammoniac and of egg yolk, then (E sprinkle it with water of sal ammoniac and dissolve), then mix it with just as much dissolved mercury and let it solidify. Then soak it, after you have ground it, in seven times with as much as the whole of the redness of blood and roast it. Then soften it with water of vitriol and of sal ammoniac and of egg calx three times and dissolve it and add a quarter as much oil of egg yolk and just as much dissolved red mercury. Let it solidify in a blind alembic [G63], so it solidifies to a powder similar to rubies. Its dirham colors 1000 of silver, and if you dissolve it, after you have ground it and softened it three times with water of vitriol, of copper acetate, and of sal ammoniac, and distilled it with calx of hair, as much as a tenth added in, and let it solidify, then its dirham colors 3000 of whatever metal you will, it transforms into excellent gold as God wills.

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VII. The Calcination of Turquoise

15. Take from it what you will, grind it and place it in the oven (atūn) with an equal amount of Andarānī salt. Then take it out, wash it, and repeat the procedure with it three times, so that it turns to powder. Then [G L grind it and] soak it with water of vitriol and of sulfur and

roast it until it turns red as God wills.

16. Another way. Take from it what you will, grind it and place it in a pouring spoon of iron and place it in a heating oven – I mean the tābistān – and heat it fiercely. Throw it in distilled salt water several time and grind it and sprinkle it with that and place it again in the oven (atūn). Repeat the procedure with it and wash it each time with sweet water, until the saltiness and the blackness has gone away. Then soak it with the redness of sulfur, that is called *Zād al-ragwa*, and roast it. Do this with it seven times, then soak it three times with water of green vitriol and just as much oil of distilled egg yolk, and roast it each time on a gentle fire, then soften it and dissolve it and soak it with mercury sublimated to redness, until the oil has absorbed three times as much mercury and has solidified to red powder; its dirham colors 300 (E 100) of silver.

[G E and if you grind it and soften it seven times with water of vitriol, dissolved with moisture, and water of sal ammoniac, and dissolve it and add its tenth part of ferric oxide and just as much calx of skull and as much calx of distilled redness of sulfur, and then let it solidify, so its dirham colors two (E one) ratl of whichever metal you will as God wills. [G64].

* * *

VIII. The Calcination of Hematite

17. Take of the lens-like stone (E as much as you will) and grind it well with distilled saltwater and roast it three times, then make it into a paste (L grind it) with purified water of vitriol, grind it an hour, and roast it in a light fire. Do this with it until it turns red, then make a paste with it with egg yolk and roast it and repeat the procedure with it three times, so it becomes a red powder.

18. Another way. Take it and grind it (E and make a paste) with vinegar which contains vitriol, green vitriol, and ferric oxide in equal amounts, each equal to a quarter of the vinegar, and roast it one night in a clay-coated flask in a fire of sheep dung. Do this constantly, until it has become red powder. Then take of it one part, of red mercury one part, and of gold marcasite a half part. Grind the entire amount with

eggwhite, put it in a flask, set it in a kettle with hot ashes and plug it with wool from time to time, until its moisture comes out with it. Then close its top tightly and heap ashes on it and heat it underneath for three days and their nights, then take it out (E thus you will find it) as powder red as blood. Cast its dirham on 50 of silver and grind it ten to one, so it comes out red (as gold).

* * *

IX. The Calcination of Kohl.

19. Take as much as it as you will, put it in a (L E long-handled) iron roasting pan and place it in a tābistān and heat it until evening. Then grind it thoroughly and make a paste of it with distilled vinegar and salt, grind it well together and place it in an oven in a clay-coated jar; then take the jar out, when the oven has cooled, and repeat the procedure with it, until it has become a white powder as God wills.

20. Another way. Take from it what you will, grind it with just as much soda salt (E and place it in the tābistān and heat it there until evening. Then grind it and make a paste with soapy water and burn it one day long in the tābistān. Then soak it with water of Andarānī salt) and place it in the oven (atūn) in a clay-coated jar; take it out, when it has cooled and repeat the procedure with it, until it has become white powder. Then take just as much calx of iron and just as much calx of silver and calx of tin equal to the entire amount and soften all of it with water of sal ammoniac, until it has become a salt that dissolves in moisture. Pour on it [G65] three times the amount of dissolved mercury and bury it 40 days, then dissolve it to a clear water. Put this aside, take just as much calx as kohl (E sublimated white stable arsenic sulfide and three parts) mercury, sublimate to whiteness (E I mean three times as much kalk as kohl) and one part sublimated sulfur, soak it with the water that was put aside and roast it on a fine fire. Do this with it until it has absorbed all the set-aside water and has solidified to white powder. Then grind it and soften it three times with water of tinkar and pure borax, put it in a flask between alum, made into a paste with eggwhite, and roast it, after you have sealed the lid, in a dung fire throughout one night. Cast one dirham on 1000 of any metal you will, then it transforms it to white

silver. (E It returns to purity as God wills.)

* * *

X. The Calcination of Talc

21. Take from it what you will and make it into a milk with bean-water and let it set. Filter it and soak it with water of natron and soda and grind it together thoroughly three times, until it is dry. Soak it every time, until you obtain a soupy liquid, roast it one night in a hot oven (tannūr) and take it out, when it has cooled, and repeat the procedure with it, thus it calcines [and melts] as God wills. And the sign of its calcination is, that it absorbs water (L and makes it vanish].

22. Another way. Take from it what you will, make it into a milk (E with water of soda and make a paste) and place it in the oven (atūn) in a clay-coated jar; do this with it, until it becomes white powder. Then combine this with an equal amount mercury, sublimated to whiteness, and soak it with borax of Zarāwand and natron, both dissolved with moisture, and roast it in a clay-coated flask with a gentle fire and repeat the procedure with it seven times, so it becomes white powder. Its dirham transforms 20 of lead to silver, as God wills.

23. Another way. Take from it what you will, heat it on a (E long-handled) iron roasting pan in a tābistān, and throw it in soda water seven times, then combine it with hot soapy water, (E after you have made the talc into milk, and put it in a clay-covered jar and place it in the oven and place in the hot soapy water) as much as its quarter of very white soda salt and sal ammoniac and egg shell calx in equal parts, and as much as a tenth part whitened sulfur, and let it stand one day [G66]. Clean it and throw as much as its fifth calcined sea foam in it and as much as its tenth urine salt, let it stand several days. Shake it every day and clean it; then roast it in the oven, take it out, when it has cooled, grind it (E and wash it on a filter with sweet water, dry it and grind it) and repeat the procedure with it three times, thus it becomes white powder. Now pour three times as much dissolved mercury on it (E and just as much sublimated arsenic sulfide in which there is no blackness) and bring it to dissolving, so that it dissolves to a water without residue in 40 days. Then let it solidify, so its dirham transforms 500 of lead and

mercury into silver as God wills.

[At this point, the chapters on calcination of gypsum and white arsenic must follow.]

* * *

XI. The Chapter of Glass.

24. [E] Take from it what you will, heat it and cast water of soda in it seven times, then make it into a paste, and place it in the oven, thus it calcines in three times.

25. (E Another way.) Take of it what you will, grind it well, and put it in a (E oven for heating, that is the) tābistān. (Then take it out), spray distilled saltwater on it and shake it continually, three times on three consecutive days, then wash it on the fourth day with the filter and clean it; then on the fifth day place it in the tābistān and heat it and shake it and scatter nothing in it, before you have shaken it. You obtain an impalpable powder that melts on the tip of the tongue.

26. Another way. Take of it what you will, grind it well, make a paste of it with soapy water in which a fourth of it (E soap and) eggshell calx and sal ammoniac were cast in. Grind it well and put it in a clay-coated jar and place it in an oven (atūn), thus it becomes white quicklime (powder) in seven times. Then take one part of it, soften it and dissolve it and put it aside, and [*sic*] of whitened sublimated stable (E softened) dissolved (G distilled) sulfur (E one part and of distilled sublimated mercury) three parts.[407] (G E Then mix all and bury it for 40 days, thus it dissolves into a water without residue. Let it solidify in a blind alembic,) thus it solidifies into a white powder. Its dirham transforms 500 of mercury and lead to silver as God wills.

* * *

XII. The Calcination of Salts.

27. [G67] Take from it what you will and grind it well and put it in a clay-coated jar with a tight plug (lid). Place it in an oven and take it

out when it has cooled; (E crush it and take out what is in it,) grind it and weigh it and repeat the procedure with it, until it remains unaltered at one weight that does not diminish.[408] This is the sign that the goal has been reached. And another sign is this, that when you lay (L spread) some of it on a hot iron, it does not change color. This is the sign of its stability, therefore keep it for your work as God wills. [L God leads, if he wills, on the straight path.]

28. Another way. Take from it what you will, and grind it thoroughly, put it in a clay jar and seal its opening (lid) tightly and cover it with artist's clay; place it in a baking oven and leave it in there three days with their nights, then take it out, let it cool and crush it and grind it and put it in the tābistān. Heat it three days with their nights, until it becomes white and its whiteness persists in its state. Then take it out, when it has cooled, and dissolve it with moisture and mix it with an equal amount of whitened, dissolved, distilled sulfur and soak it with mercury that is sublimated to whiteness, until it becomes white powder. (E grind it and roast it, until it is stable and does not smoke and becomes white powder, so changed and) one dirham of it colors one ratl of whichever metal, that you will; it leaves it behind as white metal.

29. It is now the end of the chapter on metals and stones and salts, and it remains yet for us to describe the calcination of mussels, eggshells, and skulls. We will mention these in the chapter on animal substances, and begin now with the description of softening as God wills [G68].

* * *

Part Two
The Chapter on Softening.

1. There are four methods: Softening through spirits, softening through salts, softening through oils, and softening through borax.

2. The softening of spirits happens through spirits and salts and borax and oils. Metals are softened through spirits and salts and borax, and salts are softened through oils; God is the helper.

A. The Softening of Spirits

I. The Softening of Spirits through Salts

3. The best way to soften the three spirits is under the salts of sublimated sal ammoniac, ground with an equal amount of eggshell calx in a dissolved state. And soak each sublimated spirit with this water until it becomes like a soup, then grind it, until it is dry, and steam it in a clay-coated bowl on coals and (E take care,) if its surface begins to steam and to smoke, put it aside, until it has cooled, and repeat the procedure ten times. Then (E take it out and) grind it and repeat the procedure until it has become a salt, that melts with moisture. Then dissolve it (E and grind it) and soak it with whichever calx of metals, salts, and stones you will, and roast it (E L with a gentle fire) in a flask in a kettle with hot ashes (E or in a clay-covered flask with a dung fire) several times, until it solidified and does not smoke and flows on a heated test tablet of silver or (G and) copper, so that it becomes solid on them.

4. Observe that the calxes which you use in this procedure are all precursors (ru'ūs, beginnings),[409] which color that which lies between 20 to 50; and if the calx softens over again and dissolves, and if you mix it with the softened dissolved spirit and let it solidify, then it will become a agent, that colors everything, that lies between 40 and 80 as God wills.

II. The Softening of Spirits through Oils

5. Soften the spirits with distilled olive oil and distilled naphtha and distilled sesame oil (E and castor oil). Soak that which was sublimated from them with these oils and roast it in a flask, not clay-covered, in a kettle, in which [G69] there are hot ashes, and drive its moisture off. Then secure the closure (lid) and fill ashes over it and light small coals under it, until it turns to powder similar to Chinese iron, and is stable on the fire. Its dirham colors what lies between 20 and 40, to gray silver; so work with it and take note of it. [L I praise God, that I am in awe of him, and God is the helper.]

III. The Softening of Spirits through Boraxes

6. Dissolve whichever borax you will with moisture according to that which we have mentioned, and make it into a paste with whichever of the sublimated or whitened without sublimation spirits that you will and grind it, until it is dry. Then place it in a clay-coated flask, seal its

closure (lid) and roast it in hot ashes several times on any day (L one time). Then take it out over again and soak and grind it, until it is dry, and place it back in the flask and roast it, until it is stable and turns to a (G coloring) precursor. Its dirham colors what lies between 20 and 30 (E L from copper), and leaves it behind as gray silver as God wills.

This is the end of softening of spirits; therefore we will begin with the softening of metals as God wills.

* * *

B. The Softening of Metals

1. The Chapter of the Softening of Gold.

First Chapter. The Softening of Gold through Spirits.

1. Take what you will of red gold, pound it into thin sheets, take for it a clay-covered kettle and put it in a layer of sublimated sulfur, in which there is no blackness, and a layer of gold leaf (E until you are finished). Then fill the rest of the kettle with vitriol, until you have filled it completely (L E set the lid on it), seal the connection tightly and place it in a medium fire, I mean a dung fire, in an oven (tannūr) and take it out, when it has cooled. Do this with it, until it flows and melts as God wills.

2. Another way. Take from it what you will and melt it and mix it with red whitened stable arsenic sulfide [G70] in one-quarter its amount (E little by little, then pour it and repeat the procedure, until it flows like lead, even if it must be repeated several times. Then soak it with water of white vitriol and roast it, until it becomes red and melts.

3. Another way. Take as many filings you will, amalgamate it with an equal amount of mercury and grind both of them with an equal amount of the best sal ammoniac; then place it between two beakers, the lower one of them being coated with clay, set it on coals, and when it smokes, take it off, until it cools, then put it back. Do this with it five times, then open it and take it out (E grind it) and soak it after the grinding with (E L water of) sal ammoniac and grind it until it is dry. Then put it back in the two beakers, seal the connection and repeat the procedure five times like the first one. Then grind it and test it on tablets so that it flows and melts and penetrates into it (E and now is it accomplished); if not, then repeat the procedure as long, until it melts and flows, and is white, and does not smoke as God wills.

4. Soak that which you will from these (E three) chapters with reddened dissolved mercury, that is cast in the color of distilled sulfur is cast, roast it in a flask on a gentle fire three times, each time with its weight, then it comes out as a coloring (E stable) precursor; its dirham colors (E 50 mithqal) as God wills. And if you soften this, until it becomes a salt, which melts in moisture, and you dissolve it and let it solidify, so its dirham colors 100 mithqal of whichever metal you will.

Second Chapter. The Softening of Gold through Salt.

5. Take dustlike calx of gold and soak it with water of dissolved sal ammoniac in an amount equal to its part. Grind it, until it is dried, put it in a clay-covered bowl and set it on coals, without covering, and observe it. When the surface begins to smoke, take the bowl away and let it cool an hour, then put it back. Do this with it ten times, grind, and soak it with dissolved sal ammoniac and repeat the procedure ten times, until it becomes a salt, that melts in moisture [G71] then keep it.[410]

6. Another way. Take salt that has dissolved in moisture, distill it, add a fifth of its amount of sal ammoniac to it and grind calx of gold with it until it is dry. Soften it in a clay-coated bowl on a coal fire, and if its surface begins to smoke, take it off. Do this with it five times and grind it each time and soak it with saltwater and repeat the procedure until it becomes a salt that melts. Then keep it (E for your use) as God wills.

7. Another way. Take what you will from its calx and grind it with distilled water (L with saltwater) in which a quarter part sal ammoniac and an equal amount of soda salt is dissolved, and evaporate it, as in the preceding, in a clay-coated bowl, until it has become a salt that melts.

8. Next, dissolve what you will from these chapters, mix it with mercury sublimated for redness and make a paste and bury it, until it dissolves therein. Then add the full weight of the dissolved calx (E and from mercury suffocated to red) and bury it again, (E and each burial lasts three weeks) until all the substances have dissolved (G in three weeks). Then let it solidify in a blind alembic, then take it out (E and grind it) and soak it with water of vitriol and copper acetate and dissolved ferric oxide and roast it, until it has becomes red powder. Its mithqal colors 70 mithqal silver and leaves it behind as excellent gold (G transforms it into excellent gold) as God wills.

Third Chapter. The Softening of Gold through Boraxes.

9. Take gold filings and soak them with water of tinkar and grind and roast it. Do this with them, until they become like lead (L melts) and flows on the test tablet as God wills.

10. Another way. Take its filings, grind them with borax from Zarāwand and with tinkar, both dissolved during grinding and roast them. Do this with them, until it melts like lead and flows on the test tablet as God wills.

11. Another way. Take its filings, grind them [G72] with water of natron and borax from Zarāwand, both dissolved with (E sharp, purified) soda water , and roast it. Do this with it, until it melts and flows, then amalgamate each of the two [E he means the first portion, that was treated, and the second portion; this portion is the third after washing with the filter] with 10 parts mercury and roast it in a clay-coated flask. Do this with it seven times, then soak it with oil of egg yolk and roast it, until it becomes as red as blood; then soften it with water of sal ammoniac between alum and vitriol with a fine fire or with hot ashes, until the 10 in 7 is returned (evaporated). Then grind it with vitriol and sulfur, both dissolved with hot water of borax (E and roast it in a clay-coated flask. Do this with it seven times, then soak it with oil of egg yolk and roast it, until it is red as blood, then soften it with water of sal ammoniac) seven times and dissolve it, then it dissolves in 30 days. Now let it solidify in a blind alembic, so it solidifies into a red powder like garnet. Its dirham colors one ratl of whichever metal you will and leaves it behind, pure as excellent gold as God wills.

II. The Chapter on the Softening of Silver

First Chapter. The Softening of Silver through Spirits.

12. Take sheets of silver (E take the silver and make it into sheets), put it in a casing of crucible clay, make a layer of sublimated arsenic sulfide and a layer of the sheets, until you reach the last, then fill what in the casing remains free with salt and sal ammoniac (L E alum), both ground, set the lid on it and coat with clay and seal the connection tightly. Then roast it on a gentle fire and take it out, when it has cooled, and repeat the procedure with it, until it melts and (G on the test tablets) flows like wax as God wills.

13. Another way. Take the silver, melt it, mix it with whitened arsenic sulfide and pour it in a mold. Repeat the procedure the same way (L E until it is softened) and melts (E like wax).

14. Another way. [G73] Take silver filings and amalgamate them with an equal amount (G best living) mercury and with as much sal ammoniac as

mercury. Roast them between two beakers. (G E the lower one clay-coated, and observe them, and when the smoke begins, set it aside and let it cool. Repeat the procedure with it five times, until it becomes a salt that melts. And always, when you have done the five times, grind it once and soak it with water of sal ammoniac, and put it back in the clay bowl) and seal the connection. Do this with it, until it becomes (like) a wax, which melts and flows on the test tablet and colors as God wills.

15. Soak what you will from this chapter with an equal amount dissolved mercury in seven times and roast it with each repetition, after you have ground it for one day over a gentle fire, until it solidifies into white powder. Its dirham colors 100 of copper (G and transforms it) into white silver as God wills.

Second Chapter. The Softening of Silver through Salts

[L When you understand the calx, you will attain the desired.]

16. Take calx of silver and grind it with sal ammoniac, dissolved with moisture in ten (E six) hours, then put it in a clay-coated māwardiyya[411] and soften it, until the smoke (E completely) comes out. Then let it cool, take it out, grind it and repeat the procedure with it, until it becomes a salt that melts on the test tablets (L E and turns white on them) and does not smoke as God wills.

17. Another way. Take powdery calx of silver and (E grind it well and) soak it with water of sal ammoniac and egg shell calx, and grind it therewith ten (E six) hours, then steam it in a māwardiyya, until its smoke goes out, then grind it and repeat the procedure with it, until you see it as a salt that melts as God wills.

18. Another way. Take soda salt and urine salt and sal ammoniac and eggshell calx in equal parts, pour on them the four times the amount of distilled vinegar and boil it thoroughly, purify both and soak the calx of silver with it and steam it in a māwardiyya, until its smoke emerges. Then grind it and repeat the procedure with it until [G74] it becomes a salt that melts in moisture as God wills.

19. Soak whatever from this chapter you will with dissolved, whitened sulfur and roast it in a flask, according to what has gone before (L what you know) until it becomes white powder. Its dirham transforms 50 of lead (L and changes it) into gray silver or 30 dirhams mercury. It turns to an elixir, one dirham of which colors 20 dirhams of copper to white silver.

Third Chapter. The Softening of Silver through Boraxes

(L When you understand softening and know its nature and ways, you will attain the desired.)

20. Take as many silver filings as you will, grind them and soak them with water of tinkar and bat dung and sal ammoniac and roast it in a clay-coated flask, then take it out and grind it and repeat the procedure with it seven times, so that it melts and softens like wax as God wills.

21. Another way. Take silver filings (G and grind them) and soak them with water of natron and borax from Zarāwand, both dissolved in soda water, and roast it. Do this with it continuously until it becomes soft like wax and melts as God wills.

22. Another way. Take silver filings and soak them with water of natron and dissolved bat dung and roast it. Do this with it until it melts and flows.

23. Soak whatever from this chapter that you will with mercury, sublimated with vitriol and (G dissolved) sulfur, (E L both dissolved, and roast it and soak it,) until it has absorbed an equal amount of it and has solidified to powder. Its dirham colors (E transforms) 60 of any metal you will, to white silver as God wills.

III. The Chapter on Softening Copper.

First Chapter. The Softening of Copper through spirits.

24. Amalgamate copper filings with three times as much mercury and an equal amount of sal ammoniac, grind it and roast it in a flask with a sealed plug (lid) in a dung fire throughout one night. Then take it out and grind it and soak it with water of sal ammoniac, and repeat the task with it, until it melts and flows and does not smoke as God wills.

25. [E] Another way. Take copper, melt it and mix it with an equal amount of stable arsenic sulfide, in which there is no blackness, in five times and sublimate it, until it melts and runs like lead.

26. Another way. Take sheets of cleaned copper and melt them and mix them with an equal amount of whitened stable sulfur in seven times, until they become soft and melt like lead. [G75]

27. Saturate whatever you will from this chapter with an equal amount o f mercury, dissolved in four repetitions, and roast it with each repetition, so that it turns into a precursor. Its dirham colors 70 of whichever metal you will.

28. Another way. Take (G L clean) copper filings and amalgamate them with four times as much dissolved mercury (E and grind it with an

equal amount of sea foam, then soak it with copper acetate), until it becomes like butter.[412] Then grind it and soak it one day with vitriol and copper acetate and sal ammoniac (G and ferric oxide) and sulfur, dissolved with distilled vinegar, and roast it (E one night) between vitriol made into a paste with egg yolk, in a clay-covered flask on a dung fire, until it turns to red cinnabar as God wills.

29. Another way. Take copper and melt it and mix it thoroughly with yellow sulfur or (E and) red arsenic sulfide, until it melts and flows like lead. Then soak it with (E the water from) the five vitriols, namely green vitriol, yellow vitriol, white vitriol, red vitriol, and dissolved vitriol, grind it on a grindstone and roast it. Do this with it until it becomes purple red, then soak these two waters with red stable dissolved mercury, in which is a quarter of the color of distilled sulfur, and roast it. Do this with it, until it (E has absorbed an equal amount and) has become powder. It absorbs an equal amount of each, its dirham colors 100 of silver to pure gold as God wills.

Second Chapter. The Softening of Copper through Salts

30. Take calx of copper and soak it with water of sal ammoniac that was sublimated with vitriol, and evaporate it in a mawardiyya, until its smokes comes out. Do this with it seven times, until it becomes a salt, which melts, as God wills.

31. Another way. Take calx of copper and soak it with water of green vitriol and of sal ammoniac and of distilled copper acetate and roast it, and do that with it, until it becomes a salt, which melts.

32. Another way. Take calx of copper and soak it with water of green vitriol and of sal ammoniac and of distilled copper acetate and roast it, and repeat the procedure seven times; then soak it three times with water of sal ammoniac by itself, thus it becomes a salt which melts, as God wills.

33. Soak whatever you will from this chapter with the redness of blood and of hair in equal amounts, three times the amount in three repetitions, [G76] and roast them each time; then soften them (E and grind them) in three softenings with water of sal ammoniac and dissolve it, thus it dissolves in 30 days. Then soak suffocated mercury with it, grind it with it and roast it, until it has absorbed twice its amount of this

water and has become red powder; its dirham colors 100 from whichever metal you will.

* And if the mercury softens and dissolves and blends between the two waters and becomes solid, then the power of the coloring doubles. And if you soften it a second time and dissolve it and let it solidify, then its dirham colors 400 to pure gold as God wills.

Third Chapter. The Softening of Copper through Boraxes

Take copper filings and soak them with water of natron and of borax from Zarāwand, roast them, and repeat the task with it, until it becomes a wax, that melts and flows.

35. *Another way. Take copper filings and soak them with (water of) natron and borax of Zarāwand and roast them, repeat the procedure and the process with it until it becomes a wax, which melts and flows.

36. Another way. Take filings of copper, grind them and soak them with tinkar and sal ammoniac and vitriol and copper acetate, dissolved in four times as much distilled vinegar and roast it. Do this with it, until it flows and melts (E and turns into a wax) as God wills.

37. *Amalgamate [what you will from] this chapter with ten times as much living mercury, and put it in a plate of clay, that is set on a saucer of clay and set into a clay-covered kettle. Put yellow sulfur around the saucer (E as much as the amalgam) and also cover the amalgam with sulfur (E and seal the connection) and heat it from beneath with a moderate fire according to what has gone before, so that it becomes a precursor. Its dirham colors 30 of silver, and if it is soaked three times with water of redness and roasted each time, thus will its dirham color 40 dirhams, and if it is softened with dissolved sal ammoniac several times (E and dissolved) and some purified vitriol is added and solidified, then will its dirham color 60 (E silver to gold).

IV. The Chapter of Softening of Iron

First Chapter. The Softening of Iron through Spirits.

38. Take iron filings, then grind it with a quarter of its amount of red whitened arsenic sulfide for one day and one night with water of sal

ammoniac (L tinkar) and of natron; put it in a clay-coated jar and pack [G77] powdered and roasted salt over it and roast it one night in a strong fire; then put it in a clay-coated open beaker and place it in an oven, until its smoke goes out. Repeat the procedure with it seven times (E and dry it), then soak it and let it melt, until it becomes like a soup. Then grind it, until it is dry, and let it melt down, so that it melts like a (E white, G stable) melting metal. Then mix it thoroughly with sublimated red arsenic sulfide, until it melts and flows. And if you want to treat it to redness, then soak it with the five vitriols, dissolved in wine vinegar, and roast it; do this with it until it turns red.

39. Another way. Take iron filings, mix an equal amount whitened sulfur with them, soak and grind them with soda water (E one day) and roast them one night in a clay-covered jar in a hot oven (tannūr) with a fierce fire. Do this with it seven times, grind it by day and roast it by night, until it becomes a wax, which melts as God wills.

40. Another way. Take iron filings, grind them with an equal amount of red whitened arsenic sulfide and yellow whitened arsenic sulfide and whitened sulfur, (E grind it) and soak it with distilled urine in each ratl of it (E one uqia soda salt and) one uqia natron and one uqia bat dung. Grind them carefully with it and roast one night with a strong fire, then take it out and grind and soak it with the urine and repeat the procedure with it, until it has become soft like wax and melts and flows like lead.

41. Add sublimated mercury to whatever you will from this chapter and soak it with whitened, dissolved distilled sulfur. Roast it in a clay-coated flask on a dung fire until it has absorbed an equal amount and has changed into white powder. Its dirham colors (E transforms) 50 of mercury or both leads and transforms it into white silver as God wills.

Second Chapter. The Softening of Iron through Salts

42. Take dust-like calx of iron and soak it [G78] with dissolved sal ammoniac and a quarter its amount of shell lime and grind it carefully several times, (E L and soften it in a clay-coated māwardiyya, until its smoke comes out; however the grinding must take place on a grindstone. Grind it then every time three days and do this L ten E seven times), so it becomes a salt, that melts with moisture.

43. Take calx of iron and soak it with water of dissolved sal ammoniac and alum, both distilled, and in so doing a uqia of bitter calcined salt is added to each ratl. Soak it and grind it on a grindstone by day and spread it thereover by night, and spray it with water until it is pulverized. Do this with it one week long, then steam it 30 times (E and soak it each time with water for an hour) and grind it more hours, then steam it in a clay-coated māwardiyya, thus it becomes a salt, that melts in moisture.

44. Another way. Take dust-like calx (G E filings) of iron and soak it with water of sal ammoniac and alum and with calx of egg shells, dissolved in distilled urine; roast it (E grind it) and soften it by day and roast it in the night in a māwardiyya, until it melts and its smoke comes out. Do this with it until it becomes a salt that melts in moisture. Then take three parts dissolved, whitened, distilled sulfur and three parts sublimated mercury, grind them and soak them with water of sal ammoniac and steam it in a clay-covered beaker ten times and each time, if its upper surface steams, take it away, until it has become a salt that melts.

45. After that dissolve (L and take) from any in this chapter on softening, and mix it in equal parts.[413] Then let it solidify with a blind alembic, so that it solidifies to white powder (L E and belongs to precursors). Its dirham colors 100 of copper and one ratl of lead (E both leads) and mercury to white silver, as God wills).

Third Chapter. The Softening of Iron through Boraxes

46. Take iron filings and grind (G soak) them on a grindstone for three days with water of natron and of tinkar, dissolved with sharp water of soda, in which a tenth of its amount of yellow whitened sulfur has been added, and every time it is dry, moisten it with (G E and grind it), until it becomes like mud. Then roast it one night [G79] in a clay-coated top opening māwardiyya, and repeat the process with it, until it becomes a salt that melts (L like wax). Then soak it one single steeping with water of sal ammoniac and grind it therewith one full day (G E and soften it in a māwardiyya) and store it for your use, as God wills.

47. [G L] Another way. Take iron filings and soak them with water of natron and borax from Zarāwand, dissolved in a jug and beaker, and

pulverize (L soak) it one day and roast it one night continuously in a māwardiyya; grind it by day and roast it by night, until it melts and flows like lead as God wills.

48. Another way. Take iron filings and grind them with tinkar (G E and natron) and bat dung and purified borax and borax from Zarāwand and urine salt in equal amounts. Grind it by day and roast it by night, until it turns to powder, that melts like wax. Then soak it with water of dissolved sal ammoniac and steam it. Do this with it seven times, until it flows like wax as God wills.

49. Soak whichever from this chapter you will with dissolved mercury and bury it, until is dissolves, then let it solidify. For it is the substrate, from which one dirham colors one ratl of any metal that you will. And if you dissolve the first (L E and with an equal amount of mercury let it solidify, then one dirham of it transforms two ratls of whichever metal you will into white silver. And if you distill it and soften with it (E its residue) and then dissolve it and mix it with dissolved mercury and distill all of it (G until all is distilled) and let it solidify, then (one dirham) transforms four ratls. And if you soften it for the second time (E repeatedly) and dissolve it with water of sal ammoniac, in which there is eggshell calx, dissolved and distilled several times, and you dissolve and solidify it, then it transforms eight ratls for you. Each time that you elevate the substance, it increases double for you (with respect to the effect). However, your nose (E L the nostrils) should be plugged with cotton, (G and if there is some oil of violets in the cotton, L and if you can prevent touching it, then do that), because it is a poison within an hour,[414] when it is treated for the third time, I mean by dissolving and solidifying.

V. The Chapter on Softening both Leads

First Chapter. The Softening of Lead through Spirits

50. Take whichever of the two you will, mix it with an equal amount of sulfur and pour it in a mold; pulverize it and soak it with distilled urine, and pulverize it a good hour. Then place it, after it has dried through the pulverizing, in a clay-coated flask (E māwardiyya) and roast it one night on a dung fire. Do this with it, until it (G turns to powder, which [G80] melts like wax and does not smoke as God wills.

51. [G L] Another way. Take filings from whichever of the two you will and pulverize them with an equal amount of sublimated mercury and whitened sulfur and soak it with wine vinegar, as much as one-sixth vinegar as the whole, in which are equal parts of alum and sal ammoniac. It is boiled with them one hour and then purified; then soak it with them one full day and roast it one night on a dung fire in a clay-coated flask. Do this with it, until it melts and flows.

52. (E and the difference) between the fire for roasting for softening and the fire for roasting for solidifying has no one yet discovered. The difference between the fire for roasting for softening and the fire for roasting for solidifying is that the fire for roasting for solidifying dissolved substances is a powerful fire, while the fire for roasting for melting is a gentle fire; so take note of that and use it. And it works similarly with the fire for solidifying the dissolved substances, *and that is the secret of it*. Take note of it and count on it, and thus you will profit by it as God wills.

53. Another way. Take filings from whichever of the two you will, pulverize them with (L an equal amount of mercury and) an equal amount of whitened, sublimated arsenic sulfide, and soak it with dissolved sulfur; pulverize (L and soak) it therewith a full day, until it is dry, then roast it in a clay-coated flask in a gentle fire overnight. Do this with it three times, until it has transformed into powder, and then take it away, then one dirham colors 50 of copper or lead or mercury as God wills.

54. And if you soak [the product] from these sections with an equal amount dissolved mercury and bury them, after you have taken as much sal ammoniac as mercury and have pulverized both for three days on a grindstone; soak them by day (G and bury them) and roast them by night, let it become solid (E in a flask) in an ash kettle, as was described previously, three times, so that it solidifies into white powder. Its dirham colors 100 of copper (E to silver). This pertains to the first two sections and from the last section it colors 200, (L and what appends to it) from the last section.[415]

Second Chapter. The Softening of both Leads through Salts

55. Take sal ammoniac and bitter salt and rock salt and desert

salt and Andarānī salt and soda and urine salt and cooking salt, one part from each individually. Dissolve the whole in moisture in a clay-coated jug, drilled through underneath and set on a clay box, and on the holes in the jug are a piece of a hair sieve [G81] and a piece of palm fiber. Take it high, if it is dissolved, then distill it and put as much as a quarter amount of sal ammoniac in it, dissolved by itself, and soak (and pulverize) with it the calx of whichever of the two you will on a grindstone. Pulverize it one day and roast it in the night constantly on a gentle fire. Do this with it continuously until it becomes a salt that melts on the tongue.

56. Another way. Take calx of whichever of the two you will, then pulverize and soak it with water of sal ammoniac and alum, both distilled on a grindstone under strong grinding, then steam it in a māwardiyya, until its smoke comes out. Do this with it seven times, then steam it three times with water of sal ammoniac alone, thus it comes out as a salt (L it is transformed into a salt), which melts.

57. Another way. Take calx from whichever of the two you will, soak (G and pulverize) it with bitter salt, in which a tenth amount of sal ammoniac is dissolved, and grind it eight hours. Then steam it in a māwardiyya (L flask), until its smoke comes out. Do this with it five times, then soak it in five other steepings with dissolved sal ammoniac and steam it with each steeping, so that it becomes a salt which melts.

58. Dissolve (E take) whichever from these sections you will and mix them with an equal amount of whitened, dissolved, sulfur, and let it solidify, so that it solidifies and it develops one dirham to one ratl of mercury. You put the mercury in a clay-coated māwardiyya (L flask) and sprinkle the elixir on it and roast it one night in a māwardiyya on hot ashes, thus will it solidify to white silver; its dirham colors 30 dirhams of copper to excellent silver. And if you add its dirham to (L 30, G 80, E 200) of living mercury and roast it in a clay-coated flask on a medium fire (G dung fire), thus will it make the mercury solid to an elixir. Its dirham colors 50 of copper (G and leaves it behind) to white silver as God wills.

Third Chapter. The Softening of both Leads through Boraxes

59. *Take filings of whichever of the two you will, pulverize them

and soak them with borax of bread, dissolved with moisture, [G82] and roast it with a gentle fire. Do this with it seven times, until it becomes a wax, which melts as God wills.

60. Another way. Take filings from whichever of the two you will and pulverize them and soak them with water of sal ammoniac, of tinkar, and bat dung and roast it. Do this with it seven times, so that it becomes a wax, which melts (G and flows fast.)

61. [E] Another. Take whichever you will and soak it with tinkar, dissolved with water of soda, and roast it. Do this with it seven times, so that it becomes a wax, which melts and flows fast.

62. [E] Combine whichever from these sections you will with an equal amount whitened sulfur and sublimated arsenic sulfide as much as sulfur and as much sublimated mercury as the whole. Soak the whole with dissolved talc and roast it on a gentle fire, until it has absorbed a quarter of the talc in four times. Then soften the whole three times with water of sal ammoniac and dissolve it, then it dissolves; solidify it, so that it solidifies to white powder. Its dirham colors 300 of both leads and of mercury; it solidifies to pure silver, that returns it to purity.

63. [E] This is the end of the softening of meltable [fusible?] metals, which we identified as the beginning of the book. Now let us begin with the softening of stones through salt and borax in accordance with the plan that has been laid out.

[L] This is the end of the softening of the actual bodies (metals) and now we begin with the softening of stones, with the help of the highest – our God.

* * *

C. The Softening of Stones

[L] The stones are softened through salt and borax. And this is the explanation of the first and with it the process is fulfilled; the success comes from God.

I. The Softening of Marcasite

First Chapter. The Softening of Marcasite through salts.

1. [L E] Take white calcined marcasite (E as much as you will),

pulverize it thoroughly with water of sal ammoniac and roast it on a gentle fire (E dung fire). Do this 15 times until it becomes a salt that melts with moisture. Then dissolve it and soak with it (G E the amalgam) of silver and roast it on a gentle fire; the amalgam is composed of the dirham (silver) and 10 parts mercury, then it is solidified to white silver. And when you combine 100 dirhams amalgam in a clay-coated flask and one-tenth of this water with a half dirham of whitened sulfur, thus it solidifies to white silver. (E L It colors one dirham of this silver 40 (L 4) copper) to white silver as God wills.

2. Another way. Take calx from gold marcasite and pulverize it with water of sal ammoniac, sublimated with vitriol, and with an equal amount of wine vinegar, in which there is a fourth of vitriol, and roast it. Do this with it ten times, so that it becomes red, of incredible redness. Now dissolve it and put in one ratl one uqia redness of distilled sulfur, take gold amalgam, for one dirham 500, and place it in a clay-coated mārwardiyya and pour 3 dirhams of this (G substance, that is the) water, and seal the closure and bury it in hot ashes, thus it will solidify to a red elixir like gold; cast its dirham on ten mithqal of silver as God wills. And if you soak this solidified matter with water from purfied vitriol, in which the color of sulfur is added, and you roast it, thus the power of its coloring doubles for you.

3. Another way. You grind (L soften) gold marcasite and soak it with water of distilled vitriol and copper acetate and sal ammoniac (G E and roast it), until it is softened like wax. Then dissolve it and put oil from egg yolk in it and tint from distilled sulfur and the tint of blood [G83] in equal parts. After that take gold amalgam, for one part, 20 parts of mercury, and roast it with vitriol, that is made into a paste with the color (L redness) of sulfur in a clay-coated flask, whose lid is secured, so that it becomes the best vermilion. Then soften it with water of sal ammoniac, sublimated with dissolved vitriol, to which (G for each ratl of it) one uqia egg shell calx and one uqia urine salt were added, until it becomes a salt, which melts. Then dissolve and combine it with the marcasite treated by roasting and solidify it. Its dirham transforms 1000 of whichever metal you will and leaves it remaining as pure gold.

Second Chapter. The Softening of Marcasite through Boraxes.

4. Take marcasite and pulverize it well with water and salt for one hour, then pour the water and the salt off of it and (E L wash it and renew the procedure with it. Do that with it twelve times in twelve hours, dry it and soak it with water of) natron in the amount, that it

combines with, and pulverize it, until it is dry. Do this with it one day, then roast it one night in a dung fire, then soak it the second day with water of natron and tinkar, both dissolved in moisture; pulverize it by day according to what has gone before, and combine and work thereupon, so that it is completely dry by eventide, then roast it. Do this with it seven times in seven days, so that it melts and flows like wax. Then take one ratl from it and melt it and mix it with an equal amount of tin and pour it on the earth. Then pulverize it and amalgamate it with fourfold of living mercury and pulverize it well and soak it with water from whitened dissolved sulfur and roast it. Do this with it continuously in a dung fire according to that which has gone before, until it has solidified into white powder. It absorbs as much as half of the whole of water of whitened and dissolved sulfur, and its dirham transforms 200 dirhams of whichever metal you will in white silver as God wills. [G84].

II. The Softening of Magnesia

First Chapter. The Softening of Magnesia through Salts.

5. Take the calx of magnesia and pulverize it well with water of sal ammoniac (G E one day) and roast it (G E one night) in a clay-coated māwardiyya, until its smoke emerges. (L E Then take it out when the oven gets cold and pulverize it with water of sal ammoniac a whole day and soften it in a māwardiyya, until its smoke emerges.) Do this with it until it becomes a salt, that melts in moisture.

6. Another way. Take urine, let it stand (age), distill it and add to each ratl of the distillate two uqia sal ammoniac and one uqia shell calx. Let it stand one (L three) days and shake it several times a day, until it has dissolved therein. Then soak the calx of magnesia with it and soften it in a māwardiyya, until the smoke emerges. Do this with it, until it becomes a salt, that melts (E with moisture) as God wills.

7. Another way. Take the sharp water of soda and put a quarter amount of natron in it, dissolved with moisture, and an equal amount of dissolved sal ammoniac; then pulverize the calx with it until evening, and it should not become evening before it dries. Then steam it in a māwardiyya, until its smoke emerges. Do this with it continuously, until it becomes a salt, which melts in moisture and flows.

8. Then soak whichever from this section you will with mercury,

dissolved and distilled in five repetitions on five days; pulverize it the whole day for each soaking and roast it at night in hot ashes, then soak it with water of red whitened distilled arsenic sulfide (G in five repetitions of five times) and roast it until it becomes white powder (G E similar to rock crystal). Its dirham transforms 1000 of whichever metal you will, and if you pulverize it yet again and soften it with water of sal ammoniac in a (G clay-coated) beaker repeatedly until its upper surface steams, and then it dissolves and solidifies, thus will its dirham color 1000 dirhams to purity.

Second Chapter. The Softening of Magnesia through Boraxes

9. Take magnesia and make it into a paste (L pulverize it) with oil and natron and let it melt down. Then take it, pulverize it, and soak it with natron water, dissolved with soda water, [roast and] pulverize it the whole day and roast it in the night, until it (G E becomes a wax, which) melts as God wills.

10. Another way. Take magnesia and pulverize it with sea foam[416] (L E one day) and roast it one night, (L then pulverize it with oil and grind the fat one day and roast it one night) then wash it with hot water and coarse salt seven times and set it aside. Then take natron and soda salt and tinkar and borax from Zarāwand and combined borax, dissolve it with moisture [G85] and soak with it that which you have set aside. Pulverize it, soak it one day, and roast it one night, and do this with it continuously, until it melts and flows like wax.

11. After this, melt whatever you will from this section, pour three times as much melted lead on it, and grind it with one six mercury.[417] Pulverize it well, then put it in a clay-coated flask and pour a stream of whitened dissolved sulfur on it and seal the lid and put it in hot ashes, but these must not be too hot, so that the flask does not shatter. Do this with it, until it has absorbed whitened dissolved sulfur equal to the whole and has transmuted to powder. Its dirham transforms 500 of whichever metal you will and leaves it behind as white silver as God wills.

III. The Softening of Iron Ore

First Chapter. The Softening of Iron Ore through Salts.

12. Take calx of iron ore, pulverize it with water (E salt) of soda and quicklime, both dissolved for one day and steam it in a clay-coated bowl (māwardiyya). Do that with it ten times. Then soak it in water of sal ammoniac, dissolved ten times, just as much as before, and steam it with each soaking, until it becomes a salt, which melts as God wills.

13. Another way. Take sal ammoniac as much as you will and an equal amount of shell calx, pulverize it on a grinding surface with distilled salt water one day and roast it in the evening time in a clay-coated māwardiyya. Do this with it continuously, until it becomes a salt that melts in moisture.

14. Another way. Take sal ammoniac and alum and natron, dissolve them with a jug and beaker in moisture and soak the calx of iron ore with it and steam it. Do this with it until it becomes a salt which melts. [G86]

15. Soak whatever you will from these sections with three times the same amount whitened arsenic sulfide, dissolved and distilled in three repetitions, and roast it each time and soften repeatedly according to what has gone before, until it becomes a white powder. For one part, it colors 50 of whichever metal you will, and if you pulverize repeatedly and soften according to what has gone before, until it becomes a salt which melts; and if you dissolve and distill it, so will its dirham transform one ratl (G of whichever metal you will as God wills). If you mix this with an equal amount of dissolved sublimated mercury, then will its dirham transform 1000 of whichever metal you will as God wills.

Second Chapter. The Softening of Iron ore through Boraxes

16. Take the iron ore from Istahr, heat it in a powerful fire, the fire of the oven for casting iron, and cover with dissolved salt repeatedly, so that it crumbles and distintegrates into dust. Then wash it and soak it with water of the three boraxes, I mean with the tinkar and the natron and the borax from Zarāwand, dissolved in moisture. Pulverize it with them a whole day and roast it in the night. Do this with it ten times, until it becomes a wax that melts as God wills.

17. [E] Another way. Take the crumbled iron ore and pulverize it with tinkar and soap thoroughly and roast it. Do that with it

continuously, until it becomes a wax which melts.

18. Another way. Take the iron ore that was broken down through the (E powerful) heat and soak it with water of soda and quicklime, in which sal ammoniac and natron and tinkar have been dissolved. Soak and pulverize it by day and roast it by night and do this with it until it melts and flows like wax.

19. Melt that which has been elevated (L twice the amount) from these sections and mix it with an equal amount of tin and pulverize it. Then amalgamate one part of that with nine (E L seven) parts living mercury. Pulverize it well and soak it with water and salt, until it turns white. After that, soak it with dissolved, sublimated arsenic sulfide, mixed with sulfur, in which no blackness remains, and roast it in a clay-coated flask with a gentle fire, until it has absorbed as much as two-thirds of the whole and has become white powder. Its dirham transforms [G87] one ratl of whichever metal you will into white silver as God wills. (L E and if you dissolve it a second time an solidify it, so it doubles the color for you, and if you dissolve and solidify it a third time, then its one transforms four ratls of whichever metal you will as God wills.

The Softening of Tutia

First Chapter. The Softening of Tutia through salts.

20. Take dust-like calx of tutia and pulverize it with water of sal ammoniac and of vitriol, both dissolved, and steam it in a māwardiyya. Do this with it, until it softens and reddens and becomes a salt that melts in moisture.

21. [G L] Another way. Take calx of tutia, pulverize it and soak it with copper acetate and sal ammoniac, dissolved in moisture, and steam it and grind it. Do this with it continuously, until it reddens and becomes a salt that melts.

22. Another way. Take calx of tutia and soak it with (G water of) green vitriol and of copper acetate, dissolved with moisture, to which calx of eggshell and calx from egg yolk has been added, as much as one from the substances of equal parts. Roast it and pulverize it an entire day and steam it (E in the night). Do this with it continuously, until it reddens and becomes a salt that melts.

23. Take whichever from these sections you will, I mean the sections on softening, and mix it with an equal amount of red dissolved mercury and let it solidify with the blind alembic, thus will its dirham color 60 dirhams of silver. You grind it ten with two and if you soak it seven times with z*ād al-ragwa* and pulverize it with each steeping an entire day and roast it by night in a dung fire (L gentle fire), thus is the mixing not necessary. And if you soften it with water of sal ammoniac, (G E repeatedly, until it becomes a salt and you dissolve it) and then let it solidify, thus will its dirham color 200 dirhams as God wills.

Second Chapter. The Softening of Tutia through Boraxes

24. Take fresh (G blue) tutia and pulverize it with oil and natron (G E and let it melt down repeatedly, then pulverize it and wash it repeatedly with water and salt, until it is pure. Then make a paste with water of natron) and [G88] of borax from Zarāwand, pulverize it one day and roast it one night and do this with it until it becomes soft and melts as God wills.

25. Another way. Take the sublimated tutia and pulverize it well and soak it with (L E water of) uschnān[418] and soda and pulverize them with it, until it is dry. Then pulverize it and roast it three hours (E in the margin: with a strong fire, then pulverize it as additional hour and roast three hours), and do this with it until it is softened and melts (E and flows).

26. Another way. Take tutia and sprinkle it with pitch and uschnān and date syrup and roast it in a clay-coated flask, open at the top, until its smoke comes out. Do this three times, then pulverize, wash, and dry it, and soak it with water and bat dung and borax from Zarāwand, both dissolved; roast it (L continuously) and do this with it, until it melts and flows.

27. Take whichever from these sections you will and combine it with an equal amount of red mercury and with whitened sulfur as much as mercury, and soak it with z*ād al-ragwa* (L as much as combines with it, and pulverize it with it a good hour) and roast it. Do this with it three times, then soak it in ten soakings with (L the water) of five reddened vitriols, in the amount that combines with it, and roast it with each soaking in a clay-coated flask, until it becomes red (L E liver-colored)

powder. Its dirham colors 100 of any metal that you will, to pure gold as God wills.

V. The softening of Lapis Lazuli and Malchite and Turquoise

First Chapter. The Softening of these three stones through salts.

28. Take the best white soda salt, dissolve it with moisture, and distill it, add a quarter of sal ammoniac to it, and distill it a second time and again add a quarter of sal ammoniac to it and distill it [G89] yet again. Do that (G in regard to the renewal of the sal ammoniac) seven times, then take whichever of the stones you will and calcine it, then soak it with this water and pulverize it with it eight hours, then steam it in a clay-coated māwardiyya on a coal fire, until its smoke ceases. Do this with it, until it becomes a salt that melts.

29. Another way. Take salt of urine (E G and bitter salt) and soda salt in equal parts, then dissolve the whole in moisture and put as much as the whole (G: its quarter) sal ammoniac in it, dissolve it, and soak the calx of whichever stone you will with it, pulverize it with it the whole day and steam it in the evening in a clay-coated māwardiyya, until its smoke ceases. Do this with it, until it becomes a salt that melts in moisture.

30. Another way. Take sal ammoniac and sublimate it with vitriol and dissolve it with moisture (G E distill it) and soften it with calx from whichever stone you will (G pulverize it an entire day) and steam it (G in the evening) in a (G clay-coated) māwardiyya, until its smoke ceases. Do this with it (L continuously) until it becomes a salt that melts.

31. Dissolve whichever from there sections you will and grind it with an equal amount (L E red) dissolved mercury and an equal amount whitened sulfur and an equal amount of redness from (L whitened) sulfur (L and equal amount vitriol). Bring the whole to dissolving, after you have pulverize it with as much sal ammoniac, as a quarter of the whole, and bury it forty days, thus it becomes a red water. Now let it solidify in a blind alembic, thus will it solidify into a essence; its dirham colors 500 of whichever metal you will (G it come out) as pure gold (E red gold) as God wills.

Second Chapter. The Softening of these three Stones through Boraxes

32. Take whichever of them you will, pulverize it well and soak it with water of natron, as much as dissolves in moisture [G90], that it becomes like a soup. Then pulverize it on a grindstone, until it has become dry, and roast it. Do this with it until it becomes a wax, that melts, as God wills.

33. Another way. Take tinkar and soda salt and alum in equal parts and dissolve them with moisture, pulverize and steam it. Do this with it repeatedly, until it (G becomes a wax) melts and flows as God wills.

34. [L E] Another way. Take whichever of the three you will, pulverized, then soak it with water of purified soda, in which as much as its half of alum is dissolved, in seven soakings. Dissolve it, until it looks like a soup, then soak (E pulverize) it with it, until it has become dry. After that, roast it with a light roasting, then soak it with water of tinkar, dissolved similarly to that one, until it melts and flows like wax when you test it on a heated test tablet. Then take some green vitriol and qalqatār[419] and white vitriol and yellow vitriol and dissolve them in the moisture.

35. (L E) Soak with it whichever of the these sections you will, until you leave it remaining as a soup, pulverize it therewith until it is dry, then steam it in a clay-coated māwardiyya. Do this with it until it has become a red powder (E liver-colored red). After that, soak it with dissolved sal ammoniac seven times and pulverize it with each soaking a half day, then steam it in a clay-coated māwardiyya, until it becomes a salt that melts. After that, take one part of it and one part of softened calx of gold and twice as much as the whole of dissolved mercury. Pour it on there and bring it to dissolving, then bury it 40 days, so that it dissolves into a water with no residue. Add an equal amount of water of hair to it and an equal amount of redness of hair and as much as these (water of egg yolk and) oil of egg yolks, and as much calx of mussels (E of egg yolk) as a quarter of the whole, and bring it to dissolve, thus will it dissolve in 40 days to a red water. Let it solidify in a blind alembic, thus will it come out as a red *grauhara* in seven days.[420] Its dirham transforms 400 (E 2000) mithqal of whichever metal you will. And if you soften it a second time and dissolve it, then add a tenth of its amount of whitened sulfur and also of redness of sulfur and bury it 40 days and let it solidify, thus will one mithqal of it color 5000 mithqals for you of whichever metal you will to pure gold, it returns to purity.

Second Chapter. The Softening of Talcs, Gypsum, and Glass

First Chapter. The Softening of these stones through salts.

36. Take whichever of them you will, calcined and dust-like, and soak it with (E the water from) bitter salt and Andarāni salt, both dissolved with moisture, in addition with its quarter of sublimated sal ammoniac and an equal amount of whitened sulfur, and pulverize it a half day and steam it in a māwardiyya, until its smoke ceases. Do this with it seven times, until it becomes a salt that melts with moisture as God wills.

37. Another way. Take stale, three-times-distilled urine and add to it (E an equal amount) soda salt and quicklime and let them stand in it three days and shake it repeatedly every day. (G E Then add (G fresh) sulfur to it, as much as a tenth of the urine, and let it stand a couple of days) and distill it and with it soak whichever calx of them you will, twenty times (G or, he says, one day) and pulverize it with each soaking eight hours, then steam it in a māwardiyya. Then (E pulverize and) soak it three additional steepings with water of sal ammoniac, and steam it, until it becomes a salt that (E L with wetness) melts as God wills.

38. Another way. Take one part distilled urine and two parts (E L water of) soda and sharp distilled quicklime, and as much as the whole (E G dissolved sal ammoniac, and as much as a tenth of the whole of dissolved tinkar, and as much as a tenth of the tinkar [G 91] whitened, dissolved sulfur. Soak with it whichever of them you will and steam it in a clay-coated māwardiyya, until its smoke ceases; proceed with it as before, until it becomes a salt that melts.

39. Soak whatever you will from these sections with three times its amount dissolved mercury and set it to dissolve 40 days, then let it solidify, thus will it solidify into a powder like silver. And if you distill it before solidifying and soften the residue and dissolve it and pour three times its amount dissolved mercury on it and bury it, until it dissolves, then distill it all and let it solidify in a blind alembic, thus will its dirham transform 700 lead and mercury to silver as God wills.

Second Chapter. The Softening of these three Stones through Boraxes

40. Take whichever of them you will, spread it out in a long-

handled roasting pan (G of iron) and put it in the tābistān, until it becomes red (L hot). Then add it to water of sharp soda, purify it with a filter spread it out in the roasting pan and place it again in the tābistān (L until it is hot). Do this with it seven times, then make the talc and the gypsum into milk, then filter it and dry it and pulverize it on a grindstone, and shake it in a thick (L soft) tied cloth (pouch) in the interior of a bustūqa[421] (G E a stove) until all comes out. The (E combine it and) soak it with water of borax from Zarāwand and of natron, from each seven separate times, and pulverize it with each soaking a half day; roast it one night on a light fire, then soak it in three soakings with virgin's milk, then it melts in the way that metals melt.

41. Soak whichever from this section you will with three times as much dissolved mercury in three times, pulverize it each time a half day and roast it one night in a clay-coated flask and secure its lid (stopper), thus will it solidify to silver-like powder; its dirham transforms 50 of mercury [G92] or lead into white silver. And if you soften it three times with water of sal ammoniac, and let it solidify again, after you have dissolved it, thus will its dirham transform one ratl (L mercury and lead as God wills.)

VII. The Softening of the Salts through Oil

42. Take cooking salt and make a paste (G and cook it) with oil and roast it in a clay-coated kettle with a secured plug (lid) in a gentle dung fire several days. Do this with it seven times, thus it melts and flows.

43. Another way. Take whichever of the salts that you will and soak it with whitened dissolved oil and roast it. Do this with it repeatedly, until it melts and flows.

44. Another way. Take whichever of them that you will and soak it with distilled naphtha and pulverize it one day and roast it one night with a powerful fire. Do this with it ten times, thus it melts and flows (E like wax) as God wills.

45. Soak whichever from these sections that you will with an equal amount of whitened sulfur in which there is no blackness, dissolved in three times, and roast it each time, so that it becomes a substrate (G a water), of which one dirham colors ten of copper (E of which one

transforms 30 of mercury into an elixir). And if you soak it with a potion of sal ammoniac and roast it (L soften) and dissolve it, and mix it with an equal amount of dissolved mercury and as much shell calx as mercury and take the whole to dissolving, then it dissolves in 40 days; and if you let it solidify, so will its dirham transform 100 dirham of whichever metal you will in white silver as God wills.

This is the end of the chapters on softening (L the metals and the stones and their calcinations) whole and complete.

Now we begin with the description of dissolving. In it is included the general mixing and the complete dissolution.

* * *

Part Three: Dissolving Spirits and softened Calx and Borax and Salt

1. There are six ways to dissolve: Dissolving with sharp waters, dissolving with dung, dissolving with moisture, dissolving with the dann, dissolving with the kettle [G93], dissolving with the blind alembic, dissolving with the karafs and the cistern, and dissolving through distillation.

I. Dissolving with Sharp Waters.

2. Description of sharp waters. Take 20 ratls of purest water and add two and one-half ratl of (E L white) soda and unslaked lime (quicklime)[422] and leave it in there three days, filter it, and repeat the procedure with it seven times and each time pour an equal amount (L E as one eighth) pure water in it, add as much as a tenth of the water of copper acetate or yellow arsenic sulfide to it, leave it three days in there, and filter it, then put as much as a half its amount of dissolved sal ammoniac in it, and let it stand several days. Dissolve in it what you will, it dissolves talc immediately (L and God is the helper).

3. Description of crushing waters. Take salt of urine and of (L sharp) soda and sal ammoniac and (G living) lime and quicklime and bat dung, one part from each individually, and sprinkle (G soak) it with water of sal ammoniac and dissolve it with a jug and moisture. Dissolve

with this anything that you wish to dissolve, as God wills.

4. Description of poison water.[423] Take equal parts of sal ammoniac and copper acetate, pulverize and distill both, then pour that which you distilled, on equal amounts sal ammoniac and copper acetate as the first time and distill both. Do this with it seven times, but during each distillation stick cotton in your nose (E soaked with violet oil or) with rose oil. Set aside what you have distilled, and combine the residue with an equal amount of sal ammoniac and its weight (L a quarter) pulp of colocynth[424] and let it sublimate. Take what is sublimated and soften and dissolve it and combine it with that which was set aside and bury it several days, so that it dissolves into a sharp water as God wills.

5. Description of waters of salts.[425] (E: Chapter of dissolving of the seven salts. That is a sharp water, that splits a rock forthwith.) Take good salt, bitter salt, Andarānī salt, rock salt [G94], Indian salt, salt of urine, and salt of soda, part for part, and as much as the whole of the best crystalline sal ammoniac, and dissolve them in moisture and distill them, so that it distills as a sharp water, which splits rocks (L talc through its sharpness) forwith. (L Praise to the all-knowing creator, he is our confidence and a marvelous protector.)

6. Description of waters of soda and of quicklime.[426] Take calcined soda and quicklime in equal parts and pour four times as much water on them and let it stand three days. Then purify (filter) it and renew the soda and the quicklime in with a quarter of the purified water. Do this with it seven times, then filter it ten times and add as much as half the water of dissolved sal ammoniac to it, then bury it, so that it becomes an extremely sharp water, that splits talc forthwith. (L And Allah is the helper through his favor and courage.)

7. Description of other crushing waters. Take as much as you will of purest water, add a seventh part unslaked lime to it, let it stand three days and filter it. Do this with it seven times, then distill it and mix it with an equal amount of distilled sal ammoniac, and store it in a Chinese barniyya[427], because it destroys (G bores through) glass and pottery (E stone] as God wills.

8. Description (G E of waters) of pulp of colocynth. Take what you will of purest water, add as much as its half of sal ammoniac in it, and let it stand several weeks. Then filter it and add pulp of colocynth to

it, as much as a quarter of the sal ammoniac, powdered in a soft bag and hang it several days in this water and shake it every day repeatedly. Then take it out and add as much as a quarter (L third) of colocynth (G soqotrische, L E yellow) aloe also in a soft bag, hang it several days in water and shake it repeatedly each day and filter it. But be careful not to smell it and be on your guard against it, for it is a very sharp water, [G 95], therefore beware of it as God wills.

9. Another sharp water. Take fresh iron marcasite and sal ammoniac in equal parts and make them both into a zinğar; then distill both and set the distillate aside. (L E Now take copper acetate and sal ammoniac and distill both and set the distillate aside). Then take yellow arsenic sulfide and pour water of soda and lime over it and filter it. After that, combine both in equal amounts and take just as much water of hair and combine the whole in a green barniyya. It is a very sharp water, that exerts a powerful effect on you as God wills.

10. Another water. Take copper acetate and sal ammoniac and sulfur in equal parts and pulverize it (G a while) with wine vinegar (L and place it in a pouch), then soak it with water of sal ammoniac (G L and soften it repeatedly with it and bury it, so that it dissolves into a sharp water. Then distill it and take the residue and soak it with water of sal ammoniac and take the residue and soak it with water of sal ammoniac in proportion to that which combines with one quarter egg shell calx. Pulverize it and let it sublimate in an aludel, then add from the sublimate as much as its quarter to the distillate and let it stand several days and purify it; it is a very sharp water as God wills.

11. Another water. Take three and a half ratls of soda and burn it strongly until it turns white. Then pulverize it well and divide it into seven parts and pour 12 ratls water on each part and boil it vigorously, until it is reduced to one ratl. After than, filter it and add another part water to it and boil it (E the same way). Do this with the seven parts, until you have done them all and there only remains two ratls of the water. Now filter it and add to it one ratl dissolved sal ammoniac and let it stand one day, and then it is a sharp water as God wills.

12. Description (G Chapter) of sharp vinegars. Take one part from the water that stands over coagulated milk and an equal amount of the acid of lemon and distill both, and set the distillate aside. Then take sal ammoniac and copper acetate, both (L distilled and) dissolved, take

from each one part and four parts from the distillate that was set aside, then it is a sharp water (G E therefore be cautious with it) because it splits (E dissolves) [G 96] talc forthwith as God wills.

13. Another excellent water (from the sharpness of vinegar). Take one part mercury, that was sublimated away from soda and sal ammoniac, and two parts sal ammoniac (L an equal amount), and one part bat dung and copper acetate. Part for part, then pulverize the whole on a grinding surface three days and bury it, so that it dissolves; then distill it, then it is a very sharp water, from which one can benefit, as God wills.

14. Another water. Take one part copper acetate and one part bat dung and two parts sal ammoniac, distill it and set it aside. After that, take one part mercury, sublimated with sal ammoniac and with water of soda, one part of zinğar from the chemist and one part sal ammoniac; pour the four parts on the set-aside water and bury it, until it dissolves, then distill it (E and pour from it on its quarter equal parts mercury, sublimated with copper acetate and sal ammoniac, and bury it until it dissolves, then distill it.) Do this seven times, then is it a very sharp water (E from which you benefit).

15. A sharp water. Take urine and let it age (get stale) one month long, then distill it and add G mercury to it with equal parts sal ammoniac and bury it for a week; then distill it and add to one ratl of it one uqia *asafoetida*[428] and one half uqia *alkekengi*[429] and one half uqia wolf's milk[430] and bury it for a week, then distill it, then it is a very powerful sharp water as God wills.

16. Another way. Take marcasite sublimated with sal ammoniac and mercury sublimated with sal ammoniac and bat dung and white soda salt, part for part, and two parts sal ammoniac, and pour water on it and bury it 14 days and distill it, thus it is a powerful sharp water.

17. Another way. Take sublimated sal ammoniac and sublimated mercury and calx of hair (L shell calx), part for part, and pour on it four times sharp soapy water, repeated seven times, and soften it ten days, then filter it. Do this with it five times, thus it will be a powerful sharp water.

The Chapter of Mercury dissolved through Sal ammoniac. [G 97]

18. Take sublimated mercury, soak it with dissolved sal ammoniac and steam it ten times in a clay-coated capsule (L beaker). Then dissolve it, and if something of it remains behind, then soak it with water of sal ammoniac and steam it several times, until it dissolves without residue; then this is the foundation of the matter. And this is a (E L very sharp) water, in which all calx and all metal filings are dissolved.

19. Another way. Take one part tin and one part living mercury, amalgamate and pulverize them well and wash both and combine them with an equal amount sublimated mercury and as much sal ammoniac as mercury; pulverize it well and steam it between two beakers with a gentle fire, so that it rises (G yellow). (L Set it aside), take it back to its residue, do this repeatedly, then dissolve it, so that it dissolves. Go to the extreme to soften its residue and steam it and dissolve it, until it all dissolves; then it is a sharp water.

The Dissolving of Living Mercury

20. Take four parts mercury, that was solidified through the vapor of black lead, and two parts sal ammoniac and one part shell calx; pulverize it one day and steam it; Do this with it seven times and dissolve it, so it dissolves to a sharp water, that dissolves everything as God wills.

Description of dissolving through this water.

21. You soften calx and metal filings using the previously described procedures and moisten them and bring them to melting (G with which ever water you wish) and dissolve them as you will with dung or other similar matter. And if you (L E carry out their preparation well and) have (E whitened and) softened them several times and doused them with a stream (of sharp water) and each time if it is reduced, have again doused it, then all will dissolve in several days, of what you wish to dissolve, as God wills.

E This is the end of the Chapter of Sharp Waters and the help is from God. Now let us begin with the description of (the procedures of) dissolving, that is the general mixtures. [The Chapter on Dissolving. There are eight chapters and one of them is the dissolving with dung.]

* * *

II. Description of Dissolving with Dung.

22. Dig two pits in a place where the wind does not come in, the depth of each of the two is two ells and their width is one ell, and smear them with dung from house doves, made into a paste with juice expressed from black radishes, and take one part dung from a purebred horse, that was produced the same day, and one part dung from house doves [G98] and make a paste from both with radish juice, not too thin, and fill both (pits) one ell deep solidly with this mixture. Then place that which you wish to dissolve in a flat-bottomed glass bottle with uniform sides above and below, and keep a mold of the shape of the bottle ready, in which the substance is, and sink (press) it in this filling of dung and turn it around in there. Then take the mold out and put the bottle in its place, after you have sealed its stopper with sārūğ.[431] Then plunge a felt-lined basket over it and pack it with the prepared dung up to the top, then cover a wash basin over it and make the closure tight, lift the bowl out each day and spray hot water on it; renew the dung each week, while you fill in the other dove-dung smeared pit up to halfway or more with the prepared dung, sink (press) the mold in it, and invert the bowl over it and leave it on there one night, without making the tight closure. Then when it is morning, uncover the bottle buried in the first pit and lift the other mold out, take the bottle out as fast as possible and bury it again, invert the basket over it and cover it with dung and bring the bowl back again and seal the closure tight. You treat it in this manner until it (the contents of the bottle) are dissolved, and in fact with this any (L E hard i.e. difficult to dissolve) thing (G E of metal and stones and others of the like) as God wills.

* * *

III. Description of Dissolving with Moisture.

23. For this dissolving there are three methods. One method is that you dig a pit in wet earth on which the sun never shines, of a depth of two ells or more, and with a width of one ell. Now you make from its

lowest end to its highest an inclined hole through which the pit is soaked with water, then fill it up to one (E two) thirds with moistened clean sand (E dung, G ashes) in which you sink the bottle with the substance to be dissolved up to its neck, after you have sealed its stopper (lid) with sārūğ, and leave an air hole in the bottle, but do not put more of the substance in the bottle than halfway. Now invert a small felt basket over it and fill damp dung (G sand) around it and on top of it until you have filled the pit. Then cover it over with a bowl and over the bowl a moist canvas bag. Now soak it every three days from the inclined hole with five ratls (G E hot) water, and sprinkle water on the canvas every day, repeatedly in the days of summer and once in the days of winter, so that all within dissolves, whose dissolving you wish, after it has become admirably softened as God wills. [G99]

24. The second method of dissolving with moisture requires that you dig a (G small) pit in a place on which the sun (E the wind) does not fall, of which the depth is two ells and the width is one ell. You line it with sārūğ and also make a top of sārūğ and put water in it in the amount of two (G one) third, and attach a ring to the top, in the middle of the inside, and hang the bottle on it, in which the substance it, after you have sealed its stopper with sārūğ, with a tight thread of cotton (G E or from the tail) of beasts, G and that is the best). Then immerse it up to its neck in the water and lay the top over it and secure the closure and sprinkle water on it every day and open it every three days and put new water in it, when this is needed, and then all that you wish to dissolve will dissolve for you as God wills.

25. The third method of dissolving with moisture is, that you dig a pit in a moist place on which the sun does not fall, which has a depth of three steps; you make a cover for it out of a clay brick and (E or) gypsum, which has a ring in the middle of the inside, and place that, which you wish to dissolve, after the best softening, in a clean washed leather bag and hang it on the ring, after you have tied up its opening with a cotton thread, so that it dips to one (E two) third or more in the water; but do not immerse it one full day (L E and watch it), because it will quickly get spoiled. It dissolves that way all, which you wish to dissolve as God wills.

* * *

Description of Dissolving with a Dann[432].

26. This is the only way. You take a wide dann with a wide mouth, that holds at least 30 ratls, put vinegar in it up to two-thirds and make a cover for it from brick clay, on which on its inner side in the middle there is a ring, and on it hang a lamp with a thread of cotton (E or from the tail of an animal, G or of hair, because that is the best). Now put that which you wish to dissolve in a cotton cloth, after you have moistened it with water of sal ammoniac, and tie it up loosely and hang it over the lamp on the ring; between the lamp and the vinegar should be two fingers wide and between the lamp and the sack should be a space a fist wide. Make the cover on it tight, as it is necessary, and connect the stopper [G 100] and fill the sides of the dann with animal dung and dove dung that is mixed into a paste with water from seeds of garden carrots or wild carrots, and sprinkle hot water on it every day, at both ends of the day. It will dissolve everything through this dissolving (method) and every hard calx as God wills.

* * *

IV. Description of Dissolving with a Kettle.

27. For this dissolving there are two methods. The first of the two requires that you take a large kettle with a cover of brick clay, under the middle of which is a ring. Then fill it with water and rice bran to two-thirds deep, hang the bottle in it with the substance, after you have sealed the lid, from a cotton thread, set the cover on it evenly, establish the connection and immerse the bottle halfway in the rice bran. Then stand the whole on a stove and light a cane fire under it and every time the stove gets hot, and you fear that the water in the kettle might come to a boil, then take it off the fire until it ceases to boil, then repeat the procedure. In the lid is a hole in which a wooden peg fits exactly, and with which you seal it; also you have a spoon curved at the end, with which any bran that accumulates in the kettle can be taken out at all times. And watch it lest the water decreases and dries up or diminishes (L every hour). On the stove there is a cooking pot (G or kettle) containing hot water, from which you scoop in a funnel, the tube of

which reaches to the kettle (L under the rice bran); and every three days you change the water and the bran, (E after you have put the water and the bran in another kettle). Now you heat and let it stay there, until its heat (L G I mean of the kettle, which contains the bottle) has abated and cooled down, so that the bottle, when you take it out, and it is exposed to the air, does not break. Consider that and treat accordingly, (L then you will do well with it as God wills).

28. The second method of dissolving with a kettle [G E that is the philosophers' bath] requires that you take wool from a (G E small) ram, pull it to pieces as fine as possible and mix an equal amount of dove dung with it. Beat it with water and put it in the kettle and proceed with it as in the first procedure [G 101], then it dissolves any type of difficult to dissolve substance. And this is the wet bath, which is referred to in the books of the philosophers; so take note of it as God wills.

* * *

V. Description of Dissolving with a Blind Alembic

29. It requires that you take the softened object and wet (L melt) it with sharp waters and put it in the blind alembic. You put water in up to half the curcurbit, with which you have wet (L melted) it and set the blind alembic on it, after you have placed the vessel on a kettle of water, seal the closure tight and heat it underneath with a gentle fire and open it every three days and take what has dissolved of it, and soften the residue and wet it again and repeat the procedure, until all has dissolved, as God wills.

* * *

VI. Description of Dissolving with Karafs and Sirdāb. [433]

30. Take a (G E large) sirdāb of a medium filtration and make it a lid out of clay, which has a ring in the middle of its lower surface, and take a vial that holds twice the amount of the substance, set a glass funnel on it, and put a layer of karafs and a layer of the material in the vial, until it gets to the end. Then hang it with a linen thread from the lid

in the sirdāb and seal the closure tightly. Cover it with a wet cloth and spray water on it every day, in summer several times and in winter a single time. Also the sirdāb is situated in a wet location, so that the dissolving will go faster for it.

* * *

VII. Description of Dissolving by Distilling

31. This dissolving is especially appropriate for salts and vitriols. It requires that you take whichever of the two you will, melt it in the evening, (G dampen it with a little water) and one night (G until morning) leave it under the open sky. Then when it is morning, distill it, then pulverize the residue with a little water one hour, until it is dry, then moisten and pulverize (G soften) it for a second and third time and pour off the distillate and pulverize it one hour, leave it one night under the open sky, and distill it (again) in the morning. Do this with it and weigh it each time and as long as its weight is increased by distilling [G102], distill it again, and when it begins to decrease, then take it away.

32. This is everything that the philosophers have used (explained) for dissolving, and nothing of it was hidden (G left out), except for a single very elegant chapter; we explain it in our book that is called “Secret of Secrets” as God wills.

Now the chapter on dissolving is at an end. Now let us begin with the description of mixtures in order according to the procedures which we have already introduced.

* * *

Part Four
The Chapter on Mixing

1. Of mixing, there are three (L perfect) methods. One of them is mixing through pulverizing and roasting, and the second is mixing through pulverizing and softening; both of these are not ideal. The third mixing is the one depending on dissolving, and this is the perfect

mixing.

I. Mixing by Grinding and Roasting

2. Concerning the mixing through pulverizing and roasting, then it is similar to that which we have explained in a previous chapter regarding the soaking of the whitened spirits, dissolved with calcined metals, and calcined metals dissolved with the whitened spirits, and their roasting in flasks in ash kettles to drive away their moisture and after that sealing their lids and covering them with ashes and lighting small coals over the ashes, so that the fire acts on it from all sides. And watch them that they do not thicken and resolidify against your wishes.

II. Mixing by Grinding and Softening

3. What pertains to mixing that takes place through pulverizing and softening, (so is it) as with mercury and sal ammoniac, when they both are sublimated and mixed and pulverized on a grindstone and when they are placed in a clay-coated beaker (G kettle) and this is set on an open fire of coals, until it steams, and when the smoke begins, they are taken off and cooled. (L Then put it back in its place and) do this with it ten times, then it is pulverized and soaked with water of sal ammoniac on a grindstone, until it becomes a salt, that melts on the tip of the tongue.

4. And likewise you proceed with calxes, only that the calxes are soaked with water of sal ammoniac and pulverized, until they are dry. Then the calx is placed in a clay-coated māwardiyya and set on a coal fire (G dung fire), until it steams and its smoke ceases.

5. The difference between the softening of spirits and the softening of calxes is that the spirits, when their upper surface steams [G103] and the smoke begins, are taken away (E from the fire), until it ceases; however the calx are left on the fire until their smoke has entirely come out and ceased. Also the spirits are softened in the two beakers, but the calx in the māwardiyyas.

III. Mixing with Dissolving

6. Concerning the third method of mixing, that takes place with

dissolving, so that is the most perfect mixing. It requires that you softened the spirit by itself and dissolve it, then the nafs[434] by itself and dissolve it, and then the metal by itself and dissolve it. After that, you combine the three waters (dissolved materials) in equal parts and bury them 40 days, until they are pure and permeate into each other and no longer separate from each other; so note this as God wills.

This is the end of the chapter on mixing. Let us begin then with the description (G the chapter) on solidifying.

* * *

Part Five
The Chapter on Solidification

1. Of these there are four methods: Solidifying through roasting, solidifying with the flask and the kettle, solidifying through burying and solidifying with the blind ambiq [E and that is the solidification of mineral matter.]

* * *

I. Solidifying by Roasting

2. With this you solidify mineral substances and their components and, indeed, while you soak it with the water to solidify it, and pulverize (the soaked matter) on a grinding surface until it is dry. Then place it in a clay-coated flask and seal its plug (lid), if there is no more moisture in it, and put it, covered up, in a dung fire; if however there is moisture in it, then take the moisture away and then seal the plug and let it stand, until it becomes dry and hot. Then cover it over with fire and let it stand as God wills.

* * *

II. Solidifying with Flask and Kettle.

3. There are two methods. The first one requires that you soak the spirits with that which you wish to soak it, in the amount in which their portions combine; then pulverize it until it is dry, put it in a clay-coated flask, and indeed place this in a kettle with ashes, so that under it is a little less ash than three fingers held together; pile many ashes around it, under (L heavy) even packing up to its neck and plug it with wool one time after another until you have driven away its moisture. [G104, Hs. 105]. As soon as a ball of wool is wet, replace it with another and press it out and let it dry (and substitute another for it) until it too (L its sister) has become wet. Then take these and bring them back to dryness, until the moisture is depleted and the wool stays dry and it shows a trace of burning (E about itself). Then put roasted salt and barley flour over the wool, made into a paste with hot water, (G E and let it dry G and get hot; then coat it with the artist's clay and in fact let the clay be made into a paste with hot water) so that the flask does not shatter. Then let it dry and become very hot, then pack ashes solidly over it and pack small coals over the ashes and light a fire in it and watch that the coal's flame does not extinguish. Take care as well, that the fire is even on all sides, so that all that you wish solidifies to a (G single) powder (L E to an enduring (in fire) powder), supported and tested through the fire.

4. The second method of this solidification (L with the flask and kettle) requires that you put the substance in a clay-coated flask and seal its lid after driving away the moisture; and the driving away of its moisture requires that you set the flask up to halfway in a dung fire and plug it with a ball of wool like the other one; (L E you drive away its moisture until the wool turns brown) and shows a trace of burning. Then seal the lid with a paste made of roasted salt and barley flour with hot water, so that the flask does not shatter, and let it stand until it dries and becomes hot. Then coat it over with artist's clay, made into a paste with hot water, so that the flask does not shatter, and let it stand, until it has become dry and hot (G and is hardened).

Then take a clay-coated kettle, six fingers higher than the flask, and put sifted (G hot) ashes two fingers deep into the kettle, then the kettle will be packed with ashes (around the flask). Inside the kettle there is a ring one fist wide underneath the brim and a cover on which the ring fits. Now the flask is

placed on the ashes and the lid is set on the projecting ring, then the closure is assembled with a cloth and laces (E and egg white) and then it is coated with clay over the lid and the adjoining parts, after you have placed the kettle on the stove. Then a gentle fire is lit under it, until the whole has become dry. Then put small coals over the lid [G105] and light a fire on the stove; be careful that the fire is even on all sides (L uniform), so that the substance solidifies by means of the fire and becomes strong in it. And with these methods of solidifying, the procedure is now repeated until the substance is solid and has become powder that withstands fire and does not smoke and does not dissolve as God wills.

* * *

IV. Solidifying by Burying

5. This is the solidification of dissolved substances, and indeed requires that you place the dissolved matter in a clay-coated flask and seal its closure. Then dig it a pit corresponding to its size and put solid earth in it and pack it solidly. Spray water on the earth and cover it with dung, put one or two baskets of coarse dung on it, depending on the lesser or greater amount of the matter, and light a fire in it. Let it stand until it solidifies, then take it out and test it. If it does not smoke and flow and has become powder, (then it is good;) and if not, then repeat the procedure with it, until it has become powder (E until it is very solid) as God wills.

* * *

V. Solidifying with a Blind Alembic

6. There are two methods. One of the two requires that you place the thing that you wish to solidify in a cucurbit and set it on a beaker; then put the closure together and set the blind alembic on a small close-fitting stove, (G to solidify) that which is in the cucurbit. You place a lighted lamp or burning naphtha lamp and take care that it does not go out, and observe it until it has solidified. The underside of the cucurbit must be heavily coated with clay, and also be careful that the wick is not

too thick, lest that which is in the cucurbit comes to a boil and breaks it, (G mark this) as God wills.

7. The other method of this solidification requires that you set the blind alembic in hot ashes of a medium heat; they will be replaced as long as it takes to solidify as God wills.

This is the totality of the chapter on solidification, and with this its description is at an end. Now let us begin with the description [G 106, Hs. 107] of the sublimation of metals and stones and their transformation into metals.

* * *

Part Six: The Chapter on Sublimation[435] [436].

1. The sublimation of metals and stones takes place through the spirits, just as the stability of the spirits depends on the metals and stones. It happens in two ways.

2. One method requires that the three spirits be mixed and soaked with water of sal ammoniac; then the mixture is placed between two crucibles, of which the lower one is clay-coated and between which a binding is established. On the lowest portion of the open crucible is a hole; so big that the little finger passes through it, it is plugged with wool (G and wax) so that the air can go through it (?)[437] and that which is sublimated can be seen. When the smoke ceases, you let it become cold in its place, then take it out and make the uppermost the lowermost and soak it with dissolved sal ammoniac and pulverize it therewith, until it becomes dry, then put it back in the two crucibles and soften it and let it stand until the smoke ceases. Do this repeatedly, until nothing more remains underneath. This is the (E method) of sublimation.

3. The second method requires that you mix the substance with spirits [G and the metals], as you will, and carefully pulverize it with water of sal ammoniac (E on a grinding surface), and in fact at least one day. Do this with it in a new aludel of the artist’s clay or birham, (G whichever of these it may be), and coat it proficiently with clay and set it on the stove (L or on the tābistān) and heat it below with a strong fire (L E from the very beginning of the task until it is sublimated) and do

not drive off its moisture.

4. The difference between the sublimation of spirits and metals consists in this: that you drive the moisture away from the spirits, but not the moisture of metals. You replace the bottom with the top (E L with pulverizing and drive it repeatedly higher) until all is sublimated. Or you set it in an oven of the shape of a self-ventilating oven and blow on it with two bellows, however take care with the blowing, until it is sublimated and the smoke ceases. Then reverse the bottom and the top [G107] (G and take care with the blowing), until it is sublimated as God wills.

* * *

A. The Sublimation of Metals

I. The Sublimation of Gold

5. This is effective and suitable for reddening (L E alone). It requires that you take gold filings and amalgamate them with an equal amount of mercury, and as much yellow sulfur as a quarter of the mercury, and add the same amount of vitriol. Soak it with water of sal ammoniac and pulverize it on a grinding surface, then let it sublimate, as we have described (L earlier), and make the uppermost the lowermost, until all is sublimated. Then soak it with the solution of five vitriols and roast it in a flask in a kettle with ashes. Do this with it repeatedly, until all of it has become red (G best) cinnabar. It (L E its dirham 30 dirhams of silver) colors for you as God wills. And if you soften it and dissolve, (L E then its one colors 100 of any metal you wish). And if you add to it an equal amount of the red of hair, then its mithqal colors for you 700 of any metal that you will, as God wills.

II. The Sublimation of Silver.

6. It requires that you amalgamate silver filings with an equal amount of mercury, and roast it one night in hot ashes with alum, made into a paste with egg white, in a clay-

coated flask, whose top is sealed. Then take it out and with it pulverize half as much mercury-whitened (L yellow) arsenic sulfide,[438] in which there is no blackness, with water of sal ammoniac on a grinding surface one full day. Then sublimate it with a strong fire at the beginning of the undertaking, and replace the top with the bottom and pulverize and soak it with water of sal ammoniac until all is sublimated. Then soften it all repeatedly and dissolve it and solidify it. Its dirham colors 500 of copper to silver as God wills.

III.

The Sublimation of copper

7. Its sublimation takes place as well to red as to white. If you wish to sublimate it to red, then proceed according to the procedure for gold, and if it should take place to silver, proceed according to the procedure for silver. Its effectiveness comes close to the effectiveness of both as God wills.

IV. The Sublimation of Iron

8. Take iron filings [G108, Hs. 109] and wash them repeatedly with water and salt and purify them from their blackness; then wash out the salt with sweet water, until its saltiness is gone away (L from it). Then pulverize it well with an equal amount of sublimated arsenic sulfide and sublimated mercury with water of sal ammoniac, and put it in an aludel and sublimate it with help from bellows and replace the uppermost with the lowermost. Then pulverize it each time, with water of sal ammoniac (L E one day) until it sublimates, and add to it each time that which has diminished from the spirits; then soften it and dissolve it and let it solidify. Its dirham transforms 100 dirhams of both leads and of mercury as God wills.

V. The Sublimation of both Leads

9. The sublimation of the two leads corresponds to silver, but the efficacy of tin exceeds the efficacy of silver; so take note of this as God wills.

* * *

B. The Sublimation of Stones.

I. The Sublimation of Marcasite, Magnesia, and Iron ore.

10. Pertaining to the sublimation of marcasite, magnesia, and iron ore, the sublimation of these three is like that of iron, and their efficacy is like its efficacy, nothing of them remains behind. And if you soak these sublimated stones with an equal amount of dissolved sulfur and with as much dissolved mercury as sulfur, and let it solidify, then its dirham colors what lies between 500 and 700 of any metal that you will as God wills.

II. The Sublimation of Tutia and Malachite and Lapis Lazuli and Hematite

11. What pertains to these, is that it is necessary that they be pulverized with three times as much mercury, sublimated with a mixture of sulfur, that is saturated with water from the five reddened vitriols. You sublimate it like you sublimate gold, and its efficacy comes close to gold as God wills.

III. The Sublimation of Talc and of Gypsum

12. What pertains to both of these is that they can not be sublimated at all, and there is no procedure for both in this regard; therefore do not burden yourself (E your heart) with them as God wills.

IV. The Sublimation of Glass.

13. Take of them what you will and let its substance truly be a pure white, and soak it with water of sal ammoniac and steam it in a clay-coated [G109] māwardiyya until its smoke ceases. Do this with it ten times, then put it in a clay-coated new aludel and set it on a strong fire or a stove shaped like a self-ventilating oven, and sublimate it and return the uppermost to the lowermost and soak it with water of sal ammoniac, (adding) with each sublimation the amount that was driven off from it. And pulverize it on a

grinding surface, until it is dry and nothing remains to evaporate (L E then it is all sublimated). Then mix it with three times as much dissolved mercury and an equal amount of dissolved sulfur and an equal amount whitened distilled (G sublimated) arsenic sulfide, and bury it 40 days in dung, so that it becomes a pure water, purer than tears (L E and than emerald). Its dirham transforms 700 of whichever metal you wish as God wills.

This chapter, that we have explained here, is the chapter of Ibrahīm (G Alī) Ibn Gafar al-Hamadānī. I have encountered a marvelous story with him that I will relate in the explanation of procedures of animal matter.[439]

14. Now it is the end of the sublimation of metals and stones and next we begin with the explanation of metal development of the procedures of stones and metals. (L And Allah is the helper with his grace and his bounty in all things, and he is our certainty.)

* * *

V. The Procedures of Developing Metals.

15. Regarding gold and silver, they are both pure (unmixed) metals and need no procedure. Regarding copper and the two leads, then one has (E if they are also less pure than the two other metals, not much work with them). Only for the developing metals of iron (is a procedure necessary) among the metals. And of the stones are marcasite and magnesia and iron ore, then talc and gypsum and glass and nothing further (L E and the treatment of all is the same, except for talc and gypsum and glass.)

16. Regarding iron, the masculine (L E its filings) is taken from it, and regarding iron ore,[440] from it the Istahrish is taken, which is coated with a fine crust. It is heated and immersed (G repeatedly) in water and salt until it crumbles and turns to dust.

17. Regarding marcasite and magnesia, then both are pulverized and a quarter part or less of red arsenic sulfide is added to them, then they are (G made wet and) pulverized well. After that it is tied tightly in a cloth and the overlap is cut off, and the bag is covered with the artist’s clay and dried as

thoroughly as possible and roasted one night in an oven (tannūr), that has been heated with an intense fire [G 110, Hs. 111]. Then it is taken out (L E and washed continuously with water and salt until it is clean), then washed with sweet water, until the water is sweet and the saltiness is removed. And among the adept there are some, who instead of the (E L raw) red arsenic sulfide use an equal amount of whitened yellow arsenic sulfide or whitened sulfur. Roast it in a clay-coated jar and (G L do not) leave a spot open, from which the steam can escape. Then mix it with a sixth of natron and make a paste with oil in the amount that combines with it, and let it melt down in a double crucible. Pour it in a dry mold, then melt it (again) and mix it with glass and sal ammoniac in equal amounts, both sprinkled with oil. Mix ten of this at a time with one dirham weight of glass and sal ammoniac, and pour it on the ground. Do this with it repeatedly (E L continuously) until it becomes white and soft.

Then add one part of it at a time to ten of lead and mix ten and a half dirham of it with a danaq[441] and two grains of whichever (E dustlike) elixir (E L to whiten) you will. It transmutes them to white (E lets them turn to white silver), after it has been in the sulfur and mercury elixir (G then it is stable in the pure state as God wills).

If you wish to calcine metals and hard stones, an amount of red arsenic sulfide equal to them is added, and if you wish to transform them into metal, as much as a quarter of it is used. Note this difference, because many errors are made on this account.[442]

18. Regarding talc and gypsum and (metallicized) glass, their sublimation occurs in only one way. It requires that whitened sulfur or whitened arsenic sulfide be sublimated from them repeatedly. Pulverize them continuously with water of natron (L repeatedly), until it has absorbed sevenfold, and with water of tinkar in the same amount. Then mix it for melting with whitened lead oxide (litharge) ten to one, so that it melts like water. Pour it in a dry mold, so that it comes out similar to ivory as in a white stream. Talc and gypsum, that you transform, can both be dissolved with bean-water (E with water of soda). Regarding glass, calcine it with water of soda, and [G 111] indeed, heat it therewith and dissolve it therewith and take an equal amount of sublimated mercury with it. Make from it a paste with egg white, distill with it what is in it from shell calx [G similar to hail] and salt of (G whitened) soda; you roast, soak it continuously, until it solidifies to white powder. It dirham transforms 30 dirhams of lead into silver, and if you

soften it in 10 softenings and dissolve and pour an equal amount of sublimated mercury on it and bury it, it will dissolve. Then let it solidify, so that its dirham colors one ratl of whichever metal you wish as God wills.

This is the end of the description of the metal generation of metals and stones, and that is the conclusion of the sixth section of this our book. (E Now let us begin with the seventh part.)

* * *

Part Seven

1. This is the last of the sections, on which the procedures depend, and it contains (L is that) the procedure of waters, that tint the whitened precursors, whose description has gone before up to this final conclusion of the book. (E and to that belongs the procedure of a red water.)

* * *

I. The Procedures of Waters.

2. Take (E one ratl) distilled wine vinegar and add a quarter of its amount of purified vitriol and let it stand a few days (Margin E: and boil it to bubbling) and purify it, then add as much as its quarter of sal ammoniac to it, let it stand a few days (Margin E: and boil it to bubbling) and purify it. Then dry it and roast it, until it becomes red as God wills.

3. Another way. Take distilled wine vinegar, in which there is a quarter portion of purified (L distilled) vitriol. Then put in that which was purified, a quarter portion of copper acetate made with sal ammoniac and wine vinegar and (L some of) washed copper filings, and let it boil to bubbling. Then purify it and use it (E for what you will).

4. [L E] Another way. Take (E distilled) wine vinegar and (E put in it) its quarter of sal ammoniac and boil it (E to bubbling) and purify it, and to that which was purified add yellow purified vitriol and boil it. The add its quarter of copper acetate, made with burnt copper and let it boil (E to bubbling) and purify it. Then add

purified ferric oxide to it and boil it and purify it and use it.

5. [E] Another way. Take burnt copper and dissolve it and add the redness of sulfur and oil of egg yolk to it and bury it a few days, until it dissolves and turns yellow. Then use it, and you will find it as a coloring material.

6. Another way. Take (G L green vitriol and) yellow vitriol and white vitriol and red vitriol and ferric oxide and as much as the whole (L a quarter of the whole) of sublimated sal ammoniac, and moisten it with wine vinegar, and soak it and pulverize it; and each time when it becomes dry, moisten it in the same way; (G do this with it) three days and each time when the three days are finished, roast it on a medium fire, until it becomes red (L G hot). Then dissolve it and use it (E for what you will).

7. Another way. Take purified vitriol and dissolve it and add an equal amount redness of sulfur and oil of egg yolk to it [G 112] and bury it a few days, until it dissolves and becomes pure. Use it, then you will find it salutary.

8. Another way. Take yellow vitriol, that has some golden eyes on its broken surface, and an equal amount green vitriol, dissolve it in moisture and purify both, then add to both their quarter of water (G E softened) gold marcasite and sun it a few days and distill it; then add to it as much as its quarter of ferric oxide, let it stand several days, and distill it, after that add to it a quarter of the whole of oil of egg yolks and set it to dissolve a few days. Now use it for your work, (G E then you will find it G effective E outstanding.)

9. Another way. Take one ratl yellow sulfur and an equal amount boiled egg yolk and pulverize both on a grinding surface one full day. Take its water and its oil, combine both while beating them and mix both with an equal amount of water of copper acetate and of distilled vitriol (G both distilled) and sun it for a few days; then use it, (G E then you will find it wonderful) as God wills.

10. Another way. Take dissolved vitriol and lead oxide and red arsenic sulfide and gold marcasite and green vitriol in equal amounts, and pulverize them continuously, until they become dry. Then soften them with water of sal ammoniac, sublimated five times with vitriol and five times with water of white vitriol, and

dissolve them with moisture; then they dissolve to a red coloring water as God wills.

11. Another way. (G it requires that you) distill egg yolk, and take its water and its oil and combine them both with the five reddened vitriols dissolved in moisture, namely with green vitriol and yellow vitriol and white vitriol and red vitriol and gold vitriol and then bury it for three weeks in dung. It dissolves into yellow water without residue, (L then use it).

12. Another way. (G It requires that you) take honey and yellow sulfur and vitriol, from each one ratl individually, and (G in addition) two staters[443] yellow white arsenic; pour distilled wine vinegar on the whole (L on it) [G 113] and cover it up to four fingers high in a kettle of birham in the shape of a cooking pot and boil it in several bubblings and purify it and pour a half-ratl water of egg yolk and a half ratl of its oil thereon, sun it (G soften it) 14 days and distill it and set it aside. Then take ferric oxide and yellow white arsenic and the dyes of sulfur and egg yolk and green vitriol and gold marcasite, and soften it with the dissolved sal ammoniac ten times and bury it, until it has dissolved. Now distill it and combine it with that which was set aside and bury it three weeks, then it dissolves into a yellow (L red) water; and if you immerse a heated tablet of silver in it, then it leaves it behind as pure gold as God wills.

13. Another way. Take green vitriol, dissolve it in moisture and (G dissolve it [with honey] and mix it with honey after it dissolves in the moisture and distill it and set the distilled matter aside. Then take ferric oxide and an equal amount of (G one part) (L E yellow) sulfur, pulverize both and soak them with that which was set aside (L E water and pulverize both) one full day and dry both, then roast them in a clay-coated flask, whose opening (lid) is tightly sealed. (E Do this with it four times) and soak it each time with it until what you have left is like a soup. Then pulverize it, until it is dry, and set it aside. Take copper acetate and pulverize it with a quarter part sal ammoniac and roast it, do that four times and each time replenish the sal ammoniac, then take from it one part and one part from that which you have set aside and pour a stream of distilled water on it, and sun it until it becomes like blood; then

use it as needed.[444]

14. Then there are the waters which color the substrate red, in which the mercury and the sulfur and the metals are included. And what pertains to those, in which no mercury is contained, so they are colored with red dissolved mercury, mixed with the redness of sulfur (L E or mixed with water of egg yolk), or mixed with water and oil of egg yolk together.

Description of the red dissolved Mercury.

15. Take mercury sublimated to red and an equal amount yellow sulfur, soak (G pulverize) both with water from dissolved vitriol [G 114] one day and dry both and let them sublimate in a māwardiyya, so it sublimates like blood. Then take one part of it and an equal amount of ferric oxide and pulverize them and pour copper acetate and vitriol and dissolved sal ammoniac on it. Pulverize it and bury it, until it dissolves into red water; after that distill it and soften the residue with water of vitriol and of copper acetate and dissolved distilled vitriol, until the whole thing is distilled. Then sun it (G soften it) 14 days long.

Now we have said enough about the sharp red-coloring waters. Therefore this is the end of the transformation of mineral matter. Now we begin with the help of Allah with the description of the procedures for vegetable matter as God wills.[445]

* * *

II. The Procedures of Vegetable Matter

1. We have in that which has gone before in this our book, said the following: “The interest of the adept is minimal with respect to the utilization of plant substances, and they make little use of them. The best, of those that are used, is the long moist uschnān, that is known under the name ‘five-finger (cabbage).”

1. The Procedure for Whitening.

2. Take what you will of the uschnān and distill its water. As

soon as it begins to change (change color) and its nafs (scent, odor) begins to rise – then once again set another receiver before it and distill it and let it stand until all is distilled. Then take a new portion of it and distill its water (G until its nafs rises), then let it stand until all is distilled over. Then take a new portion of it and distill its water, (G until its nafs rises) then let the remainder in the vessel sublimate with the aludel. Take that which rose up white from it and calcine the residue, then take one part of it and one part sublimated mercury and make a paste of it with an equal amount of distilled water and let it solidify on a gentle fire, in a clay-coated flask whose plug (lid) is sealed, then will it solidify to powder like rock crystal. Its dirham colors 100 dirham of whichever metal you will and leaves all behind as white silver as God wills.

3. Another way. You take one part of its calx and one part of its water and one part sublimated mercury and pulverize it and roast it in a clay-coated flask, according to that which has gone before. It comes out for you as a white essence (substance)[446]. Its dirham colors 150 of whichever metal you will and leaves it behind as silver as God wills.

4. Another way. You soak it with dissolved mercury in four repetitions and roast it with each soaking, so its dirham falls on 300 of whichever metal you will as God wills.

5. Another way. You soften this (L substance) and pulverize it ten times and dissolve it again and let it solidify, then its dirham colors 500 of whichever metal you will as God wills.

6. Another way. Solidify the nafs that you first distilled [G 115] in a blind alembic with the flame of a candle,[447] until it has dissolved, like honey, pour over it a stream of water distilled from it and seal the closure. Then put it on the fire again and submit it once again to this process and let it stand one night and one day; then open it and filter (L pour) the red water off of it and replenish the water and the procedure, until you have taken all its color. Then take what remains behind of the nafs (G residue) and boil it seven times with the weak water of soda, until all of its blackness has gone out of it.

7. Description of the mild water of soda. Take one ratl of soda and calcine it, until it becomes white, pour four ratls water on it and let it stand one day and one night, and boil it to bubbling; then purify it and set it aside, then pour four ratls of (L other) water on that of it which

remains behind, let it stand one day and one night and boil it to bubbling and purify it; then (G treat it thus three times and) combine the three waters in one jug (E and set it aside) and use it (E as we have mentioned) as needed as God wills. Then take one part of the wax that is the whitened nafs, (L E and one part calx and six parts distilled water) and soak it with this distilled water; pulverize both one day and roast it at night in a clay-coated flask, until it turns to white powder. Its dirham colors 300 of whichever metal you will (E to white silver) as God wills.

8. Another way. You soak the (G calcined) calx three times with as much distilled water, that it remains as a soup and pulverize it by day and roast it by night until it becomes like a white powder. Then melt it (G in its moisture) and combine it with wax (L resin) and pulverize it one full day and pour a stream of water on both and bury it 14 days in a blind alembic, so that it solidifies to a white substance. Its dirham transmutes 600 of whichever metal you will into white silver that returns to purity. If you add the weight of 10 dirhams to 10 ratl (L E substance of whitened L pulverized) glass [G 116], so it leaves it behind as pure crystal, after you have placed it in a clay-coated kettle and set it in an oven (atūn) and have taken it out, when it has become cold.

G: Now is the end of the description of the plant chapter in reference to the creation of whiteness (L E and this is the most excellent that takes place in the chapter on plant substances in regard to the creation of whiteness). Now let us begin with that which creates the redness in them.

2. The Procedures of Redness

9. Take five parts of distilled water in which redness is dissolved and one part dissolved mercury and one-half part of whitened stable sulfur; (G then take the red mercury and the white stable sulfur), place them on a grinding surface and pour an equal amount of water on it and pulverize it until it has become dry. Then pulverize it after the drying for a good hour more (E G until all is excellent) and roast it one night in a clay-coated flask on a gentle fire. Do this with it, until it has absorbed all the water and has become a red powder. Its dirham colors 100 of silver; grind one (L 10) with three, then it will come out as red gold (E pure gold) as God wills.

10. Another way. Take one part calx, I mean, that of the uschnān and one-fourth whitened stable sulfur and ten parts red water. Soak it and roast it according to what has gone before, so that it becomes red powder. Its dirham

colors 50 dirhams of silver to pure gold.

11. Another way. Take one part calx of uschnan and one part of wax (L. resin) of its nafs, pulverize both well and soak them with fourfold red water in four times and roast it with each soaking, until it becomes a red powder. Its dirham colors 200 dirham of whichever metal you will to pure gold; it returns to purity as God wills.

12. Another way. When you pour out a stream of four times as much water in which redness is dissolved, and bury it for 40 days, then it dissolves to water without residue. Let it solidify in a blind alembic, then its dirham colors 800 (L 100) of whichever metal you will to gold; it returns to purity as God wills.

13. Preparation of its essence. It requires that you [take] one ratl crystal and the weight of ten dirhams gold filings, one dirham [G 117] calx of egg yolk and one dirham of this elixir. Pulverize it on a grinding surface and put it in a flask (G māwardiyya), that is coated with a paste made of iron rust with egg white, and coated with the artist's clay and is sealed at the top. Leave it in the oven (atūn) one night and take it out when it has cooled, so that it comes out as a red jewel (essence), that is in no way inferior to the ruby in its effectiveness (power) except for the effectiveness of emery; its mithqal achieves 50 dinars as God wills.

That is all that we find from the procedures of plant matter; that which we have mentioned is guidance enough for studying, because the interest of the adept is minimal with respect to plant substances.

* * *

III. The Chapter of Animal Matter

1. Now let us begin with the procedures (G the reference) to animal stones. We have said, in that which has gone before, that there are ten stones, and indeed hair, skull, brain, egg, gall, blood, milk, urine, mussel, and horn. (L G The best of these is hair, then brain, then egg, then the skull, then blood, then horn.) So let us begin with the references to their best methods and their description, so that the book will not become too long and the reader will not grow weary.

1. The Procedures with Hair

2. Take fresh black hair (G E from the hair of adults), wash it with (G E white) clay as thoroughly as possible, (L so that all the dirt is cleaned out) then wash it also with (L E sweet water and) soap and uschnān and dry it and cut it as fine as possible, fill a vessel with it halfway and set an alembic on it and distill it until all the moisture is distilled over. Then extinguish the fire and take the residue out, after the vessel has cooled, pulverize it well and sublimate it in an aludel and take that which is white sublimated from it. And if it is not sublimated white the first time, then repeat the procedure (E I mean that) of the sublimation over again until it comes out white (L: as a white powder). Place this on a grinding surface and soak it with its water and pulverize it until it has absorbed an equal amount, after that roast it in a clay-coated flask with a dung fire [G118] one night, then) E take it out) pulverize it and soak it with an equal amount of water and pulverize it therewith, until it is dry, and roast it. Do this with it until it has become white powder like rock crystal. Its dirham transforms 400 dirhams of whichever metal you will into white silver, it returns it to purity as God wills.

3. Essence of coloring. Calcine that which remains (at the very bottom) in the aludel, by soaking it with its water in one soaking and pulverize it therewith, until it is dry. Then place it in the oven (atūn) and take it out again, when it has cooled and repeat the procedure continuously, until it has become a dust-like calx as God wills.

4. The chapter of its essence.[448] Take one part of this calx and one part gold filings and 100 parts red Egyptian mina,[449] pulverize all of it and to it add one quarter part of this calx (L elixir) and one part green vitriol and pulverize both with wine vinegar, that has been distilled with a quarter red natron one good hour. Then put it in a clay-coated kettle (L flask) and put it in the over and take it out when it has cooled, and thus it comes out as a splendid adrak.[450]

5. Another way. Pulverize this elixir and soften it with water of dissolved sal ammoniac in which as much as a quarter part of it is skull calx. (G Mix it and) bury it until it dissolves, then let it solidify in a blind alembic, with the flame of a naphtha lamp, thus it will solidify to powder. Its dirham transforms 600 dirham of any metal you will (E to silver) as God wills.

6. Another way. Take boiled egg yolk and distill its water and its

oil, and soak this elixir with an equal amount of each constituent of it while pulverizing it on a grinding surface and do not leave off grinding until it has become dry. Then roast, when you are done with the grinding (E soaking), all of it, and soak it again with dissolve green vitriol and roast it, so that it turns into [G119] red ruby-like powder. Its dirham colors 500 dirhams of whichever metal you will to pure gold as God wills.

7. Its essence. Take powder of pure emerald and pure carnelian (G take) from each one part, and ten parts pure crystal and a tenth of this elixir and one part red natron, soak and pulverize it with hair water, that has distilled a good hour, until the powder is dry. Then put it in a clay-coated kettle and place it in the over (atūn) and take it out again, when it has cooled. It comes out as a red ruby, its mithqal accomplishes 100 mithqal (L E 500 mithqal Gold) as God wills.

8. Another way. Take the hair and purify it according to the previous procedure and distill its water and its oil, as we have described. Then repeat, with the water of the distillation, until it is pure and set it aside, and solidify the oil in a blind alembic on a small stove with the flame of a lamp or a naphtha lamp or with hot ashes, or in the sun one day in the summer, until it has become solid. Then place it in a blind alembic and pour a stream of the water that was set aside on it and seal the closure and set it on hot ashes one day and one night. Then purify (filter)[451] it (G in the margin: so that it comes out) crimson. Now replenish the water and repeat the procedure until you have removed all of its color, and set it aside. After that, take the gold, calcined with mercury and vitriol and sulfur, and soak it with this water in ten repetitions 20 times and pulverize it with each soaking, until it is dry, and roast it in a clay-coated flask with a dung fire. Its dirham transforms 600 dirhams of whichever metal you will into pure gold.

9. Its essence (L essence of coloring). Take gold filings and copper filings and calx from egg yolk part for part, and ten parts powder from Yemenite carnelian and as much as the whole of red Egyptian mina[452] [G it belongs to the art of glass [G 120], and exhibits colors that are known to the glaziers] and 100 parts powder of pure crystal and a tenth of the whole of natron, and as much calx of hair as natron. Pulverize the whole well and add to every 100 mithqal of this mixture one mithqal of this elixir. Pulverize it one hour and put in a clay-coated

kettle, and place it in the over (atūn) and take it out again when it has become cold, then you will find it as red ruby. Its mithqal transforms 500 mithqals as God wills.

10. Another way. Take ten parts of the redness of hair, dissolved (E with its water) and five parts of dissolved calx of hair and five parts of whitened stable sulfur. Then pulverize the sulfur and the calx together on a grinding surface of marble[453] or glass and soak it with an equal amount of red of (L E with its water) dissolved hair and pulverize it therewith until it has become dry. Then roast it (G one night) on a gentle fire in a clay-coated flask with a sealed closure (lid) and repeat the process with it, until it has entirely absorbed the red dissolved with its water and has become ruby-like powder. Then soften it with as much sal ammoniac of hair as the entirety, steam it four times (L three times) and bury it for 40 days; do not go beyond (this period), until it has dissolved (G E to a water)as red as blood. Then let it solidify (E in a blind alembic on a small stove with the flame of a naphtha lamp, thus will it become solid to powder, with a red stronger than purple and purer than crystal. Its dirham transforms (L its mithqal colors 1000 mithqal of whichever metal you will; it leaves it behind as pure gold (E it returns it to purity) as God wills.

11. [G L] Another way. You take this calx (L this elixir) and pulverize it with an equal amount sal ammoniac of hair, the third of those which we mentioned in the chapter of sal ammoniac), and steam it therewith repeatedly and dissolve it and add to it the redness of distilled hair without its water. Then bury it three months until it has dissolved to pure water that shines in the dark. Then let it solidify in a blind alembic with a weak fire, thus will it solidify to red powder as pure as the sun [G 121]. Its mithqal transforms 2000 mithqal of whichever metal you will (L to pure gold, it turns back to purity as God wills).

12. Its essence (L It draws gold like a magnet). Take four ratls pure crystal and 10 mithqals gold filings (G and an equal amount white ruby) and pulverize with 10 mithqals Yemenite carnelian and four mithqals white ruby and the half of one mithqal of the best diamond and ten mithqals (L red) natron and an equal amount of tinkar. Pulverize the whole well in a glass mortar[454] one week long, until it becomes a powder; then add to it three mithqals of this elixir and pulverize it therewith one full day and place it (L in the oven, after you have done

that) in a clay-coated kettle, and seal its plug (lid) to the utmost. Leave it in there three days, then take it out, when it has become cold (G thus you will find it) as a red ruby. It draws gold and silver to itself, like a magnet pulls iron to itself, and its mithqal transforms 1000 (L2000) mithqal to gold as God wills.

13. Another way.[455] Take hair and purify it according to what we have mentioned, and divide it up (E cut it up) and distill its water (E its white and yellow and red) and its nafs, this is its redness and its oil,[456] and set each individually aside by itself and distill the water again until it becomes as pure as rock crystal and one no longer detects it (G in the flask). Now weigh it and put it aside and solidify the red in a blind alembic with a light fire, however watch that it does not boil, lest the blind alembic break. Then weigh it (again) when it is solid and on it in a vessel pour a stream of the water that was set aside and set the alembic on it and seal the closure and set it on a light (small) stove. Now heat under it with (G the fire) a naphtha lamp one day and one night, thus will it become a red water. Then purify it and replenish the water and repeat the procedure, until you have taken away all of its redness. Then weigh the remaining water, so that you know what has been taken from it (L has occurred), and the remaining redness, so that you know what was taken from it [G122], then combine the red waters and weigh it and set it aside. Then make white that which remained black from the oil (G and boil it) with the mild soda water, that we described in the chapter on plants, and indeed with it pour it in a blind alembic and seal the closure and coat the alembic with clay, and place it on hot ashes. Heat one day and one night, until the water turns black: pour it off from it and replenish the water repeatedly, until it is white and the water remains on it in its current state, without changing again, and then set it aside. Thereupon take the residue and pulverize it with distilled water of hair a good hour, until it is dry, and put it in a clay-coated jug with a sealed closure, and put it in a self-ventilating oven and leave it in there one day and one night. Do this with it continuously, until it (E a calx) becomes like ivory filings, and set it aside. Then take one part white wax (L resin) and one part power-fine calx and pulverize both together a good hour on a grinding plate of glass with a glass rubbing stone, until it has become one single substance. Then wet it somewhat with the water that was set aside and pulverize it together for one hour and steam it repeatedly in a

clay-coated kettle (L E beaker) and do not (?) let it stand until it smokes. [457] Then bury it until it has dissolved to a (E rose-coloring) water without residue. Then mix it with an equal amount (G dissolved, set-aside) water, in which the redness was dissolved, and bury it 40 days, until it is pure; then let it solidify, thus you will find it as red powder. Its mithqal colors 2000 mithqal of whichever metal you will to pure gold (L stable in its purity).

And when you have dissolved this elixir, after you have pulverized it with an equal amount of sal ammoniac of hair, a fifth of that which we have referred to, and you have steamed it repeatedly and dissolved and added to it as much as a quarter of the whole (G E whitened G hair E wax and as much as a tenth of calx G of hair E of eggs and as much as the whole) redness of hair, dissolved in its water, let it solidify in a blind alembic with a naphtha-fire, then will it solidify in seven days to red powder. Now pulverize it and soak it with a quarter (G with just as much) water of egg yolk and pulverize it therewith (E until it is dry) then roast it after strong pulverizing one night on a gentle fire, pulverize it, and soak it with oil of egg yolk, as much as half the whole, and pulverize it therewith until it is dry. Then roast it one night on a gentle fire in a clay-coated flask, thus it will solidify to a red powder. Its mithqal (G dirham) transforms 20,000 mithqal of whichever metal you wish. It creeps into them, like the poison of snakes creeps into the bodies of beasts[458] (G it leaves it behind as fine pure gold as God wills).

[Here follows in all three manuscripts the story reiterated in the introduction, on page 80 and following, of one of Rāzī's completed transmutions. The closing words acclaim: (G Therefore to whoever sets eyes on this book) note this elixir, because among those from animal matter there is none more excellent than this. (L And God is the one called on for help and in him we trust and God lets us attain what is right.]

14. Essence of carnelian (G essence of coloring). You take ground powder of carnelian and coral and silica and green mina (enamel) and malachite, from each of them one ratl, and one uqia ground (powder) of emerald; pulverize the whole carefully and mix with it one (L two) mithqal of this elixir and soak it with redness of hair, dissolved with its water, as much as will combine with it, and place it in the oven (atūn), after you have pulverized it, until it is dry, (G put it) in a clay-coated kettle; then take it out when the oven has become cold (G then you will find it) as red powder (L

gleaming as the sun), so that no substance of mineral rubies equals its worth (L E and nothing comes close to its value as God wills.)?[459]

15, Another way. You take (G E in the name of God) five ratls of red (G fox-colored) cleaned hair (G as came previously) and 15 (L 25) ratl of black hair. Pour on both seven ratl of (L the water of) distilled hair and bury it, until it has dissolved to a blackened water [G125] like tar. Distill it and set it aside, the white and the yellow (L E and the red) water each individually, and when the distillation is complete, put the fire out and take the alembic off of it and put in its place an alembic with a very wide opening, and let the fire act on it again (G with bellows), so that a blackened water distills over, as viscous as tar; when this occurs, throw it away, because there is nothing good in it. Then change the substrate and let the fire act on it again, so that the dry vapor rises up and it thickens in the substrate and the alembic similar to white sal ammoniac and mountain salt (G white) as salt (E as snow).

Now set it aside and take the white water again to distill, until it is as pure as rock crystal; then place the residue in a clay-coated jug and set this in the oven, until all the blackness and oiliness that remains in it is burned, and take it out, when it has become cold. Do this with it continuously, until it has become white powder as God wills. After that, pulverize it (L E and in each ratl of it place 10 dirhams of this sal ammoniac and pour it 5 dirhams of white water on it; pulverize it therewith one good hour and again place it in the oven and take it out, when it has become cold, and pulverize it) and sprinkle it with its half of the white water and dissolve it. It dissolves into a white water, and this is the *eastern mercury*. Then place it in a clay-coated flask and seal its closure (lid) and dig a pit for it according to its size, and place the flask inside it and fill the pit with dung (E earth) and throw dry dung on top of it, light a fire in it and let it become cold (again), so that it is hard as crystal. This is the *warq*,[460] its mithqal colors 1000 mithqal of any metal you will as God wills.

16. Another way. Pulverize it and sprinkle it with as much as its half of white water and pulverize it therewith until it is dry, and roast it one night with a gentle fire in a clay-coated flask, thus will it solidify into a white powder. Its dirham changes 10,000 (L mithqal) of whichever metal you will, it comes out as white silver as God wills.

17. Another way. Take four (G 10) parts of the white water, [G126] one part of the yellow water, and two parts of the red, mix one

with the others and beat (E roast) it vigorously and with it soak this (L white) elixir, after you have (G combined and) pulverized it (L E in the amount of that which is combined; pulverize it together over again) a good hour, until it is dry, and roast it in a gentle fire; do this with it, until it has solidified to a red powder. Thereupon, pulverize it, (G and pulverize) with each ratl of it one uqia (L from this) sal ammoniac and one uqia of red water, and bury it in wetness, until it has dissolved. After that to each ratl add two uqia of white water and four uqia of yellow and three uqia of red and bury it again and leave it in there 40 more days, until it has dissolved and become pure and fine, then let it solidify. It solidifies into red powder; its dirham transforms 20,000 mithqal of whatever metal you will (G and leaves it behind) as pure gold.

18. Its essence. Take yellow, green, and red mina (G that is the glass), from each individual kind one ratl and another half ratl of white silica and one ratl of crystal and one uqia copper filings and as much gold filings and two uqia silver burned with sulfur. Pulverize the whole thing and in each 100 mithqal of the total put one mithqal (L E of this sal ammoniac and one mithqal) of this elixir, and soak it with water of egg yolks and pulverize it, until it is dry; then put it in a clay-covered kettle and set it in the oven (atūn) and take it out when it has become cold. You will find it like red powder, it is (shines like) the light of a lamp in the dark of night, more splendid than natural rubies. Its mithqal equals 20,000 mithqals of pure gold as God wills.

2. The Chapter on Eggs

19. Take egg yolk and put it in a (G L clay-coated) glass beaker with a fitted lid, then pour a stream of egg white on it and take it to dissolving and bury it [G 127] during 40 days until it has dissolved. Then distill it and set its white water aside, and when it begins to change, then exchange (replenish) the substrate, until the yellow water is distilled out of it (G E and when the red begins, exchange the foregoing again, until it is also distilled. Then when the distillation has ceased, then put the fire out, and take the alembic off of it and set in its place an alembic with a wider opening and distill it, then its tar will distill (L arise) from it and its burning. Build up the fire under it, until nothing more remains of it, then take the residue and pulverize it and put it in a jug, not clay-coated, after you have made it into a paste with a tenth part of white water. Put this in a potter’s oven and take it out when it has become

cold, and repeat the procedure with it, until it is white. Then take white water and with it make sublimated mercury into a paste and roast it on a gentle fire in a clay-coated flask. Do this with it three times, but each time add as much water to it, as combines with its portion, then solidify it to an elixir. Its dirham solidifies 60 dirhams of whichever metal you will as God wills.

20. Another way. Take two parts of this water and one part shell calx (G E and one part water of egg whites and ten parts calx of egg whites and bring to dissolving, so that it dissolves in 40 days to water, pure as rock crystal. Now let it solidify in a blind alembic, so that it hardens (E in three days) to a white crystal-like powder (E white essence); and if you light a candle under it, then its dirham will transform 3000 (E 500) of whichever metal you will, it comes out as white silver as God wills.

21. Another way. You soak this powder (L dissolve it, after you . . .) with water of hair, repeated four times with an equal amount, and pulverize it there with and roast it, so that it solidifies to a white powder; its dirham transforms 6000 (L you add . . . to 3000) of whichever metal you will. And when you dissolve it, after you have repeated it soaked with the water of hair, then dissolve it to pure clear water [G 128] in 60 days. Thereupon let it solidify, so it becomes hardened to white powder. (L E its equal will not be seen). Its dirham transforms 10,000 dirhams of whichever metal you will into white silver as God wills.

22. Another way. You take one part of the residue of a calcined egg and one part water and pulverize the whole (E the calx) with a sixth of the white water one good hour (G until it becomes dry). Then pour it on the remainder and bury it until it dissolves. Then put one part of the yellow water in it and one part of the red, and bury it again another forty days, until it is pure. Then let it solidify in a blind alembic (G so that it hardens to red powder). Its dirham transforms 2000 mithqal of whichever metal you will into pure gold as God wills.

23. Another way. You soak it with a potion of its white water in the amount that leaves it as a soup, and take it (E the mercury?)[461] again to dissolve, so that it dissolves to a pure water similar to blood. Add to it an equal amount red water and let it solidify according to what you know (G E thus will it solidify G to a powder similar to garnet); its dirham transforms 10,000 mithqal of whichever metal you will into pure gold.

24. Another way. Take the egg (G and break it) in a curcurbit, whose height is one span, and set a beaker on it and seal the connection with sārūğ

and bury it for 40 days until it dissolves. Then distill it and set its water aside and its oil, each one by itself, and calcine its residue with salt water in the oven (atūn), until it has become white. Then soak the residue with an equal amount of its oil while pulverizing it, until you have made it like a soup, and do not stop pulverizing it, until it becomes dry. Then roast it in a clay-coated flask (G māwardiyya) with a gentle fire, then will it harden to powder, red as liver. Its mithqal colors 100 mithqal silver (L to gold), it comes out as pure gold as God wills.

25. Another way. Take (G pulverize) one part of this calx with an equal amount of the white water, until it has become nearly dry [G 129], then set it to dissolve, until it has dissolved, and after that add one part of its oil and take it to dissolve again, then will it dissolve to pure red water (G more pure than any purity). Then let it solidify in a blind alembic, so that it solidifies to a powder like red rubies. Pulverize it and soak it with the yellow (L white) water that was distilled from egg yolk, likewise in four repetitions, and pulverize it vigorously; then roast it (L E and soak it once again with the oil of egg yolk in four times, pulverize it and roast it), until it has solidified, then pulverize and soak it with the white water (L E one portion) which leaves it behind like a soup. Then subject it to dissolving 40 days, thus it will dissolves into a red water (L E strongly to red). Then add to it the calx of egg yolk, in an amount equal to the water you soaked it with, bring it again to dissolve another 40 days, until it has dissolved and is pure, then let it solidify in a blind alembic with the flame of a lamp, thus will it solidify in seven days to a red ruby-like powder. Its dirham transforms 100 ratl of whichever metal you will into pure gold (G it comes out as red pure gold) as God wills.

26. Its essence (L essence for coloring). Take 100 mithqals of Syrian glass and 100 mithqals (L just as much) white silica and an equal amount crushed crystal and an equal amount (E three mithqal) calx of egg yolk and 20 mithqal natron and one mithqal of this elixir[462]; after you have pulverized the mixture and have dissolved (L E dissolve it and) make a paste of it with redness of horns and pulverize it, until it is dry. After that place it in the oven (atūn) in a clay-coated kettle and take it out when it gets cold. You will find it as a (single) ruby-like red piece; neither before it nor behind it is there anything (G comparable) in excellence, weight, and color. No substance affects it except (L E the best) diamond (G and that does not equal its worth) as God wills.

27. Another way. Take fresh egg and boil it and place some alum and

salt in the water that you boil it in; then take the egg shell by itself (L E and dissolve away its thin membrane) and the egg white by itself and the egg yolk by itself and calcine the shell (G after you have removed its membrane) and dry it well, after you have pulverized it. Then calcine the residue of the egg white with as much distilled water [G 130] as combines with it into a paste, (G and pulverize it) a good hour, until it is dry. Then put this in a clay-coated kettle (L E in the oven), do this with it three times and set it aside. Then take the yellow (L white) and distill its water and its oil and calicify its residue by pulverizing with water of soda and sal ammoniac. Soak it there with, until you get it like a soup and pulverize it therewith, until it is dry, and put it in the oven in a clay-coated kettle. Do this with it over again, until it has calcined and has become the finest powder, like rock crystal. (L E Now set it aside and do the same thing with the yellow). Then take one part calx of egg shell and the same amount of water of egg white, and pulverize both on a hollowed-out grinding slab[463] one good hour and set it to dissolve 40 days, thus will it dissolve. (L E Then put one part oil of egg white in it and one part of its calx and bury it 40 more days in dung, thus will it dissolve to a pure white water. Then let it solidify in a blind alembic (G with a naphtha flame), thus will it solidify to white powder. Its one transforms 4,000 (G 40,000) mithqal of whichever metal you will into white silver as God wills.

28. Another way. Take one part calx of egg yolk and soak it with an equal amount of water of egg yolk and bury it, so it dissolves in 40 days into a red water. Put the same amount as both of oil of egg yolk in it and bury it 40 more days, thus will it dissolve and become a pure water. Then let it solidify in a blind alembic, thus will it solidify into a red ruby-like powder. Its mithqal transforms 500 (E 4,000, G 5,000) of whichever metal you will into pure gold as God wills.

29. Its essence. Take white silica and crystal and magnesia of iron, part for part, and as much as the whole of red mina and as much as this of blue emeralds and as much as a tenth of the whole of red natron. Pulverize the whole carefully and add two mithqals of the elixir[464] to it and pulverize it well therewith and put it in the oven (atūn) in a clay-coated kettle and take it out when it has become cold. You will find it like a red ruby-like piece, from the best rubies in existence as God wills.

3. The Chapter of Blood

30. Take the cup of fresh blood, put it in a curcurbit and distill its water and its oil and calcine its residue [G 131] with salt water in the oven (atūn),

thus will it calcine in three repetitions. Take this water to distill once again, until it is pure, then take one part of its water and one part of its calx and bury it in dung, thus will it dissolve in 60 (50) days. And to it add mercury sublimated to whiteness, as much as the whole, and bury it 40 days until it has dissolved into water without a residue. Then solidify it, so that it becomes solid to (G white) powder, purer than rock crystal. Its mithqal transforms 500 mithqals to whichever metal you will into white silver as God wills.

31. Another way. You take one part of its (G white) water and just as much of its calx, pulverize both in a glass mortar one good hour and bury it until it dissolves. Then add one part of the wax (L resin) of whitened hair and bury it again, until it has dissolved and is pure; then let it solidify. Its dirham transforms 1000 mithqals of whichever metal you will into white silver as God wills.

32. Another way. You pulverize this and soak it with a potion of its white water in the amount that leaves it like a soup, and bury it until it dissolves. Then let it solidify, then its mithqal will transform 4000 of whichever metal you will, it comes out as white silver as God wills.

33. Another way. You take one part of its water and one part of its oil (L nafs) and an equal amount of its calx as of the water, then you pulverize the whole amount in a glass mortar one day and bury it in dung until it has dissolved and is pure; then let it solidify, thus will it solidify to a pure red powder. Its mithqal (G dirham) transforms 1000 mithqals of whichever metal you will (G it comes out as pure gold as God wills).

34. [L E] The treatment of gall and skulls and horns and others like those from the animal stones are done following these procedures. So take note and work accordingly, and you will have success as God wills.

This is the end of the description of the procedures of minerals and animal matter, as we have promised.

(L Praise be to God, the Lord of the world and prayers for our lord Muhammad.)

Addendum I.

The Chapter of Rarities

a. (G E Now we begin with the details of the rarities and that is the last chapter of our book.)

We call it rarities (addenda), because it in we gather that which

appeared too briefly (G what was passed over and was doubtful) in this chapter, that we have discussed in this our book.

1. Sublimation in the Māwardiyyas

2. You place the substance, whose sublimation you wish to undertake, in a māwardiyya (E pl.), then take for it a small (E large) kettle [G 132], clay-coated as well as possible, whose height exceeds (E by a fist's width) the māwardiyya (E pl.) that you wish to set it in. Then place in the kettle a fist deep of sifted ashes and pack it quite firmly, then set the māwardiyya (E pl.) in it (the kettle) on the ashes and pack ashes around it up to the mouth of the flask; (E and pack) the flasks, if there is moisture in it, with wool and drive off its moisture (G and replace the wool with another) until you, when the wool turns dry and yellow (L E and burnt), (E seal) the mouth of the flask. Light a fire under the kettle until evening, then let it get (E stand and) get cold in its place.

2. Description of Purified Borax

3. Take one ratl of white borax of bread and five staters salt of dough, pulverize both well (L E and water it), beat both and let it solidify, after it has set, and filter the water out of both.

4. Another way. Take one part white borax and an equal amount of borax of bread and pulverize (L E and water) both and let them sit. Then pour off of both, what is pure from the water, and let the remainder become solid; this is the purified borax.

3. Description of Soda Salt (L E and Quicklime)

5. Take what you will of white soda and an equal amount of quicklime, and on both pour seven times as much water as both and boil it, until half of it remains, and purify (filter) it ten times, and place it in a clean porous jar and hang it over a beaker and gather what falls below continuously and take it away and keep it from dust, so that it does not touch the beaker, (E and let it solidify to salt).

4. Description of sharp Soda water

6. Take on ratl white soda and pour twelve ratls (E pure water) on it and let it stand one night and one day. Then boil it to bubbling and filter it (E and pour the water on another ratl of soda and let it stand one day and one night and boil it and purify it). Do this seven times, then distill it and keep it safe, because it lets talc and gypsum turn to milk (E is that which dissolves talc and gypsum) as has been described earlier in our book.

5. Distillation of Oil [G133]

7. Take from it what you will (E new) and boil it with an equal amount of water and some white clay, until a third of the water has gone away. Then filter it from what remains of the water and the clay, and replenish the water and the clay and the procedure ten times. (E Do this with it three times) then place it in a curcurbit and strew powder on it in an amount that makes it like a thin soup (E and distill it). Do this with it several times, until it ignites no fire, when you take it out (E test [it]).

8. Another way. Take oil, boiled with water and white clay and put powder and bitter salt in it in the amount that makes it like a soup, and distill it therewith, until it lights (no) fire.

6. Distillation of Naphtha

9. Make naphtha into a paste with an equal amount of sal ammoniac and distill it. Do this with it, until it distills like water and absolutely does not ignite a fire.

10. [E] Another way. Take black naphtha and make it into a paste with white clay, until it is like a soup, and distill it. Do this with it, until it distills like water and it does not ignite a fire.

7. Description of Lead burnt through Vitriol.

11. Take of lead what you will, put it in an iron spoon and add a quarter part of yellow vitriol to it and place it in the tābistān and shake it back and forth and take it out, when it is burnt and has turned to ashes. Then soak it with vitriol and roast it, until it becomes red, as God wills.

8. Calcination of soda.

12. Take of soda what you will (E a fresh piece of soda) and put it in a clay-coated kettle and place it in the oven (atūn) and take it out, when it has become cold. Do this with it, without pulverizing it, until it has become burnt and white as God wills.

9. Preparation of Green vitriol.

13. Take strong yellow vitriol, as much as you will, and boil it with an equal amount of copper acetate in a copper kettle in four times as much water, until a third of the water is driven off, then purify it and let it solidify in beakers in the sun, and let each beaker be covered with a beaker, until it has solidifies. Then pulverize it and spread it on a glass funnel[465] after pulverizing it and put a piece of sieve on the end of the funnel and put a layer of cotton on it and a layer of green vitriol, until it reaches the other end, and hang it in a sirdāb from the ring on the cover with a linen thread (kattān), after you have set the funnel (E beaker) on the flask (E qinnīna), then will it dissolve to a red water and solidify in the beaker in the sun; it solidifies like emerald as God wills.

[G 134] 10. Distillation of Egg White, in which Calx of Egg Shells and Salt of Soda are found.

14. Take one ratl of egg white and add to it one uqia calx of egg shells and an equal amount of soda and beat it strenuously one good hour. Then distill it and keep it safe.

11. The Dissolving of Wise Pythagorus.

15. (G He says:) Take the thing whose dissolving you will, after you have made it into a salt that melts with moisture, and sprinkle it with sharp water and put it in a new jug, that is as narrow below as it is above, and in which the lower part is pierced so that the little finger passes through it. And after you have immersed the jug in water, until it stands at the same depth, fasten a leather on its upper end, on which is a wet felt, and set it on a beaker (E and outside the hole that is in the jug, between the beaker and the lower end of the jug, place a piece of sieve, that you have glued down around it with wax, so that whatever dissolves from it will be strained) and seal the connection with sārūğ and let it dry and hang it on a cotton thread in a cone-shaped pit whose upper portion

is narrower than its lower; its depth should be one (E two) ells and its width one ell and its upper one span. Add water up to halfway (E cistern water however), and furthermore there should be a groove, whose depth is two fists, filled with water, and furthermore a lid with a ring. Hang the jug in it and the beaker, and seal the plug and observe the groove and the pit, and refill the water, when it decreases, until all that was in the jug has dissolved, and dripped into the beaker as God wills.

12. The Chapter on the Dissolving of Salts.

16. * You dissolve the salt, after you have made it wet, (and indeed) in winter inside a lemon, that (E in its upper portion) is hollowed out, and in whose lower portion a hole is found and in the hole a little piece of palm fiber, that stands on a beaker in a large jug, which has a lid (and) (stands) on a pillar (E on pillars) of clay on a damp board, where the wind does not blow on it, after you have covered the jug with a wet cloth of coarse fabric (linen); and in summer in a curcurbit.

13. The Chapter on Mineral Substances.

17. * Take in the name of Allah and with His help (E one ratl of) the best yellow (E pulverized) arsenic sulfide and let its smoke dissipate and grate the rot [G 135] off of its upper surface and sprinkle it with water and salt and roast it. Then wash it and dry it and repeat the procedure with in, until it becomes white and does not blacken (E the silver). Then (G soften it now and) dissolve it and set it aside, then take mercury sublimated to whiteness and soften it and dissolve it and set it aside. Then take calx of silver or lead – burnt dust-like lead – and soften it and dissolve it and combine these three waters in equal parts. Take it to dissolving, until they are clean and fine, then let it solidify, then it will solidify to a powder like lead. Its dirham colors one ratl copper to white silver (E the qibrisī,[466] it returns back to purity) as God wills.

18. * Thus says Abulhasan (G ibn al-Lait): I have seen, that Abū Sahl (G Abū Sa'īd), the scribe of Abū Tāhir, cast this substance (E chapter) on 100, which came out as white silver. He sold it in my presence at the marketplace.[467]

19. * Another way. You take one ratl yellow smoke-free arsenic

sulfide and make a paste with one uqia honey (G with vinegar) and roast it in a clay-coated flask with a dung fire and pulverize it and repeat the procedure three times. Then soak it with salt water and roast it continuously, until it turns white, and wash it with each roasting, after you have pulverized it and dried it. Repeat the procedure with it, pulverize it with salt and sublimate it, until it no longer blackens silver. Then make a paste with egg white, distilled with calx and salt of soda and pulverize it until it is dry. Now put it in a clay-coated flask sealed tightly and bury it in a dung fire seven days and observe the fire that it does not get weaker, so that it comes out as white powder like rock crystal.

20. * Take mercury, solidify it through the scent of sulfur (E of lead) and pulverize it with an equal amount of vitriol and three times as much soda salt, and roast it one night on a gentle fire. Place it in the aludel, set the alembic on it, seal the connection and drive away its moisture [G 136]. Then take the alembic off and set the lid in its place and sublimate it three more times. Each time, place the top one underneath, after you have mixed it with an equal amount of bitter salt, then sublimate it three more times with calcined bones, as explained previously. Then take dust-like calx of silver and soften it and dissolve it, then soften the whitened mercury and dissolve it, and combine the three waters in equal parts and bring it to dissolving, and thus will it be pure and fine in forty days. Then let it solidify, thus will it solidify to white powder. Its dirham colors 500 of copper to silver as God wills.

21. * Another way. You distill these waters and combine them and let them solidify, so that it solidifies to powder like rock crystal. Its dirham colors 1500 of copper, it comes out as pure silver.

14. The Chapter of Gold

22. * Take yellow sulfur, pulverize it well and soften it with water of sal ammoniac several times, dissolve it, and distill it and set its oil (G and its residue) aside. Then boil (E its oil) several times with the mild water of soda, until its color is clear and its fire goes away, and set it aside. Then take the residue and treat it according to the procedure of arsenic sulfide in the first section of the chapter on whitening, until it no longer blackens (E the silver). Then take calx of gold, that we have

mentioned in the chapter on arsenic sulfide (E zingar) and soften it and dissolve it, then take red mercury, that we have mentioned in the chapter on procedures with spirits, and soften and dissolve it, then take whitened sulfur (E and soften) and dissolve it. Then combine the waters in equal parts and set them in a pit so that they become fine and pure. Then solidify it, it solidifies to red powder (G like rubies); its mithqal transforms 500 mithqal of whichever metal you will into pure gold (E it returns it to purity) as God wills.

23. [G] And better than all of these is, that you distill these liquids and combine them and mix them in equal parts and solidify them. It solidifies to red powder, one mithqal transforms 4000 of whatever metal you will into pure gold, it returns to purity.

* * *

Appendix II.
Fragments from Rāzī's Book of Safekeeping
From the Manuscript of the Escorial folio 84 ff.

1. About Sal ammoniac and Mercury

In the Book of Safekeeping it says: Sal ammoniac is a natural element (essence), hot and sharp; it flies before the fire and one distills its water and its oil. When the oil begins (to distill over), the fire will flare up. The alembic (for this distillation) must be narrow and have an ample receiver, that is placed away (as far as possible) from the fire and whose tube is long and wide. Also, one lays a wet cloth or felt on the receiver and heats under the alembic, until one sees that dry steam drains into the receiver and settles (inside the receiver) near the cloth or felt. This is a sharp sal ammoniac.

He says: Mercury resists fire, until (or if?) it becomes strong from the bellows, and it does not steam (literally: 'flee'), when you take an iron spoon, on which there is no rust. Then heat it, until it is red as blood, similar to a glowing ember; pour the mercury on it and do not cease and blow on it an entire day. There are countless forms of it, which . . .). Also it is solidified through the exhalation of both leads together.

b. About Silver and Copper

He says: Silver takes the yellow color through red lead and Egyptian Mina and burnt copper, when they are melted together. Take as much as a lentil and place it on the upper surface of a drachma and heat it, so it covers it

with a coating of gold . . .

And the copper is colored in all its parts, so that it resembles the value of bad silver, when you take 80 dirhams of arsenic sulfide and of magnesia and proportionately 30 dirhams of yellow tutia and 6 dirhams of tin and 18 dirhams of mercury. Amalgamate the mercury with the tin and pulverize it with the other substances, then add the weight of 40 dirhams of spruce resin and 10 dirhams borax of bread and 40 dirham of incense and strengthen the pulverizing with these substances. Then roast it in a vial throughout one night, or, if you will, in a kettle; then put it in the vial and take away its moisture with a ball of wool. Then strengthen the fire for one full day and one full night; then take off what has sublimated, and add resin and a fourth part of incense and to it. The let it sublimate still more and add one dirham to 20 of purified copper, and thus will it come out as it if were white tin.

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[3] al-Rāzī, 6.

[4] *Shorter Oxford English Dictionary*, 5th ed., s. v. "laboratory."

[5] Examples of agencies that provide laboratory accreditation include the International Organization for Standardization under ISO 17025, the Food and Drug Administration, and the National Accrediting Agency for Clinical Laboratory Sciences. http://www.quality.co.uk/custpage.htm, http://www.fda.gov/default.htm, http://www.naacls.org/, viewed 4/18/13.

[6] Theodore M. Porter, *Trust in Numbers* (Princeton: Princeton University Press, 1995), 15.

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[9] al-Rāzī, *Al-Rāzī's Buch Geheimnis der Geheimnisse*, 22.

[10] Kraus, 13.

[11] Julius Ruska, "Al-Razi als Bahnbrecher einer neuen Chemie," *Deutsche Literatur-Zeitung* 44 (1923): 117-124.

[12] For example: Julius Ruska, "Über das Schriftenverzeichnis des Gabir ibn Hajjan und die Unechtheit einiger ihm zugeschriebenen Abhandlungen," *Archiv für Geschichte der Medizin* 15 (1923): 53-67. Julius Ruska, "Chemische Apparatur bei den Arabern und Persen und im Abendland am Ausgang des Mittelalters," *Chemische Apparatur* 10 (1923): 137-139. Julius Ruska, "Der Urtext der Tabula Smaragdina," *Orientalistische Literaturzeitung* 28 (1925): 349-51. There are many more.

[13] "Der Abstand zwischen der unendlich vielgestaltigen Darstellung der Ğābir-Schriften und der nüchtern sachlichen Form von Rāzī's

Arbeiten ist so groß, daß man über die Feststellung einer gemeinsamen Basis hinaus kaum noch weitere Beziehungen wahrscheinlich machen kann." Ruska in al-Rāzī, *Al-Rāzī's Buch Geheimnis der Geheimnisse*, 12-13.

[14] Aristotle (384-322 B.C.), *Meteorology*, vol.1 of *Great Books of the Western World*, ed. Robert Maynard Hutchins (Chicago: William Benton, 1952), 445, 482 .

[15] Avicenna (980-1037 C.E.), "On the Formation of Minerals and Metals and the Impossibility of Alchemy," trans. and ed. E. J. Holmyard and D. C. Mandeville, in *A Sourcebook in Medieval Science*, ed. Edward Grant (Cambridge, Mass.: Harvard University Press, 1974), 569-70. Earlier Islamic scholars questioned alchemy, but Avicenna's emphatic refutation of it was the basis for continuing debate in medieval Europe.

[16] "Elle transforme alors le métal comme une teinture qui pénètre la trame d'un tissu, ou un ferment qui agit au coeur de le la pâte." Bernard Joly, "Alchimie et Rationalité, " 98. Unless otherwise stated, all translations are my own.

[17] Al-Rāzī, *Al-Rāzī's Buch Geheimnis der Geheimnisse*, 9, 83.

[18] Albertus Magnus (1193-1280), *Albertus Magnus Book of Minerals*, trans. Dorothy Wyckoff (Oxford: Clarendon Press, 1967), xiii. George Ripley (c.1415-90), *George Ripley's Compound of Alchemy (1591)*, ed. Stanton J. Linden (Aldershot, U.K.: Ashgate, 2001), vii-viii.

[19] References to *Alchemia* as the first chemistry textbook include: Bruce T. Moran, *Andreas Libavius and the Transformation of Alchemy: Separating Chemical Cultures with Polemical Fire* (Washington Publishing Company: Sagamore Beach, MA, 2007), 34. J. R. Partington, *A History of Chemistry* vol. 2 (London: MacMillan & Co., 1961), 253. Owen Hannaway, *The Chemists and the Word: The Didactic Origins of Chemistry* (Baltimore: The Johns Hopkins University Press, 1975), 81, 89.

[20] Petrus Bonus, *The New Pearl of Great Price: A Treatise concerning the Treasure and most Precious Stone of the Philosophers*, ed. Arthur Edward Waite (London: James Elliott & Co., 1894; reprint, London: Vincent Stuart Ltd, 1963), viii. Written in c. 1330. Geber and William R. Newman, *The "Summa Perfectionis" of Pseudo-Geber: A Critical Edition,*

Translation and Study, trans. and ed. William R. Newman (Leiden: E. J. Brill, 1991). According to Newman, the *Summa Perfectionis* was probably written in the late thirteenth century by Paul of Taranto.

[21] George Sarton, *Introduction to the History of Science, Vol. I: From Homer to Omar Khayyam* (Baltimore: Williams and Wilkins, 1927; reprint, 1962), 587.

[22] Ibid., 610.

[23] H. E. Stapleton, R. F. Azo, and M. Hidayat Husain, "Chemistry in Iraq and Persia in the Tenth Century A.D.," *Calcutta: Memoirs of the Asiatic Society of Bengal* 8 (1927): 369.

[24] Ibid., 320.

[25] Kraus, 11.

[26] This translation was published in al-Rāzī and Ruska, *Al-Rāzī's Buch Geheimnis der Geheimnisse, Quellen und Studien zur Geschichte der Naturwissenschaften und der Medizin*.

[27] Ibid., vi.

[28] Al-Rāzī, 27.

[29] Bettina Meitzner, *Die Gerätschaft der chemischen Kunst. Der Traktat "De seuastica artis" des Andreas Libavius von 1606: Übersetzung, Kommentierung und Wiederabdruck* (Stuttgart: Franz Steiner Verlag, 1995). Note: The 1606 edition was published under the title *Alchymia*.

[30] Herman Boerhaave, *Elementa Chemiae* (Leiden: Isaacus Severinums, 1732).

[31] Michael Faraday, *Chemical Manipulation; being Instructions to Students in Chemistry on the Methods of Performing Experiments of Demonstration or of Research, with Accuracy and Success* (London: W. Phillips, 1827).

[32] Andrea Libavius, *Die Alchemie des Andreas Libavius: ein Lehrbuch der Chemie aus dem Jahre 1597: zum ersten mal in deutscher Übersetzung mit einem Bild- und Kommentarteil*, trans. Max-Planck-Gesellschaft zur Förderung der Wissenschaften, Gmelin-Institut für

anorganischen Chemie und Grenzgebiete und Gesellschaft Deutscher Chemiker (Weinheim: Verlag Chemie, 1964). According to Meitzner, the work on this translation lasted from 1942 to 1964 with significant interruptions. (Meitzner, xiii).

[33] Meitzner, ix.

[34] Holmyard, 274.

[35] Arthur Greenberg, *A Chemical History Tour: Picturing Chemistry from Alchemy to Modern Molecular Science* (New York: John Wiley & Sons, Inc.: 2000), 112. Herman Boerhaave, *A New Method of Chemistry* (London: J. Osborn and T. Longman, 1727).

[36] Alan Hirshfeld, *The Electric Life of Michael Faraday* (New York: Walker & Co., 2006), 100.

[37] *Kīmiyā* can be translated as either *chemistry* or *alchemy*. *A Dictionary of Modern Written Arabic*, 3rd ed., s. v. *kīmiyā*.

[38] William R. Newman and Lawrence M. Principe, "Alchemy vs. Chemistry: The Etymological Origins of a Historiographic Mistake," *Early Science and Medicine* 3.1 (1998), 41.

[39] Andreas Libavius, *Alchemia*.

[40] Boerhaave, *A New Method of Chemistry*, 9.

[41] Ibid.

[42] Bernard Joly, "Alchimie et rationalité : la Question des Critères de Démarcation entre Chimie et Alchimie au XXIIe Siècle, " *Sciences et Techniques en Pespective* 31 (1995), 107.

[43] ". . . nous ne pouvons cependent la suivre plus loin sans faire mention d'une singuliere manie qui attaqua la tête de tous les Chymistes . . . dont la guérison enfin, qui n'a commencé à paroître que dans le dernier siecle, a été la véritable époque du renouvellement de cette Science & de ses progrès vers la perfection." Pierre Joseph Macquer, *Discours Préliminaire, sur l'origine et les Progrès de La Chymie*, http://gallica.bnf.fr, accessed 1 Sept. 2007.

[44] Gooding, *Experiment and the Making of Meaning*, 6.

[45] Bruno Latour, *The Pasteurization of France*, 15-16.

[46] Gooding, *Experiment and the Making of Meaning*, 197.

[47] Owen Hannaway, "Laboratory Design and the Aim of Science: Andreas Libavius versus Tycho Brahe," *Isis* 77 (1986): 585.

[48] "Dann aber bleibt auf alle Fälle für Rāzī das Verdienst, die Alchemie zum ersten Mal in eine streng wissenschaftliche Form gebracht zu haben." Ruska, 13.

[49] Stapleton, 317.

[50] E. John Holmyard, *Alchemy* (Middlesex, England: Penguin Books, 1957; reprint, New York: Dover Publications, 1990), 88. Robert P. Multhauf, *The Origins of Chemistry* (London: Oldbourne, 1966), 130.

[51] Holmyard, 88-89.

[52] William R. Newman, "Alchemy, Assaying, and Experiment," in *Instruments and Experimentation in the History of Chemistry*, ed. Frederic L. Holmes and Trevor H. Levere (Cambridge, Mass: The MIT Press, 2000), 37.

[53] William H. Brock, *The Chemical Tree: A History of Chemistry* (New York: W.W.Norton & Co., 2000), 22.

[54] Richard Morris, *The Last Sorcerers: The Path from Alchemy to the Periodic Table* (Washington, D.C.: Joseph Henry Press, 2003), 8.

[55] ". . . [ich] habe ihm ein kurzegefaßtes [*sic*], feines Buch über diesen Gegenstand zugeeignet." al-Rāzī, *Al-Rāzī's Buch Geheimnis der Geheimnisse*, 83. *Kitāb al-Asrār*, Dedication. All citations of the *Kitāb al-Asrār* include the page number in Ruska's translation followed by the Section and Procedure number to facilitate location of the passage in both the German and the English translations.

[56] ". . .und das ist das lezte Kapitel in diesem unserem Buch. " Al-Rāzī, 220. *Kitāb al-Asrār*, Appendix 1, Procedure 1.

[57] ". . . tränke es mit dem *zermalmenden Wasser* [*sic*]. Wir

werden dieses erwähnen bei den scharfen Wässern in den Kapiteln des Lösens." The instructions referred to are located in that chapter on page 182. Al-Rāzī, 123,182. *Kitāb al-Asrār*, Section 3, Part 1, procedure 61; Sect. 3, Part 3, Proc.3.

[58] Al-Bīrūnī in Ruska, "Al- Bīrūnī als Quelle," 32. Al-Bīrūnī gives al-Rāzī's date of birth as "Ersten Scha'ban 251" which converts to 25 March, 865 C. E.

[59] Frances Wood, *The Silk Road: Two Thousand Years in the Heart of Asia* (Berkeley: University of California Press, 2002), back matter map "The Silk Road."

[60] R. N. Frye, ed., *The Period from the Arab Invasion to the Saljuqs*, vol. 4 of *The Cambridge History of Iran* (Cambridge: Cambridge University Press, 1975), 136-142.

[61] *The Encyclopedia of Islam*, 1995 ed., s.v. "Al-Rayy," by V. Minorsky and C. E. Bosworth.

[62] Al-Rāzī, in *Al-Rāzī's Buch Geheimnis der Geheimnisse*, 84, 85, 87.

[63] Sa'id ibn Ahmad al-Andalusi, *Science in the Medieval World: "Book of the Categories of Nations"*(Austin, TX: University of Texas Press, 1991): 49.

[64] Ruska in al-Rāzī, *Al-Rāzī's Buch Geheimnis der Geheimnisse*, 4.

[65] Ruska, "Al-Biruni als Quelle," 32.

[66] Al-Nadim, *Fihrist*, 702.

[67] Abū Bakr Muhammad ibn Zakarīyā al-Rāzī , *The Spiritual Physick of Rhazes.* Trans. Arthur J. Arberry. (London: John Murray, 1950), 16.

[68] Ruska, "Al-Biruni als Quelle," 48.

[69] al-Nadīm, *Fihrist*, 703-5, 863.

[70] Al-Rāzī , 83.

[71] al-Andalusī, 49.

[72] Ruska, *Al-Biruni als Quelle*, 32.

[73] al-Andalusī, 49.

[74]Al-Rāzī and Max Meyerhof, "Thirty-three Clinical Observations by Rhazes (Circa 900 A.D.)," *Isis* 23 (Sep 1935), 327.

[75] Sarton, *Introduction to the History of Science, Vol. I*, 609.

[76] Cyril Elgood, *A Medical History of Persia and the Eastern Caliphate from the Earliest Times until the Year A.D. 1932* (Cambridge: Cambridge University Press, 1951), 92-93.

[77] Meyerhof, 329.

[78] Donald Campbell, *Arabian Medicine and its Influence on the Middle Ages*, vol. 1 (London: Kegan Paul, Trench, Trubner & Co., 1926; reprint, New York: AMS Press, 1973), 66-68.

[79] Edward Theodore Withington, *Medical History from the Earliest Times: A Popular History of the Healing Art* (London: The Scientific Press, 1894), 146.

[80] Campbell, 69.

[81] Sarton, *Introduction to the History of Science, Vol. I*, 609. Campbell, 201-02.

[82] "Der Ort da es Rhases beschreibt / ist das Capital von den Geschwärn der Augen im ix. Buch an Almansorem."Joseph Santino, *Dispensatorium Medicum Oder Büldene Apothek/Von Præparierung und Bereitung allerley Arzneyen/ deren man heut zu Tag sich gebrauchet/ wieder allerhand Schwachheiten und Grebrechen* (Frankfurt am Mayn: Palthenii Buchladen, 1606), 335.

[83] Robert P. Multhauf, *The Origins of Chemistry* (London: Oldbourne, 1966), 130.

[84] al-Nadīm, *Fihrist*, 703-09, 863. Sarton, *Introduction to the History of Science, Vol. I*, 609.

[85] Campbell, 65-72. Holmyard, 86-92.

[86] “C’est également un organisateur . . . en organisant des consultations externes, des soins à domicile, une aide médicale aux nécessiteux.” Yvon Houdas, *La Médicine Arabe aux Siècles d’Or : VIIIème – XIIIème Siècles* (Paris : L’Harmattan, 2003), 81.

[87] Al-Nadīm, 704.

[88] Paracelsus, *Hermetic Chemistry*, vol. 1 of *The Hermetic and Alchemical Writings of Aureolus Philippus Theophrastus Bombast, of Hohenheim, called Paracelsus the Great,* trans. and ed. Arthur Edward Waite (London: James Elliott, 1894; reprint, Boulder, Colo.: Shambhala, 1976), i. Bruce T. Moran, *Distilling Knowledge: Alchemy, Chemistry, and the Scientific Revolution* (Cambridge: Harvard University Press, 2005), 8.

[89] Guillaume de Lorris and Jean de Meun, *The Romance of the Rose*, trans. Charles Dahlberg, 3d ed. (Princeton: New Jersey, 1995), 1, 271.

[90] Geoffrey Chaucer, *Troilus and Cressida and the Canterbury Tales*, vol. 22 of *Great Books of the Western World*, ed. Robert Maynard Hutchins (Chicago: William Benton, 1952), 166.

[91] Lemgo: Neues von den 10 “Weisen” am Apothekenerker [online]; accessed 28 August 2011; available from http://www.lemgo.net/241.html?&MP=241-572.

[92] Abufalah, *The Book of Em haMelekh*, in *The Jewish Alchemists: A History and Source Book*, trans. and ed. Raphael Patai (Princeton: Princeton University Press, 1994), 110.

[93] Albertus Magnus, *Libellus de Alchemia*, trans. Sister Virginia Heines, in Grant ed., 599.

[94] Petrus Bonus, 229. This edition of *The New Pearl of Great Price* cites al-Rāzī at least thirteen times by my count, on pages 6, 80, 109, 112-13, 115, 229, 259 (twice), 279, 362, 365, 375, 382. The book was originally written in c. 1330 as *Pretiosa Margarita Novella*.

[95] Roger Bacon (c. 1220-92), *Speculum Alchymie: The True Glass*

of Alchemy, in *Collectanea Chymica: A Collection of ten several treatises in chymistry, concerning the liquor alkahest, the mercury of philosophers and other curiosities worthy the perusal* (London: Pelican, 1684; Ann Arbor, Mich.: University Microfilms, 1963), 130. Nicolas Flamel (1330-1418), *Écrits Alchemiques*, ed. Didier Kahn (Paris: Les Belles Lettres, 1993), 39, 43.

[96] Thomas Norton, *Ordinall of Alchemy* in *Theatricum Chemicum Britannicum: Containing Severall Poeticall Pieces of our Famous English Philosophers, who have written the Hermetique Mysteries in their owne ancient language*, eds. Elias Ashmole and Allen G. Debus (London: n.p., 1652; reprint, New York: Johnson Reprint Corporation, 1967), 8.

[97] Julius Ruska, "Übersetzung und Bearbeitungen von al-Rāzīs Buch *Geheimnis der Geheimnisse*," *Quellen und Studien zur Geschichte Naturwissenschaften und der Medizin* 3 (Berlin, 1935), 159, 162. The translator and exact date for the Latin translation are unknown according to historian Moritz Steinschneider. Moritz Steinschneider, *Die Europäischen Übersetzungen aus dem Arabischen bis Mitte des 17. Jahrhunderts* (Graz, Austria: Akademische Druck- und Verlaganstalt, 1956), 48.

[98] Dorothea Waley Singer, *Catalogue of Latin and Vernacular Alchemical Manuscripts in Great Britain and Ireland Dating from before the XVI Century*, vol. 1 (Brussels: Maurice Lamartin, 1928), 107.

[99] Patai, 420-22, 583.

[100] Ruska in al-Rāzī, *Al-Rāzī's Buch Geheimnis der Geheimnisse*, 14-24. In a letter dated Dec. 1936, Stapleton also refers to three copies of al-Rāzī's *Kitāb al-Sirr al-asrār* in the collection of the Asiatic Society of Bengal in Calcutta. This title, which means *The Book of the Secret of Secrets*, refers to a shorter and possibly earlier version of the *Kitāb al-Asrār*, and the two names can be a source of confusion. Both Ruska's translation and this paper are concerned with the longer work, the *Kitāb al-Asrār*. See Ruska, *Al-Rāzī's Buch Geheimnis der Geheimnisse*, 32. For Stapleton's letter, see: H. E. Stapleton, "Further Notes on the Arabic Alchemical Manuscripts in the Libraries of India," *Isis* 26 (1936): 128. There are three manuscripts of the *Kitāb al-Sirr al-asrār* in Iran, one in Tashkent (Uzbekistan), and one (thought to be 17th or 18th century) at the National Library of Medicine in Bethesda, Maryland. National Library of Medicine, Islamic Medical Manuscripts at the National Library of Medicine; accessed 22 April 2007; available from

http://www.nlm.gov/hmd/arabic/alchemy45.html.

[101] "Vergegenwärten wir uns, daß das Werk Rāzī's viele Jahrhunderte lang von Kundigen und Unkundigen immer wieder abgeschrieben worden ist, und daß die drei oder vier Handschriften, die wir noch besitzen, nur die letzten Reste einer von Indien bis Marokko reichenden Überlieferung sind, so wird man sich weniger über die Lücken und Abweichungen, als über die weitgehende Übereinstimmung der Texte wundern." Ruska in al-Rāzī, *Al-Rāzī's Buch Geheimnis der Geheimnisse*, 32.

[102] Ruska in al-Rāzī, *Al-Rāzī's Buch Geheimnis der Geheimnisse*, 22.

[103] Ruska, "Übersetzung und Bearbeitungen," 7.

[104] Steinschneider, 48.

[105] Singer,107.

[106] Patai, 583. Note: This list does not claim to be complete.

[107] Gabriele Ferrario, "The *Liber de Aluminibus et Salibus*," in Lawrence M. Principe, *Chymists and Chymistry: Studies in the History of Alchemy and Early Modern Chemistry* (Watson Publishing International: Sagamore Beach, MA, 2007), 138.

[108] Ruska, "Pseudepigraphe Rasis-Schriften," *Osiris* 7 (1939): 40. The dates and descriptions for Bacon and de Beauvais are from: Holmyard, 113 and 118-19. Newman and Principe characterize the author of *De Aluminibus et Salibus* as "written by a much later follower [of al-Rāzī]," Newman and Principe, 39.

[109] Robert Steele, ed., "Practical Chemistry in the Twelfth Century: Rasis *de aluminibus et salibus*," trans. Gerard of Cremona, *Isis* 12 (1929): 10. See also: Gabriele Ferrario, "The *Liber de Aluminibus et Salibus*," 148.

[110] Steele, 13. Multhauf, 160-61.

[111] Paul Kraus, who did extensive studies of Jabir's work, points out that as early as 1893 chemistry historian Marcellin Berthelot was convinced of the *Summa's* European origin: "But, on the other hand, he [Berthelot] proclaimed with great emphasis that the *Summa Perfectionis*

magisterii, upon which the whole European development of experimental alchemy was based, were spurious writings which originated in the 14th century." Kraus, 16.

[112] "Auf einem anderen Weg als dem der geduldigen Quellenforschung wird sie nicht gefunden werden können." Ruska, "Übersetzung und Bearbeitungen," 87.

[113] Newman, *The Summa Perfectionis*, 26.

[114] Ibid., 65.

[115] Ibid., 58, 193-4, 199.

[116] Ibid., 65.

[117] Patai, 98.

[118] Ibid., 109.

[119] "Nimm von welchem der beiden du willst [G34] [*sic*], dann pulvere es mit Weinessig, worin ein Viertel Qalisalz [*sic*], und röste es eine Nacht in gelindem Feuer, wenn es Schwefel ist, und wenn es Zarnich ist, an einem mittleren Feuer." Al-Rāzī, 120. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 55.

[120] Sublimation, which was used as a purification process, consisted of heating a substance to a vapor and then cooling it to recondense it back into a solid. Holmyard, 46, 56. It is only one of the alchemic processes, but it furnishes a common thread for purposes of illustration.

[121] Newman, *The Summa Perfectionis*, 691.

[122] "Was die Hochtreibung des Quecksilbers anlangt, so gibt es davon zwei Arten . . . Die eine findet statt zur Wegnahme seiner Nässe (Wässerigkeit), die andere dient zur Erzeugung seiner Trockenheit, damit es ganz trocken wird." Al-Rāzī, 102. *Kitāb al-Asrār*, Sect.3, Part 1A, Proc. 12.

[123] Paracelsus, 142.

[124] Holmyard, 187. George Ripley, *The Compound of Alchemy* in *Theatricum Chemicum Britannicum Containing Severall Poeticall Pieces of our Famous English Philosophers, who have written the Hermetique Mysteries in their owne ancient language*, eds. Elias Ashmole and Allen G.

Debus (London: n.p.,1652; reprint, New York: Johnson Reprint Corporation, 1967), 172.

[125] Petrus Bonus, 259.

[126] John Read, *Prelude to Chemistry: An Outline of Alchemy, Its Literature and Relationships* (London: G. Bell and Sons, 1936; reprint, Cambridge, The M. I. T. Press, 1966), 92, 102. Compare Thomas Norton's *Ordinall of Alchemy*: "Then is the faire white woman mariede to the rodie mane." Thomas Norton, *Ordinal of Alchemy,* trans. John Reidy (London: Oxford University Press, 1975), 83.

[127] "Du nimmst vom Quecksilber, das durch Aufstreuen von Schwefel (zur Röte) verfestigt ist, ein Ratl [*sic*], und vom Vitriol ebensoviel, und vom gelben Schwefel so viel wie die Hälfte des Vitriols, pulverst es mit bestem Weinessig eine gute Stunde, wirfst dann ebensoviel geröstetes Salz als Vitriol daruf und läßt es, nachdem seine Nässe weggenommen ist, siebenmal aufsteigen. " Al-Rāzī, 107. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 23. When used as a unit of solid weight a *ratl* is equal to 360 grams. Ruska in al-Rāzī, *Al-Rāzī's Buch Geheimnis der Geheimnisse,* 63-64.

[128] Hannaway, *The Chemists and the Word*, 81.

[129] Libavius, *Alchemia*, xxx.

[130] Ibid., 426.

[131] Hannaway, *The Chemists and the Word*, 155.

[132] This definition is from the New Zealand Code of Laboratory Management Practice. Issue 2, December 1988. Harvey E. Schock, ed., *Accreditation Practices for Inspections, Tests, and Laboratories* (Philadelphia: American Society for Testing and Materials, 1988), 129.

[133] Bruno Latour, "Give Me a Laboratory and I will Raise the World," in *Science Observed*, eds. K. Knorr and M. Mulkay (Beverly Hills: Sage, 1983), 159.

[134] Sara Schaefer Munoz, "Lead Concerns Spread To More Products; Federal Agencies Widen Focus Beyond Chinese-Made Toys To Mexican Dishes, Cookware; Vinyl Goods Scrutinized, Too," *Wall Street Journal*, Eastern edition,18 September 2007.

[135] Amy Harmon, “In DNA Era, New Worries about Prejudice,” *New York Times*, 11 November 2007.

[136] Jeff Hansel “Demand for specialized tests means growth at Mayo lab,” *Knight Ridder Tribune Business News*, 28 August 2007.

[137] “. . . damit es ihm ein Führer sei.” Al-Rāzī, 83. *Kitāb al-Asrār*, Dedication.

[138] Michaela Pereira, “Alchemy and the Use of Vernacular Languages in the Late Middle Ages,” *Speculum* 74 (1999), 344, 346, 347, 350.

[139] Thomas S. Kuhn, *The Structure of Scientific Revolutions*, 3d ed. (Chicago: The University of Chicago Press, 1996): 139.

[140] Office of the Surgeon-General, War Department, Washington, D. C. *Medical War Manual No. 6: Laboratory Methods of the United States Army*, compiled by the Division of Infectious Diseases and Laboratories, 3rd edition (Philadelphia: Lea and Febiger, 1919), 9.

[141] Sandy Weinberg, ed., *Good Laboratory Practice Regulations*. (New York: Marcel Dekker, 2003): 7, 68.

[142] Sublimation is the process of converting a solid substance to vapor by applying heat, and then cooling the vapor quickly to convert it back to a solid. Holmyard, 46.

[143] “Nimm von welchem der beiden du willst ein Ratl, dazu ebensoviel Salz und halb so viel Eisenfeile. Pulvere nun das ganze sorgfältig mit Weinessig an drei (E aufeinander folgenden) Tagen (E jeden Tag dreimal in drei Stunden, eine Stunde am Anfang, eine in der Mitte und eine am Ende) und röste es in einem mittleren Feuer; nimm es dann heraus, pulvere es, tränke es mit Essig und röste es.” Al-Rāzī, 114. *Kitāb al-Asrār*, Sect.3, Part 1A, Proc. 42. Note: Ruska uses the letter *E* to refer to phrases found only in the Escorial manuscript.

[144] Al-Rāzī, 98-99. *Kitāb al-Asrār*, Sect. 2, Part 1, Proc. 2-23.

[145] Ibid., 141,186. *Kitāb al-Asrār*, Sect. 3, Part 1B, Proc. 57; Sect. 3, Part 3, Proc. 23.

[146] “Das Geheimnis bei der Behandlung der Schwefel und der Zarnīche,” Ibid., 112. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 37.

[147] “Dann gehst du damit an einen Ort, wo niemand den Geruch wahrnimmt, in der Wüste oder anderswo (L oder an einen Ort frei von Bewohnern), und gräbst für ihn in der Erde eine Grube und zündest darin ein mittleres Feuer an, setzest den Kessel auf das Feuer und beobachtest, was von Rauch herausgeht.” Ibid., 112. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 37. *L* designates text found only in the Leipzig manuscript.

[148] “. . . im Hause oder in deiner Wohnung oder wo du willst, denn es schadet dir (jetzt) nicht. ” Ibid. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 37.

[149] Labavius, *Alchemie*, Bildteil 7-9.

[150] Faraday, 12, 13-18.

[151] “Nimm stark gelben Vitrol so viel du willst und koche ihn mit ebensoviel Kupfergrün in einem Kupferkessel in dem Vierfachen von Wasser, bis ein Drittel des Wassers weggegangen ist, dann reinige es und laß es fest werden in Bechern in der Sonne. . . ”Al-Rāzī , 222. *Kitāb al-Asrār*, Appendix 1, Proc. 13.

[152]Faraday, 14.

[153] Owen Hannaway, “Laboratory Design and the Aim of Science: Andreas Libavius versus Tycho Brahe,” *Isis* 77 (1986): 586.

[154] Sandra Wilson and Geoff Weir, *Food and Drink Laboratory Accreditation: A Practical Approach* (London: Chapman and Hall, 1995), 43.

[155] Meyerhof, 324. Ruska, *Al-Rāzī’s Buch Geheimnis der Geheimnisse*, 4. According to Meyerhof, “This was the Sāmānid Prince Abū Sālih Mansūr ibn Ishāq, Governor of the Eastern and Southern provinces of Persia, killed in 302 A.H. (925 A.D.).”

[156] Stapleton, “Chemistry in Iraq and Persia,” 318.

[157] Moran, *Andreas Libavius and the Transformation of Alchemy*, 17.

[158] Hannaway, *The Chemists and the Word*, 81.

[159] Lindeboom, 323 .

[160] Ibid., 337.

[161] Ibid., 112-13.

[162] Day, *The Philosopher's Tree*, 2.

[163] Faraday, *The Selected Correspondence of Michael Faraday: Vol. I: 1812-1848*, ed. L. Pearce Williams (Cambridge: Cambridge University Press, 1971), 117.

[164] Day, 67.

[165] Latour, "Give Me a Laboratory," 159.

[166] Faraday, *Chemical Manipulation*, 12, 24.

[167] "Und hütte dich, den Kopf der Flasche zu verschließen, bevor die Feuchtigkeit ausgetrocknet ist; dann sichere ihren Kopf und stopfe im Kessel gesiebte Asche darüber . . . " Ibid., 117-18; *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 50.

[168] Petrus Bonus, 110.

[169] Wilson and Weir, 107.

[170] Al-Rāzī, 84. *Kitāb al-Asrār*, Sect. 1, Proc. 1. Al-Rāzī appears to be the first to use the three-part classification of animal, vegetable, and mineral. See Holmyard, 89. Holmyard also provides a good diagram of al-Rāzī's classification system on page 91.

[171] "Geister, Metalle, Steine, Vitriole, Boraqe und Salze." Al-Rāzī, 84. *Kitāb al-Asrār*, Sect. 1, Proc. 1.

[172] Alessandro Bausani, *The Persians: From the earliest days to the twentieth century* (Florence: Sansoni, 1962; English translation: London: Elek Books Limited, 1971), 86.

[173] "Zweiter Abschnitt. Von der Unterscheidung der guten und schlechten Arten."Al-Rāzī, 84. *Kitāb al-Asrār*, Sect. 1, Part 2.

[174] "Nicht geeignet." Al-Rāzī, 85. *Kitāb al-Asrār*, Sect. 1 Part 2, Proc. 12.

[175] "Eine rote, von reinem Rot, blättrig, is vortrefflich für unser

Werk.” Al-Rāzī, 85. *Kitāb al-Asrār*, Sect. 1, Part 2, Proc. 10.

[176] “Ein Geruch nach gekochten Eiern.” Al-Rāzī, 90. *Kitāb al-Asrār*, Sect. 1, Part 2, Proc 10.

[177] Al-Rāzī, 87, 89. *Kitāb al-Asrār*, Sect. 1, Part 2, Proc. 18-24.

[178] “Wenn mann es durch ein Tuch preßt, darf nicht etwas dem Kuhl (Augenpulver) Ähnliches darin zurückbleiben.” Al-Rāzī, 85. *Kitāb al-Asrār*, Sect. 1, Part 2, Proc. 8.

[179] S. Suzanne Nielsen, *Food Analysis Laboratory Manual* (New York: Springer, 2010), 34.

[180] “Nimm Feile des Goldes, mische mit ihr rotten Zarnīch und fülle es in ein Beutelchen, verlehme es mit Kunstlehm und röste es eine Nacht mit starken Feuer.” Al-Rāzī, 126. *Kitāb al-Asrār*, Sect. 3, Part 1B, Proc. 2.

[181] “Andere Art.” Al-Rāzī, 126. *Kitāb al-Asrār*, Sect. 1, Part 2, Proc. 32.

[182] “Die Erweichnung der Metalle.” Al-Rāzī, 156-57. *Kitāb al-Asrār*, Sect. 3, Part 2B, Proc. 1-4.

[183] Porter, 16.

[184] “Les Vaisseaux de verre font de très grand usage : ils ne changent, n’ajoutent, ni n’ôtent rien aux Corps qu’ils contiennent.” Boerhaave, *Elemens de Chymie*, 882.

[185] “Das Glas. Es gibt verschiedene Arten. . . Das beste davon ist das syrische, weiße. Reine, das dem Bergkristall (Billaur) an Reinheit gleicht.” Al-Rāzī, 87. *Kitāb al-Asrār*, Sect. 1, Part 2, Proc. 26.

[186] Holmyard, 45.

[187] Al-Rāzī, 91, 139, 186. *Kitāb al-Asrār*, Sect. 1, Part 2, Proc. 45; Sect. 3, Part 1B, Proc. 50; Sect. 3, Part 1B, Proc. 22.

[188] Ibid., 210, 219, 190, 222. *Kitāb al-Asrār*, mortar: Sect. 3, Part 7C, Proc. 12, 31, 33; funnel: Sect. 3, Part 3, Proc. 50; Appendix 1, Proc. 13.

[189] “. . .und bewahre es in einer chinesischen Barniyya auf, denn es zerstört (G durchbohrt) das Glas und die Töpferware (E das Gestein). Ibid.,

183. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 51. Ruska suggests that a *barniyya* is a "wide-necked kind of flask of fired clay. " ("eine weithalsige Art von Flaschen aus gebrannten Ton." Ruska in al-Rāzī, *Al-Rāzī's Buch Geheimniss der Geheimnisse*, 60.

[190] "Es steht auf drei Füßen und wird auf einem Untersatz aufgestellt, dessen Wände durchlöchert sind. In der Mitte seines Bodens befindet sie ein Loch, aus dem die Asche herausfällt. In seinem unteren Teile werden Kohlen geschüttet, und das, was verkalkt werden soll, wird darauf gesetzt und in die Kohle eingegraben und mit Kohle zugedeckt. Du stellst ihn hin, wo ihn die Winde treffen. Sein Feuer ist äußerst stark, es verkalkt die Metalle und vereinigt sie und schmelzt sie. " Al-Rāzī, 99. *Kitāb al-Asrār*, Sect. 2, Proc. 23. "Calcines the metals" means that the strong heat transformed the metal into a fine powder. Holmyard, 277.

[191] Libavius, *Alchemia*, 30.

[192] Faraday, *Chemical Manipulation*, 94.

[193] Ibid., 98.

[194] ". . . grabe es dann 40 Tage in Mist ein, so wird es zu reinstem Wasser, reiner als die Träne. " Al-Rāzī, 198. *Kitāb al-Asrār*, Sect. 3, Part 6, Proc. 13.

[195] ". . .und es dann drei Wochen im Mist eigräbst. Es löst sich zu gelbem Wasser ohne Rückstand." Ibid., 202. *Kitāb al-Asrār*, Sect. 3, Part 7A, Proc. 11.

[196] Friedrich Dobler, "Der Firmus als Wärmequelle in der alten Pharmazie," *Pharmaceutica Acta Helvetiae* 32 (1957), 67.

[197] Terence Young, "From Manure to Steam: The Transformation of Greenhouse Heating in the United States, 1870-1900," *Agricultural History* 72 (1998), 586.

[198] Ibid. 586.

[199] Al-Rāzī, 218. *Kitāb al-Asrār*, Sect. 3, Part 7C, Proc. 30.

[200] Libavius, *Alchemia*, 367.

[201] Ibid, 370.

[202] Faraday, *Chemical Manipulation*, 175-77.

[203] Wilson and Weir, 70.

[204] Petrus Bonus, 355.

[205] Al-Nadīm, *Fihrist*, 702.

[206] Al-Rāzī, 83. *Kitāb al-Asrār*, Dedication.

[207] "Davon gibt es vier Arten: Die Erweichung durch die Geister, die Erweichung durch die Salze, die Erweichnung durch die Öle und die Erweichnung durch die Boraqe." Ibid., 155. *Kitāb al-Asrār*, Sect. 3, Part 2, Proc. 1.

[208] "Man muß jedoch aufpassen, daß das Feuer nicht ausgeht (E und die Asche nicht kalt wird, bevor es sich golöst hat und fest geworden ist.)" Ibid., 95-96. *Kitāb al-Asrār*, Sect. 2, Part 2, Proc. 12.

[209] "Dann nimm schwarzes Naft und tue ebensoviel Salmiak dazu und destilliere es; wiederhole damit die Arbeit und achte darauf, daß es sich nicht entzündet." Ibid., 122. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 60.

[210] ". . . tue es in heiße Asche, doch darf diese nicht zu heiße sein, damit die Flasche nicht zerspringt. Ibid., 173. *Kitāb al-Asrār*, Sect. 3, Part 2C, Proc. 11.

[211] Albertus Magnus, *Libellus de Alchemia*, 590.

[212] George Ripley, *Compound of Alchemy*, 19-20.

[213] Petrus Bonus, 113.

[214] "Für Leute, die das Wesen der chymischen Disziplin nicht kennen, klingt alles, was man sagt, geheimnisvoll, auch wenn es in deutlichen, treffenden Begriffen dargelegt wird, die in genugsam [*sic*] Eingeweihten verstehen werden." Libavius, *Alchemia*, XII.

[215] "daß du in nasser Erde, auf die die Sonne nicht fällt, eine Grube gräbst, deren Tiefe zwei Ellen oder mehr, und deren Breit eine Elle beträgt. . . . dann stopfst du die bis zu einem (E zwei) Drittel mit angefeuchtetem reinem Sand." Al-Rāzī, 186. *Kitāb al-Asrār*, Sect. 3, Part 3, Proc 23.

[216] “pulvere es acht Stunden.” Al-Rāzī, 169. *Kitāb al-Asrār*, Sect. 3, Part 2B, Proc. 57. “[nachdem du] beide drei Tage hintereinander auf eine Reibplatte gepulvert hast.” Ibid., 168. *Kitāb al-Asrār*, Sect. 3, Part 2B, Proc. 54.

[217] Holmyard, 52.

[218] Faraday, *Chemical Manipulation*, 155.

[219] Ibid., 161. A *muller* is: “A stone or piece of similar substance, with a flat base or grinding surface used for grinding powders etc. on a slab.” *OED, s.v.* “muller.”

[220] Petrus Bonus, 115.

[221] Al-Rāzī, 177-78. *Kitāb al-Asrār*, Sect. 3, Part 2C, Proc 35.

[222] Lindeboom, 197.

[223] Ibid., 198.

[224] Wilson and Weir, 64.

[225] U.S. Food and Drug Administration, accessed 28 August 2011; available from http://www.fda.gov/Food/GuidanceComplianceRegulatoryInformation/Guidar . U.S. Department of Health and Human Services and U.S. Environmental Protection Agency, accessed 28 August 2011; available from http://www.cfsan. fda.gov/~frf/sea-mehg.html

[226] “denn es schadet dir (jetzt) nicht.” Al-Rāzī, 112. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 37.

[227] “in der Wüste oder anderswo (L oder an einen Ort frei von Bewohnern),” Ibid., 112. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 37.

[228] “hüte deine Hand und deine Nase, denn es ist ein Gift.” Ibid., 118. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc.52.

[229] “denn es ist ein Gift einer Stunde.” Ibid., 167. *Kitāb al-Asrār*, Sect. 3, Part 1B, Proc.49.

[230] “Es ist ein sehr scharfes Wasser, das dir eine kräftige Wirkung ausübt.” Ibid., 183, *Kitāb al-Asrār*, Sect. 3. Part 3, Proc. 9.

[231] Petrus Bonus, 27.

[232] Holmyard, 122-23.

[233] Petrus Bonus, 328.

[234] Faraday, *Chemical Manipulation*, 549.

[235] Ibid., 544.

[236] Ibid., 581.

[237] Latour, *The Pasteurization of France*, 15-16, 20.

[238] Latour, “Give Me a Laboratory,” 166.

[239] Edward O. Wilson, *Consilience*: *The Unity of Knowledge* (New York: Vintage Books, 1998), 58.

[240] Porter, 28.

[241] “[du] nimmst ihn dann jede Stunde heraus und betrachtest (E was an ihm hängen geblieben ist) ,” Al-Rāzī, 109. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 28. “Pulvere dies unter Rösten eine gute Stunde.” Ibid., 131. *Kitāb al-Asrār*, Sect. 3, Part 1B, Proc. 21.

[242] David A. King, “A Survey of Medieval Islamic Shadow Schemes for Simple Time Reckoning,” *Oriens* 32 (1990), 193.

[243] “[du] es mit Senf einige Stunden zerstoßest, bis es schwarz geworden ist.” Al-Rāzi, 100. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 42.

[244] “Jeden Tag drei Stunden, eine Stunde an seinem Anfang, eine in seiner Mitte und eine an seinem Ende.” Ibid., 132. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc 42. “Schüttle es jeden Tag morgens, mittags und abends.” Ibid., 119. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 53.

[245] “[du] erhitzest unter dem Uthāl für jedes Ratl zwölf Stunden lang. ” Ibid., 103. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 16. “Zünde unter der Lampe ein gelindes Feuer an, zehn Stunde lang.” Ibid., 108. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 27.

[246] King, 198.

[247] Meyerhof, 338.

[248] “An einem gelinden Feuer wie die Brutwärme des Vogels.” Al-Rāzī, 108. *Kitāb al-Asrār*, Sect. 3, Part 1C, Proc. 9. “Erhitze ihn in einem mächtigen Feuer, dem Feuer des Ofens der Eisengießer.” Ibdi., 174. *Kitāb al-Asrār*, Sect. 3, Part 2C, Proc. 16.

[249] “Bring ihn an die Sonne . . . in die großtmögliche Hitze.” Ibid., 174. *Kitāb al-Asrār*, Sect. 1, Part 2, Proc. 45.

[250] “Mit gelindem Feuer.” Ibid., 94. *Kitāb al-Asrār*, Sect. 3, Part 7B, Proc. 2. “[du] zündest darin ein mittleres Feuer an.” Ibid., 112. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 37. “Mit starkem Feuer.” Ibid., 196. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 64.

[251] Examples: “Damit ihr Feuer von allen Seiten wirke.” Ibid., 191. *Kitāb al-Asrār*, Sect. 3, Part 4, Proc. 2. “darunter geheizt.” Ibid., 195. *Kitāb al-Asrār*, Sect. 2, Part 2, Proc. 9.

[252] “Der Unterschied zwischen dem Feuer der Röstung des Eweichens und dem Feuer zur Röstung des Verfestigens ist daß das Feuer der Röstung der gelösten Dinge ein mächtiges Feuer ist, während das Feuer der Röstung des Erweichens ein gelindes Feuer ist.” Ibid., 168. *Kitāb al-Asrār*, Sect. 3, Part 2B, Proc. 52.

[253] Libavius, *Alchemie*, 33-36. Kapitel XIV, “Über die Feuerkunde.”

[254] Boerhaave, *Elemens de Chymie*, 158-59.

[255] Lindeboom, 294-95.

[256] Faraday, *Chemical Manipulation*, 136, 140.

[257] Ibid., 103.

[258] Bausani, 90.

[259] Ibid., 85.

[260] Ruska, *Al-Rāzī’s Buch Geheimnis der Geheimnisse*, 64.

[261] “Dann nimm Vitriol, Kuperfurgrün, Zinnober und Salmiak, von jedem einzelnen eine Ūqia, gieße ein Ratl destillierten Essig darauf und vergrabe es im Mist.”Al-Rāzī, 128. *Kitāb al-Asrār*, Sect. 3, Part 1B, Proc. 9.

[262] Ruska in al-Rāzī, *Al-Rāzī's Buch Geheimnis der Geheimnisse*, 64.

[263] Bausani, 85.

[264] "Nimm Feile des Kupfers was du willst,amlagamiere sie mit drei ihresgleichen Quecksilber, füge ebesoviel Alaun wie Kupfer hinzu und so viel wie die Hälfte des Alauns Salmiak." Al-Rāzī, 187. *Kitāb al-Asrār*, Sect. 3, Part 1B, Proc. 44.

[265] Antoine Laurent Lavoisier and Robert Kerr, *Elements of Chemistry* (Edinburgh: G.G. and J. J. Robinsons, 1790), 296.

[266] "An der untersten Stelle des oberen Bechers ist ein Loch; so groß, daß der kleine Finger hindurchgeht." Ibid., 195. *Kitāb al-Asrār*, Sect. 3, Part 6, Proc. 2.

[267] "So daß der Kopf einer Packnadel durchgeht." Ibid., 109. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 28. "Und gehst [du] mit einer Besprengung von Öl darüber weg, so daß von seiner Oberfläche keine Stelle übrig bleibt, die das Öl nicht berührt hat." Ibid., 100. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 6.

[268] DPDx – CDC Parasitology Diagnostic Web Site, available from: http://www.dpd.cdc.gov/dpdx/html/PDF_Files/Malaria_procedures_benchaid. accessed 28 August 2011.

[269] Faraday, *Chemical Manipulation*, 81.

[270] Ibid., 524.

[271] End point: "a point marking the completion of a process or stage of a process; especially: a point in a titration at which a definite effect (as a color change) is observed (Merriam-Webster online Dictionary s.v. end point.) http://www.m-w.com/dictionary/endpoint, accessed 13 August 2007. Here, I use the term in the first, more general, sense of the definition.

[272] Faraday, *Chemical Manipulation*, 603, 273.

[273] Mozayani and Noziglia, 98.

[274] Israel Davidsohn and Benjamin Wells, eds., *Todd-Sanford*

Clinical Diagnosis by Laboratory Methods (Philadelphia: W.B.Saunders, 1962), 453. This titration from the mid-twentieth century is a manual method, but even modern automated laboratory testing commonly detects color change as the end point.

[275] "Bis es schwarz geworden ist."Al-Rāzī,100. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 14. "Wenn es [der Rauch] aber weiß herauszukommen beginnt." Ibid.,112. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 37. "Rot wie Leber." Ibid.,140. *Kitāb al-Asrār*, Sect.3, Part 1A, Proc. 24. "rot wie Blut." Ibid.,151. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 25. "Weiß wie der Schnee." Ibid., *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 44.

[276] "Bis es wie Schaum wird." Ibid.,133. *Kitāb al-Asrār*, Sect. 3, Part 1B, Proc. 25. "Wie Honig." Ibid., 205. *Kitāb al-Asrār*, Sect. 3, Part 7B, Proc. 6. "Wie der Teer." Ibid., 213. *Kitāb al-Asrār*, Sect. 3, Part 7C, Proc. 15. "Bis es (G dir gefällt und) ein unfühlbares weißes Streupulver geworden ist." Ibid., 130. *Kitāb al-Asrār*, Sect. 3, Part 1B, Proc. 13. "Rub a piece of white marble of about 400 grains in weight into an impalpable powder." Faraday, *Chemical Manipulation*, 597.

[277] Examples: "Bis der Rauch (E ganz) herauskommt. Ibid., 160, *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 52. "Bis sein Rauch aufhört." Ibid., page 198. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 24.

[278] "Du erhälst ein unfühlbares Pulver, das auf der Spitze der Zunge schmilzt." Ibid., 154. *Kitāb al-Asrār*, Sect. 3, Part 1C, Proc. 25. Faraday, *Chemical Manipulation*, 168.

[279] "Bis es wie Wasser destilliert und sich durchaus nicht Feuer an ihm entzündet." Ibid., 221. *Kitāb al-Asrār*, Appendix 1, Proc. 7.

[280] "Mache das Naft zu Teig mit ebensoviel Salmiak und destilliere es. Tue dies mit ihm, bis es wie Wasser destilliert und sich durchaus nicht Feuer an ihm entzündet." Ibid., 221. *Kitāb al-Asrār*, Sect. 3, Proc. 9.

[281] Ruska states that the exact construction of the tablet is not clear. Ruska in al-Rāzī, *Al-Rāzī's Buch Geheimniss der Gerheimnisse*, 55.

[282] "Das Kennzeichen davon ist, daß du von ihm auf eine erhitze Probetafel von Silber streust, es diese nicht schwärtzt und über sie läuft und

nicht raucht." Al-Rāzī, 108. *Kitāb al-Asrār*, Sect. 3, Part 1A, Proc. 25.

[283] "Pulvere es und wäge es und wiederhole das Verfahren damit, bis es unverändert auf einem Gewicht stehen bleibt, das sich nicht vermindert." Ibid., 154. *Kitāb al-Asrār*, Sect. 3, Part 1C, Proc. 27. The two other examples are: Ibid., 190. *Kitāb al-Asrār*, Sect. 3, Part 3, Proc. 31. Ibid., 211. *Kitāb al-Asrār*, Sect. 3, Part 7C, Proc. 13.

[284] "Dann wäge den Rest des Wassers, damit du weißt, was darin zugenommen hat." Ibid., 211. *Kitāb al-Asrār*, Sect. 3, Part 7C, Proc. 13.

[285] Faraday, *Chemical Manipulation*, 593.

[286] Al-Rāzī, 6.

[287] "Quel est l'auteur de ce petit traité?" Hartwig Derenbourg in Ruska, *Al-Rāzī's Buch Geheimniss der Gerheimnisse*, 24.

[288] Wilda C. Anderson, *Between the Library and the Laboratory: The Language of Chemistry in Eighteenth-Century France* (Baltimore: The Johns Hopkins Press, 1984), 14, 30, 159. (The French translation is Anderson's.)

[289] A. Rupert Hall, *The Scientific Revolution, 1500-1800: The Formation of the Modern Scientific Attitude* (London: Longmans, Green and Co., 1954; 2d ed., 1962), 310.

[290] William H. Brock, 33.

[291] Bruno Latour, *Science in Action: How to Follow Scientists and Engineers through Society* (Cambridge: Harvard University Press, 1988), 21, 24.

[292] William Newman and Lawrence M. Principe, *Alchemy Tried in the Fire: Starkey, Boyle, and the Fate of Helmontian Chymistry* (Chicago: The University of Chicago Press, 2002); David Gooding, *Experiment and the Making of Meaning: Human Agency in Scientific Observation and Experiment* (Dordrecht, Netherlands: Kluwer Academic Publishers, 1990); Owen Hannaway, "Laboratory Design and the Aim of Science, 584-610; Marcos Martinón-Torres, "The Tools of the Chymist: Archeological and Scientific Analyses of Early Modern Laboratories," in *Chymists and Chymistry: Studies in the History of Alchemy and Early Modern Chemistry*,

ed. Lawrence M. Principe (Sagamore Beach, Mass.: Watson Publishing International, 2007), 149-63.

[293] Pamela Smith, *The Business of Alchemy: Science and Culture in the Holy Roman Empire* (Princeton, NJ: Princeton University Press, 1994).

[294] "There are now over 100 operational laboratory accreditation programs worldwide. The oldest seems to be a German program for the accreditation of organizations that test gas and water distribution equipment. It was established in 1859 and currently has 2 accredited laboratories." Malcolm R. Bell, "Laboratory Accreditation and Quality System Accreditation—A Merging of the Ways," in Schock, ed., *Accreditation Practices*, 120.

[295] Andrew Cunningham and Perry Williams, *The Laboratory Revolution in Medicine* (Cambridge: Cambridge University Press, 1992), 1.

[296] Kurt Vonnegut, *Slaughterhouse Five or The Children's Crusade: A Duty-Dance with Death* (New York: Dell Publishing Co., 1969. The story begins: "Listen: Billy Pilgrim has become unstuck in time."

[297] For example, see the divisions in the *Todd-Sanford* chapter on syphilis testing: reagents, equipment, and tests. Davidsohn and Wells, 839-877.

[298] Kuhn, 25.

[299] This translation uses Ruska's notation for referring to the four manuscripts he used: L for Leipzig, G for Göttingen, E for Escorial, K for Lucknow.

[300] Ruska explains in his introduction that al-Rāzī had a known difference of opinion with al-Kindī and Muhammad Ibn al-Lait. Al-Kindī, who had already died (in 873 C. E.), was a recognized opponent to alchemy. Julius Ruska, *Al-Rāzī's Buch Geheimnis der Geheimnisse: Quellen und Studien zur Geschichte der Naturwissenschaften und der Medizin* Band 6 (Berlin: Verlag von Julius Springer, 1937), 9.

[301] "Any of various sulphates of metallic elements; spec. ferrous sulphate." *Oxford English Dictionary*, s.v. "vitriol."

[302] "A hydrated sodium borate . . . which is a white efflorescent

crystalline solid found as a native deposit or prepared from other minerals." *OED*, s.v. "borax."

[303] Ammonium chloride. *A German-English Dictionary for Chemists*, 1934 ed., s.v. "sal ammoniac." Ruska uses the word *salmiak*. Ruska, 39. See also: Paul Kraus, "Julius Ruska," *Osiris* 5 (1938), 14-15 for explanation of salmiac compared to sal ammoniac.

[304] "A sulphide of arsenic, orpiment, realgar". *OED*, s.v. "sulphide of arsenic." Ruska states that in Latin alchemic texts this mineral is called arsenic (*arsenicum*). Since this was a sulfide of arsenic and not arsenic in its modern form, Ruska retained the term *zarnīch* as more appropriate. Ruska, 40.

[305] Holmyard describes a *khar sini* or "Chinese iron" from Jabir which could be polished to a shiny mirror-like surface. E. John Holmyard, *Alchemy* (Middlesex, England: Penguin Books, 1957; reprint, New York: Dover Publications, 1990), 80. Stapleton suggests it may have been zinc. H. E. Stapleton, R. F. Azo, and M. Hidayat Husain, "Chemistry in Iraq and Persia in the Tenth Century A.D.," *Calcutta: Memoirs of the Asiatic Society of Bengal* 8 (1927), 321, footnote 3.

[306] "Orig. a metallic sulphide (as pyrites) or similar compound. . ." *OED*, s.v. "marcasite."

[307] Al-Rāzī would have meant manganese ores when he used the word *mağnīsiyā*, according to Ruska. Ruska, 36. However, the dictionary definition of magnesia is of interest: "Alchemy. A mineral supposed to be one of the ingredients of the philosopher's stone. . . " *OED*, s.v. "magnesia."

[308] Ruska uses the word *daus*, and suggests that "*Daus* must be a local Persian name for iron ore." Ruska, 43.

[309] Tutia: Zinc ores. Ibid., 44.

[310] Al-Rāzī uses the word *lāzward* which can be translated as azurite. Stapleton classifies it as azurite (321) and translates it as lapis lazuli (370). Stapleton, 321, 370. Lapis lazuli, which derives from the Persian *lāzward*, is defined as "A blue semiprecious stone composed chiefly of a sulphur-containing silicate of soldium and aluminium. . ." *OED*, s.v. "lapis lazuli."

[311] "A monoclinic basic copper carbonate, usu. occurring as bright-green masses of fibrous aggregates, which is used ornamentally and as an ore of copper." *OED*, s.v. "malachite."

[312] Ruska defines this mineral as arsenic derived from smelting arsenic-laden silver ore. He cites a passage from al-Rāzī describing its efficacy as a rat poison. Ruska, 45.

[313] A sulphide of antimony used in powdered form as an eye makeup. Ibid., 45-46.

[314] This talc referred to mica and to the transparent plates that split off some kinds of gypsum. Alchemists liked the way mica made their elixirs glitter. Ibid., 46.

[315] "Hydrated calxium sulphate, a soft mineral that occurs as colourless, white, or grey monoclinic prismatic crystals in many sedentary rocks and is used in making plaster of Paris and fertilizer." *OED*, s.v. "gypsum."

[316] Bakers in Cairo coated the surface of bread with a watered-down borax to produce a hard shiny brown crust in the oven, a practice which Ruska compares to the similar use of potash to coat pretzel sticks before baking. Ruska, 47.

[317] "Native hydrous sodium carbonate . . . occurring chiefly in solution and in evaporative residues." *OED*, s.v. "natron."

[318] Al- Rāzī later explains that this is an artificial borax. See al-Rāzī, *Geheimnis der Geheimnisse,* in Ruska, 89 and this translation, 11.

[319] *Zarāwand* refers to a river in Armenia, the source of this borax. Stapleton, 348, footnote 3.

[320] Ruska uses the term *tabarzad salt*. "The word *tabar-zad* means 'ax-split', referring generally to large crystals of mountain salt. . ." Ruska, 48.

[321] Stapleton states that Andarānī salts includes a red rock salt "out of which plates and dishes were turned on a lathe." Stapleton, 322.

[322] Ruska uses the word *qali*. Holmyard's chart uses "qali (soda)". Holmyard, 91. Note: The English word *alkali* is derived from *qali* or *kali*

which is defined as: “soda ash = alkali ; vegetable alkali, potash.” *OED* s.v. “kali.”

[323] Ruska uses *nura*. Stapleton translates this as *salt of lime*. Stapleton, 347.

[324] “Zarnich” is translated as “arsenic sulphide” in Stapleton, 321.

[325] “A resin obtained from either of two coniferous trees, *Tetraclinis articulate* of NW Africa and . . . *Callitris endlicheri* of Australia, which is used in the preparation of varnishes and (formerly) for blotting ink.” *OED*, s.v. “sandarac.”

[326] Daus is translated as “iron oxide” in Holmyard, 91.

[327] The tenth-century geographer Ibn Hawḳal reports that Işţakhr (Persepolis) was a source of both iron and mercury. G. Le Strange, *The Lands of the Eastern Caliphate: Mesopotamia, Persia, and Central Asia from the Moslem conquest to the time of Timur* (London: Frank Cass & Co., 1905; reprint, New York: Barnes & Noble, 1966), 294-95.

[328] Kerman is a city in southeastern Iran.

[329] Bergkristall: rock crystal (transparent quartz). *German-English Dictionary for Chemists*. Holmyard points out that the art of glass-blowing originated in Syria in the first century B.C., making glass containers available in a variety of shapes and sizes. Holmyard, 45.

[330] These will be referred to by their colors throughout this translation. According to Karpenko and Norris, these names are derived from Arabic transliterations of the Greek: *chalcathon*, *chalchitis*, *colcothar*, and *sory*. They were derivatives of copper and iron sulfates of various colors. Vladimir Karpenko and John A. Norris, “Vitriol in the History of Chemistry,” *Chemické Listy* 96 (2002), 998-99.

[331] Ruska translates *zinǧār* as *Kupfergrün*. Ruska, 51. Stapleton translates *zinǧār* as *copper acetate*. Stapleton, 323, 373.

[332] Ruska states that a dirham is four grams. Ruska, 64.

[333] Ruska’s footnote: “E ‘and to this belongs the tinkar, that is a borax and a salt, made from animal fat.’” (“E ‘und zu ihm gehört der Tinkar, das ist ein Boraq und ein Salz, gewonnen aus (mit) Fett der Tiere.’”). Al-

Rāzī, 89. Unless otherwise stated all translations are my own.

[334] Ruska's footnote: "The text about borax deviates so strongly that I will share it here in its entirety: 'The borax of bread is in white hard pieces; the natron is better than it. The borax of the goldsmiths is white and resembles the efflorescence that forms at the base of a wall. The borax from Zarāwand pounds into red and is the best kind.'" ("Der Text über den Boraq weicht in L so stark ab, daß ich hier vollständig mitteile: ‚Der Boraq des Brotes, das sind weiße, harte Stücke; das Natrūn ist besser als er. Der Boraq der Goldschmiede ist weiß und gleicht den Ausblühungen, die sich an den Fundamenten der Mauern bilden. Der Boraq von Zarāwand schlägt ins Rote und ist die beste Art.'" Al-Rāzī, 89.

[335] Ruska suggests that this may be a beaker or drinking vessel. Ruska, 48, footnote 5.

[336] The *Kitāb al-Asrār* mentions ashes of oak four times. Stapleton points out that the fifth-century B.C.E. Greek physician Democritus uses oak ashes as the source of a mild alkali, which is one indication of Greek connections for al-Rāzī's science. Stapleton, 376.

[337] "Calcination, conversion of a metal or other mineral to the state of a fine powder, typically by means of heat." Holmyard, 276 (glossary).

[338] "Za'farān des Eisens," Ruska, 50. Stapleton suggests that it may be iron rust. Stapleton, 323. A dictionary definition provides more clarification for iron saffron or crocus of iron: "Ferric oxide obtained as a reddish or purplish powder by calcination of ferrous sulphate and used for polishing metal; any of the various red or yellow powders obtained from metals by calcination." *OED*, s.v. "crocus."

[339] This is the only mention of this substance. Ruska states the meaning is not certain. Ruska, 50.

[340] Ruska uses *martak*. See Ruska, 50. Stapleton defines it as: "Lead Oxide, PbO, made by blowing air on to heated lead." Stapleton, 323.

[341] I have found no reference to translate the last five substances. They are not mentioned in the rest of the text.

[342] "Fuse or melt (ore, etc.) in order to extract the metal; obtain

(metal) by this process." OED, s.v. "smelt".

[343] Ruska translated the word *māšiq* as *Treibhammer* and the word *miksar* or *mukassir* as *Zerbrecher*. He suggests the latter was probably a goldsmith's tool to break hard materials up before grinding them. Ruska, 55. I could not locate English equivalents to these words, so I have used *hammer* and *crusher* to approximate their meaning.

[344] Ruska's footnote: "Closing words in L: 'Some of them are at the goldsmiths and others well-known, some are unfamiliar; we will explain what is unfamiliar.'" ("Schlußworte von L: ‚Einige davon sind bei der Goldschmieden und anderen bekannt, einigen sind unbekannt; wir werden erläutern, was unbekannt ist." Ruska, 92.

[345] Ruska's footnote: " Here the L breaks up." ("Hier bricht L ab.") Ruska, 92.

[346] Ruska's translation trails off, presumably reflecting a break in the text at this point.

[347] Ruska's translation uses the obsolete coin *Heller* as a measure of relative size. It can also be translated "farthing." *German-English Dictionary for Chemists*, 2d edition, s.v. "Heller."

[348] Tannūr: Large baker's oven. Stapleton, 325.

[349] Curcurbit is defined as "flask or 'gourd' forming lower part of a still." Holmyard, 276.

[350] Alembic: "[Old French from medieval Latin *alembicus* from Arab, *al-'anbīk*, the still cap from Greek *ambix* . . .] An obsolete kind of still consisting of a gourd-shaped vessel and a cap having a long beak for conveying the products to a receiver; the cap of such a still." OED, s.v. "alembic."

[351] Blind alembic: See diagram on p. 68. Ruska.

[352] Aludel: "[Old French *alutel*, later *aludel*, from Spanish from Arab, *al-'utāl* the sublimation-vessel . . .] A pear-shaped earthenware or glass pot, open at both ends so that a series could be fitted one above another, formerly used in sublimation." OED, s.v. "aludel."

[353] Grinding plates: Ruska uses the word "Reibplatte," and points

out that it was probably a flat hard stone, because al-Rāzī only specifies a concave grindstone once in the text. Ruska, 55. This is found in paragraph 27 of “The Procedures with Hair.”

[354] *Tābistān* in Ruska, described by Stapleton as: “brasier or chafing-dish, similar to that used by food-hawkers, the glowing charcoal being contained in a tray on top of the oven.” Stapleton, 325.

[355] *Selbstbläser* in Ruska, described by Stapleton as: “a stove with perforated sides, half-filled with charcoal, and mounted on three legs – in which the receptacle containing the substances to be calcined or brought into combination was placed.” Stapleton, 325.

[356] “The action or process of subliming or converting a solid substance by heating directly into a vapour which resolidifies on cooling; the state of being so vaporized.” *OED*, s.v. “sublimation.”

[357] Ruska’s translation is *kürbis*. Ruska, 109. Stapleton translates it into English as *cucurbit*. Stapleton, 381.

[358] “Sharp waters” refer to strong solvents used in many of the procedures. These are reagents mixed in the laboratory. See pages 135-41 for the chapter on making them.

[359] Ruska describes *birām* as a white stone which is used to make kettles, pans, beakers, and other items which might otherwise be made of glass. Ruska, 61.

[360] Ruska adds a footnote stating “K Mist, E trochenen Mist,” i.e. the Lucknow manuscript says “dung” and the Escorial manuscript says “dry dung.” Ruska, 110.

[361] The question mark is in Ruska’s text.

[362] Stapleton translates *Uthāl* as *aludel*. The aludel is made by spreading clay in a mold of ashes, which have been shaped by the impression of another aludel. Stapleton, 356.

[363] Ruska uses the word *dauraqa* in the text, and compares it to a *burma*. Ruska, 61. Stapleton defines *burma* as “a large vessel used in Khurāsān, made out of stone.” Stapleton, 362.

[364] Wilson uses a passage from *A Book of the Twelve Waters*,

ascribed to al-Rāzī, to illustrate that the word *water* was used for any liquid at this time, since there was no broad term for fluids in general. W. J. Wilson, "An Alchemical Manuscript by Arnaldus de Bruxella," *Osiris* 2 (1936): 298-99.

[365] Ruska's translation uses the German verb *ersticken* for this process. In his discussion of the Lucknow manuscript, he quotes a letter in which H.E. Stapleton explains that the Arabic term refers to "the process by which a substance is volatized and confined ('strangled') in the neck of a phial." Ruska, 20.

[366] *Eibisch* is here translated "the mallow herb." "A shrubby herb, *Althea officinalis*, of the mallow family, which grows in brackish ditches and has ovate leaves, pale pink flowers, and a mucilaginous root." *OED*, s. v. "marshmallow."

[367] Ruska's translation for *durğ* is *Kapsel*, which can also be translated *saggar*. The definition is: "A protective case of baked fireproof clay in which fragile ceramic wares are enclosed while being fired in a kiln; any case used to protect objects in a furnace." *OED*, s.v. "saagar."

[368] Calcination is defined as: "conversion of a metal or other mineral to the state of a fine powder, typically by means of heat." Holmyard, 276.

[369] Amalgamate: "Chemistry. a. verb trans. Soften by combining with mercury; alloy with mercury." *OED* s.v. "amalgamate." Amalgamation: "The action or process of amalgamating; the state of being alloyed with mercury." *OED* s.v. "amalgamation."

[370] Gall: cell tissue in plants rich in resin and tannic acid.

[371] Ratl: 360 grams. Ruska, 64.

[372] Ruska's footnote: "That is to say that the walls of the flask look like a metal mirror." "Damit soll wohl gesagt sein, daß sich an der Wand der Flasche ein Metallspiegel zeigt." Ruska, 104.

[373] Reagent preparation for "virgin's milk" is in paragraph 40 of this section.

[374] Calcination used heat to reduce a substance to a powder, which was then its *calx*. Holmyard explains that this might or might not change the composition of the calcined matter, i.e. calx of gold was still a metal, but calx of lead is lead oxide, a "yellowish-brownish powder of a non-metallic nature." Holmyard, 45.

[375] Ūqia: A ratl is divided into 12 ūqia (ounces) so that one ounce is 30 grams. Ruska, 105.

[376] Preparation is in Section B, "The Calcination of Metals," paragraph 58. This is a solution of calcium polysulfide. Stapleton, 391.

[377] The vinegar, which was prepared earlier in this procedure.

[378] Comment in brackets is Ruska's and appears to relate to the Escorial reference to tin earlier in this sentence. Ruska, 108.

[379] Where Ruska has said *nuqra*, I have used *powder*. Ruska's commentary says that usually there is no doubt that it means powder and that it may be considered another word for elixir. Ruska, 76-77.

[380] *Martak*, see "What One Must Know About Substances," paragraph 47. Preparation of "water from lead oxide" follows in paragraph 34 of the current section.

[381] Ruska uses *martak* in the title of this procedure and *murdāsanǧ* as the main ingredient. Ruska, 111. According to Stapleton, they are both lead oxide. Stapleton, 353.

[382] Ruska states that *zubd al-bahr* or *zabad al-bahr* may be understood as "butter" or "sea foam." He suggests it may possibly mean "foamy borax" ("schaumigen Boraq"). Ruska, 52.

[383] Stapleton describes *mashaqūiniyā* as a salt-like drying substance used in glassmaking. Stapleton, 352.

[384] This is the only mention of medicines in the *Kitāb al-Asrār*.

[385] Ruska's footnote describes *anzarūt* as "a kind of gum" ("eine Gummiart"). Ruska, 112.

[386] Ruska's commentary states that the description "virgin's milk" was used as a symbolic name for mercury and other substances in Greek

texts. It took on additional meanings in the later medieval alchemic writings under the Latin phrase “virgineum lac.” Ruska, 67.

[387] Regarding this parenthetical phrase, Ruska’s footnote states: “writer’s addition” (“zusatz des Schreibers”). Ruska, 113.

[388] Instructions for making this strong solvent are in Part Three, “Dissolving Spirits and Softened Calx and Borax and Salt,” paragraph 3.

[389] Reagent preparation for “virgin’s milk” is in Section Three, “About the Individual Parts of the Procedures,” paragraph 40.

[390] Ruska uses the word *barniyya*. In his commentary he suggests that it is a wide-necked baked clay flask. Ruska, 60.

[391] See Part Three, “Dissolving Spirits . . . ,” paragraph 3.

[392] “A gum resin from Arabia and Iran, having the form of yellow or red grains.” *OED*, s.v. “sarcocolla.”

[393] “An acrid gum resin with a strong smell like that of garlic, obtained from certain Asian plants of the umbelliferous genus *Ferula*, and used in condiments. Also a plant yielding this.” OED, s.v. “asafoetida.”

[394] “Lead monoxide, PbO, a toxic red or yellow solid prepared by oxidation of lead in air and used as a pigment and in making glass and ceramics. Also litharge of lead. . .Any of various impure ores or mixtures containing lead monoxide.” *OED*, s.v. “litharge.”

[395] Amalgam: “*CHEMISTRY*. Orig. a soft mass formed esp. by combination (of gold, etc.) with mercury. Now any alloy with mercury.” *OED*, s. v. “amalgam.”

[396] Ruska’s footnote: “Therefore confers on it superior qualities to those that natural metals possess.” (“D.h. verleiht ihnen bessere Eigenschaften, als sie das natürliche Metall besitzt.”) My note: This is an allusion to the transmutation debate in which al-Rāzī was very engaged. It is also an unusual deviation into opinion for the *Kitāb al-Asrār* which for the most part is rather detached.

[397] Ruska translates *zinǧār* as *Kupfergrün*. Ruska, 51. Stapleton translates *zinǧār* as *copper acetate*. Stapleton, 323, 373. The German

Chemistry Dictionary defines *Kupfergrün* as copper green or verdigris. I have chosen to use copper acetate for readability, in spite of the possible anachronism of choosing this more modern term.

[398] This parenthetical question is in Ruska's translation.

[399] The preparation is in Section B, "The Calcination of Metals," paragraph 58. This is a solution of calcium polysulfide. Stapleton, 391.

[400] Reference to paragraph 42 above. This procedure includes many steps of preparation, even in the first sentence, and then builds on them.

[401] Cinnabar: "Native mercury sulphide, a bright red hexagonal mineral which usu. occurs in massive form and is the only important ore of mercury; this mineral is used as a pigment, vermilion." *OED.*

[402] Stapleton calls this procedure for *Zād al-ragwa*, "Solution of Calcium Polysulfide." Stapleton, 391.

[403] Ruska suggests that the word *ra's*, which meaning "head" or "beginning," may mean an elixir that is sufficient to change color, but has not reached its highest potency. "Dann muß *ra's*, pl. *ru'ūs* 'Kopf' oder 'Anfang' die technische Bezeichnung für ein Elixir sein, das zwar nicht den höchsten Wirkungsgrad erreicht hat, aber doch schon Silber in beständiges Gold unzuwandeln vermag." Ruska, 77.

[404] Note: this is the first mention of a glassmaker's oven.

[405] First mention of this mortar.

[406] Instructions for this reagent are in Section Three, "The Calcination of Metals," paragraph 58. This is calcium polysulfide, per Stapleton, 391.

[407] The verb in this clause is missing.

[408] This is the first direct reference to weighing, and appears to indicate that there is a balance in the laboratory.

[409] *Rū'us* is the plural of *ra's*, mentioned earlier, which Ruska describes as an elixir that effects color change, but is not the fullest potency. Ruska, 77.

[410] First direct reference to storing something made in the

laboratory.

[411] Ruska defines the *mārwadiyya* as a “rosewater bottle.” Ruska, 59.

[412] Sea foam: see footnote 84.

[413] Probably an instruction to choose a product from paragraphs 42-44.

[414] Ruska’s footnote: “That is, a poison, that kills within an hour.” (D.h. ein Gift, das in einer Stunde tötet.”)

[415] Probably referring to section 53 above.

[416] Ruska’s footnote: “G *zubd al-baqr* ‘cowbutter’, [sic] L *zabad al-baqar* ‘foam of cow’.” (“G *zubd al-baqr* ‘Kuhbutter, [sic] L *zabad al-baqar* ‘Schaum der Kuh’.” See also footnote 83.

[417] This proportion is not clear: “Vermähle mit dem eins sechs Quecksilber.” Al-Rāzī, 173.

[418] Uschnan: “Five-fingered cabbage.” See the section on vegetable matter.

[419] Al-Rāzī defines qalqatār as yellow vitriol on page 10, so the repetition in this listing is unclear.

[420] Science historian Gerard Heym suggests that *grauhara* or *jauhar* is a word for elixir or essence which is more potent than *ra’s*. “Therefore,” he states, “we have here a new term for the ‘lapis philosophorum.’” Gerard Heym, “Al-Rāzī and Alchemy,” *Ambix* 1 (1938), 190. Al-Rāzī does not mention the philosopher’s stone, but a note in Latin in the front of the Escorial manuscript refers to the “lapis philosophorum.” The unknown author of this note may have been an owner or perhaps a reader of the book.

[421] Ruska’s footnote for *bustūqa* states, “a water jug according to Wahrmund.” (Nach Wahrmund ein Wasserkrug.”)

[422] Unslaked means not hydrated. To slake lime is to hydrate it “to produce calxium hydroxide”. *OED*, s.v. “slake.”

[423] Stapleton labels this procedure “Impure Solution of Ammonia.” Stapleton, 392.

[424] Colocynth: “The bitter apple, *Citrullus colocynthis*, a plant the the gourd family, whose pulpy fruit furnishes a bitter purgative drug.” *OED*, s. v. “colocynth.” Al-Rāzī also describes administering colocynth to his patients in his massive medical work, *Hāwī*: “He then drank the pulp of colocynths in great quantity and was healed.” Max Meyerhof, “Thirty-three Clinical Observations by Rhazes (Circa 900 A.D.),” *Isis* 23 (Sep 1935), 347.

[425] Stapleton suggests that this procedure, which uses seven salts, “may be explained as a primitive method of obtaining Hydrochloric acid.” Stapleton, 333.

[426] Stapleton’s description: “Solution of Caustic Soda and Ammonia.” Stapleton, 392.

[427] A rare reference to storage. Ruska suggests that a *barniyya* is a “wide-necked kind of flask of fired clay.” (“eine weithalsige Art von Flaschen aus gebrannten Ton.” Ruska, 60.

[428] Asafoetida: “An acrid gum resin with a strong smell like that of garlic, obtained from certain Asian plants of the umbelliferous genus *Ferula*, and used in condiments.” *OED*, s. v. “asafoetida.”

[429] Alkekengi: “An ornamental plant, *Physalis alkekengi*, native to southern Europe and Asia, bearing red berries enclosed by an inflated red calyx. Also called Chinese cherry, winter cherry, and other names.” *OED*, s.v. “alkekengi.”

[430] Wolf’s milk is a plant exudate obtained from spurge. Spurge: “Any of numerous plants constituting the genus *Euphorbia* . . . which exude an acrid milky juice with purgative properties. . .” *OED*, s.v. “spurge.”

[431] According to Ruska, *sarug* is a medium used for a watertight coat or seal, similar to potter’s clay. It may have been a cement-like compound of sand and lime or a mixture of gypsum and ash. See Ruska, 61.

[432] According to Ruska, the *dann* was a large-bellied wine jug, whose lower section was buried in the earth. Ruska, 59.

[433] Ruska states that *karafs* was translated as *celery* (*apium*) in

Latin, but a slight vowel variation might make it *cotton*, In any case, he says its function in this procedure is unclear. He suggests that s*irdāb* in this context is a cold- or ice-cellar. Ruska, 68, 60. Stapleton translates *karafs* as “parlsey.” Stapleton, 334.

[434] Heym states that *nafs*, which literally means *soul*, refers to “a substance that rises when the distilled water begins to change colour.” Recognizing this stage would therefore require close observation of the liquid during the distillation process. Heym, 190.

[435] Note that the following procedures utilize the techniques of softening, dissolving, and solidifying which have now been explained.

[436] Earlier chapters covered sublimation of mercury, sal ammoniac, sulfide of arsenic, and sulfur, all of which are classified as *spirits*. This chapter introduces the sublimation of stones and metals.

[437] The question mark is in Ruska’s translation.

[438] For the properties contributed by sulfide of arsenic, see page 27. Yellow sulfide of arsenic is used for whiteness, i.e. the color of silver. Chapter III has the procedures for handling sulfur and sulfide of arsenic, and paragraph 40 in that chapter gives a method for sublimating sulfide of arsenic with mercury.

[439] This is a rare reference to sources in the Kitāb al-Asrār. Unfortunately, the story is not in this text.

[440] Daus is an ore of iron, described on page 5, where al-Rāzī states that the best is from Istahr.

[441] Ruska’s footnote: “A sixth [of a] dirham.” (“Ein sechstel Dirham.”). Ruska, 199.

[442] Warning against using the wrong amount of arsenic sulfide by confusing two procedures.

[443] Stater: “1. An ancient weight equal to half an ounce. 2. Any of various ancient coins, esp. a gold coin or daric of Persia, or a gold or silver coin of ancient Greece.” *OED*. This term occurs twice in the *Kitāb al-Asrār*, here and later in the procedure for purification of borax in the Chapter of Rarities.

[444] Note there are three main steps in this procedure, all using processes that have been explained previously. It requires planning to have enough liquid left for part three.

[445] In accordance with al-Rāzī's threefold division into animal, vegetable, and mineral, this is the end of the longest section – the minerals or earthy substances.

[446] The word used here for "essence" is *ǧauhara*.

[447] First reference to a candle. The introduction of a different kind of heat may indicate a different source for the procedure or may be a variation between the manuscripts. Ruska's footnote states the reference is uncertain.

[448] Both this procedure and the preceding one use the word *ǧauhar*, which can also be translated "elixir."

[449] Ruska's commentary states: "colored Egyptian melted glass (*mīnā*) was used to generate the desired colors." (Zur Erzeugung der gewünschten Farben warden farbige ägyptische Glasschmelzen (*mīnā*) zugesetzt.") Ruska, 46.

[450] Ruska's footnote: "An unknown gemstone that is also mentioned by Bīrūnī." ("Ein unbekannter Edelstein, der auch von Bīrūnī erwähnt wird."). Ruska, 208.

[451] Example of filtration as a method of purifying.

[452] Melted colored glass; See previous footnote on paragraph four of this section.

[453] Only reference to marble.

[454] First mention of glass mortar

[455] This procedure is particularly long and leads to an especially potent end product. It is actually quite condensed because it utilizes many procedures that have already been explained.

[456] Ruska notes that G and L say "redness" and E says "oil." Ruska, 211.

[457] The question mark is in Ruska's translation.

[458] The imagery of coloring permeating base metal and changing its essence emphasizes the power of this elixir.

[459] The question mark is in Ruska's text.

[460] Ruska's note: "The usual meaning of *warq* is 'silver'; here the word is actually used as another name for nuqra." ("Die gewöhliche Bedeutung von *warq* ist 'Silber'; hier ist das Wort wohl als ein Deckname für Nuqra gebraucht.") Ruska, 214.

[461] The question mark is in Ruska's text.

[462] Presumably the elixir produced in one of the previous seven procedures.

[463] Ruska suggests that the grinding plate was usually a flat surface, because al-Rāzī only mentions using a concave grindstone once. This must be the procedure he is referring to. "Es scheint, daß der Reibstein gewöhnlich eine ebene Platte war, da bei Rāzī nur ein einziges Mal ausdrücklich ein konkaver Reibstein, also eine Art Reibschale vorgeschrieben wird." Ruska, 55.

[464] I.e. the elixir from the preceding procedures.

[465] First reference to a glass funnel.

[466] Reference not known.

[467] Rare personal reference and the only reference to selling.