

Mesopotamian Origins and the Material Discipline

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Synthesis:

This investigation focuses on the area of Mesopotamia during a period of time stretching from the end of the Paleolithic through the Bronze Age. The first part is a preliminary attempt to uncover something of the relationships between technological advances and a concomitant system of images. This imagery is intimately connected with the complex of ideas, techniques and dreams that, among many other things, made possible historical alchemy and the Material Discipline—and arguably the Disciplines as such.

In our study we are not seeking the flower (an alchemical process per se) but simply one of the important roots from which it grew and took various shapes at various times and places. The second part of this study briefly looks at the substances, apparatus and procedures, potentially available in ancient Mesopotamia and related to the historical alchemy (and our Material Discipline).

Summary:

This study is only a preliminary investigation; nonetheless it sets out to understand, through the “archeology” of the Neolithic, how certain system of images were formed and some of their concomitance in other ambits. This imagery forms part of a system of translations that continues from pre-history through historical alchemy up to the present day. In this way we hope to approach a useful classification and ordering of images (taking into account their cultural and technological context).

Fundamental to this point of view is the realization that **certain ideas, or certain ways of thinking are possible only under certain conditions**. That is, every system of ideation, or imagery, is rooted in a time and place. The translation of those impulses underlying the images can only work with the available raw material. And we will uncover images that translate changes directly linked to specific upheavals in the material culture, especially to certain technological changes (whether in ceramics, metallurgy, or innovations in agriculture and irrigation).

Our concern is with the conditions that permitted “alchemical” intuitions to take shape, and with those intuitions themselves. These intuitions, ideas, and imagery interacted, giving rise to new ideas about: the relation between the internal and the external, the microcosm and the macrocosm, about process in general, evolution and transmutation, stages of life/death/resurrection, the golem, the homunculus, the chymical wedding, et al.

For example, the great Neolithic accomplishment of domestication represents an unprecedented intervention in the natural order. That intrusion is concomitant with a system of images that has to do with the human being changing the natural order, transforming destiny, giving birth to a new creature.

In other words, the experiences of domestication supplied raw material for thinking certain thoughts. In this case placing places human intervention as the key to the surpassing of the natural order. And in much the same way we will

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find other systems of images connected to the great Neolithic accomplishments but which go far beyond permitting technical advances and indeed make possible the ideas, intuitions, and imagery connected with our Royal Art.

The second part of this study takes our Material Discipline and asks, of all our substances, apparatus and procedures, which could have originated in Neolithic Mesopotamia. We are not asking if they were used in the way we use them. That is not the point. It is sufficiently surprising and instructive to realize that almost without exception the apparatus, substances, and procedures of our art originate before the Arab alchemists of the Middle Ages and even before the grand synthesis of Alexandrian alchemy.

The apparatus used in Neolithic (and in some cases Paleolithic) cooking, perfumery, ceramics, and metallurgy include all kinds of containers, sieves, and ovens, furnaces and fires. We will also find mortars, pestles, and grinders of all types.

Along with these apparatus we will find an enormous range of procedures including distillation and sublimation.

Our list of substances is ample and includes, fire, water, earth (clay), and glass, along with sulfur, and the various metals, as well as mineral acids. We look at each one in turn trying to describe their basic chemistry, geology, and history.

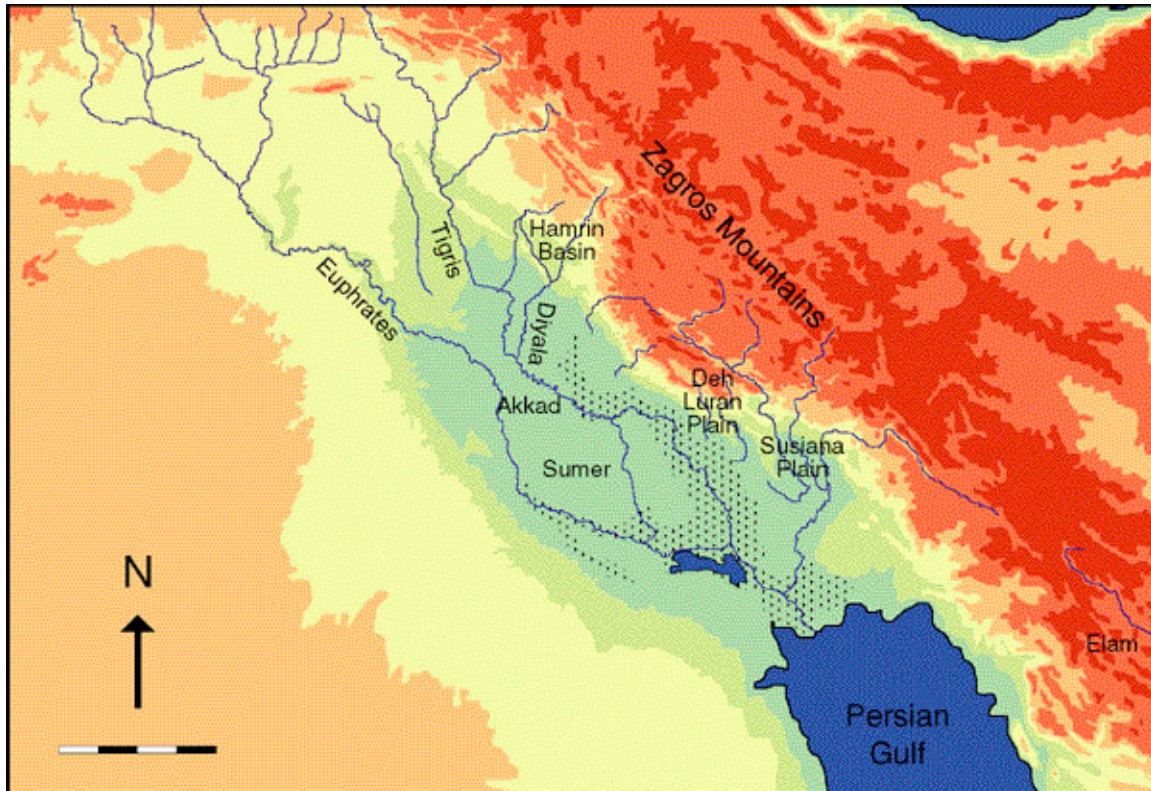
As we stated earlier, we are not arguing that anything like what becomes alchemy existed in Babylon or Sumer (much less the process of our Material Discipline). In the same way it is not our argument that the mineral acids, or electrolysis were known, or used in that period. But as we show, adequate (though simple) distillation apparatus existed and the procedures for producing distilled water, and various acids was certainly potentially available. Seemingly more unlikely (and in no way certain) we will see that it is certainly possible that even the antecedents of electrolysis can be found in the late Babylonian world.

Danny Z

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This study is only a preliminary investigation. Nonetheless it sets out to understand, through a particular kind of “archeology” of the Neolithic, the formation of a certain kind of imagery. These images are part of a system of translations that continues from pre-history through the historical alchemy up to the present day. In this way we hope to approach a useful classification and ordering of images (taking into account their cultural and technological context).



Introduction and Point of View

Imagery, Ideas and Intuitions from Neolithic Mesopotamia

The focus of this study was originally on the ancestors or progenitors of the apparatus, substances and procedures used in our Material Discipline. The interest was to discover which ones originated in Mesopotamia and show how continued – with all their modifications and improvements – through the historical alchemy up to the present. It was surprising and instructive to realize that almost without exception all the apparatus, substances, procedures of our art originate before the Arab Alchemists of the Middle Ages and even before the grand synthesis of Alexandrian Alchemy. We would include in this list, distillation,

arguably mineral acids and conceivably (though it is in no way certain) even the antecedents of electrolysis. All of this is to be found in prehistoric Mesopotamia.

That exploration now forms the second part of this study. Another sort of “archeology” became the focus of the first part¹. With this, the central concern shifted from the Mesopotamian origins of alchemical technology to the sources and origins of the archaic imagery and conditions that permitted “alchemical” intuitions to take shape. And it is in that place (though not necessarily only there) in the period between the late Paleolithic and the Bronze Age (though not only then) that events took place that made these systems of images possible.

It is there, in Mesopotamia, that the various advances in the mastery of fire, domestication, agriculture, irrigation, ceramics, metallurgy, etc., permitted revolutionary intuitions. They also permitted the articulation of previous insights in new ways. In the context of our art these ideas, imagery, and intuitions interacted, giving rise to images of: the relation between internal and external, microcosm and macrocosm, process in general, evolution and transmutation, stages of life/death/resurrection, the golem, the homunculus, the chymical wedding, et al.

Fundamental to this point of view is the realization that **certain ideas, or certain ways of thinking are possible only under certain conditions**. That is, every system of ideation or imagery is rooted in a time and place.² The translation of those impulses underlying the images can only work with the available raw material. The systems of images that we are sketching out, do not necessarily originate in Mesopotamia or in the Neolithic. Some certainly predate that period. Some of the images we will uncover clearly translate changes that are directly linked to specific upheavals in the material culture, especially to certain technological changes (whether in ceramics, metallurgy, or innovations in agriculture and irrigation). The most archaic images however appear almost as if they were translations of the human structure itself in relation to the world.³ Nonetheless the transformations of impulses into a specific form will vary according to the context, and our context is Neolithic and Bronze age Mesopotamia. The form these images took in that place and time has been potent enough to continue working for more than 12 thousand years.

¹ "[The] archaeological level -- the level of what made [an event or a situation] possible." M. Foucault, *The order of Things: An Archaeology of the Human Sciences*. New York: Vintage Books. 1970. This nod to Foucault's "archeology" should not be taken to imply that our methodology and orientation have anything to do with those of so-called structuralism or "post-modernism"

² While this study deals largely with what some might consider the province of history of technology or history of science, Silo's explanation of the translation of impulses is key to this entire work. See Silo, *Obras Completas Vol 2, Apuntes de Psicología*, Plaza y Valdes, Argentina (2004) Also L. Amman *Self Liberation*, Samuel Weiser, York Beach (1981) pp. 42-89.

³ Such a structure of fields of imagery translating various levels of (psychophysical and cultural-historical) profundity would allow one to speak of a human mental form, a cultural mental form, etc.

It is important to note that in any case none of this presupposes that we expect to find in ancient Mesopotamia either a Discipline per se, or a process like the one we know.

Beyond the limited focus of this study it is obvious that the changing technologies of the Neolithic had many, and far reaching impacts that continue to the present (cities, writing, etc). These “external” changes were concomitant with massive psychosocial changes. For example, one case, which will be touched on briefly because of its connection to the rise of agriculture, is the articulation of *the tensions between hunters and herdspeople and later between pastoral and farming peoples. This can be clearly seen in the story of Enkimdu and Dumuzi⁴ (or later in the biblical tale of the relation between Cain and Abel⁵ or Jacob and Esau⁶)*. Such tensions are not trivial things and continue to play out even up to the present. Consider the very bloody role they play in the current violence in Rwanda,⁷ the Sudan⁸ and Nigeria⁹ just to site three recent cases.



Jacob and Esau relief, *Gates of Paradise*
From the east portal of the Baptistery of San Giovanni, Florence, 1425/52
Lorenzo Ghiberti (Italian, 1378-1455) Museo dell'Opera del Duomo, Florence

⁴ Stuart Noah Kramer, *Sumerian Mythology* revised edition University of Pennsylvania Press, Philadelphia (1944, revised 1961) See appendix A below p.69

⁵ *Genesis* Chapter 25, King James Translation
<http://www.biblegateway.com/passage/?search=Genesis%204:1-16;&version=9;>

⁶ *Genesis* Chapter 25, King James Translation
<http://www.biblegateway.com/passage/?search=Genesis%2025;&version=9;>

⁷ Where we can easily trace a long and violent history between the pastoral Tutsi and the agricultural based Hutu.

⁸ See the United Nations Development Program website <http://www.sd.undp.org/projects/cp3.htm>

⁹ Umar, Bello Farouk, *The Pastoral-Agricultural Conflicts in Zamfara State, Nigeria*; North Central Regional Centre for Rural Development, Iowa State University, Ames

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This then is an attempt to uncover the structure wherein changes in our relation with the material world (i.e. new techné, and new technologies) made possible the translation of a particular mental direction into imagery that guided further action in the world.¹⁰ These actions in turn make possible new images that once again open or facilitate certain habits, mental directions, as well as directions of action and intent. This dynamic structure, and these archaic images continue to act in the world and in our Material Discipline.

The Discipline and Its Historic Roots

Perhaps the oldest extant alchemical text as such is *Isis the Prophetess to Her Son Horus* written around 300 A.D by *Zosimus of Panopolis*. Though his name indicates that he was from Panopolis he is most identified with *Alexandria*, and it was there, in the syncretistic crucible of the Hellenistic world, that the initial synthesis of Western Alchemy took shape.

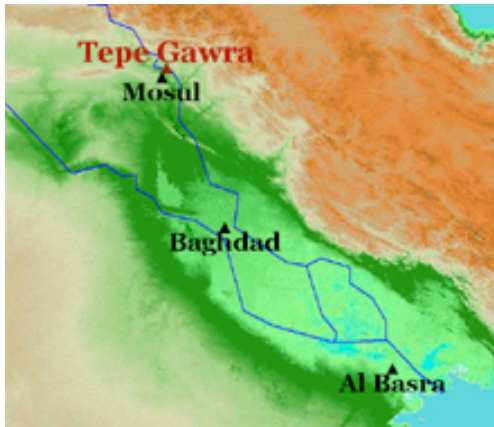


Ivory relief of the city of Alexandria represented as Isis, 6th c. Alexandria (Aachen: Cathedral).

Our focus in this investigation will be on a previous cultural stage where *we do not expect to discover Alchemy per se, but a set of ideas, dreams, hopes, substances, apparatus and procedures* that will later flow from the Fertile Crescent (*via Sumer, the Akkadians, the Babylonians, the Chaldeans, the Jews and others*) to the melting pot of Alexandria. But this stream was not simply one source of the influences

¹⁰ Silo, *Collected Works Volume 1*, Latitude Press, CA (2003), p.45 *External Landscape*: “1.Yet it is clear that as you go forward your vision is modified. 2.There is no learning, however small, that you achieve through contemplation alone. You learn because you do something with that which you contemplate. And the more you do the more you learn, for as you go forward your vision continues to change. 3.What have you learned of the world? You have learned what you have done. What is it that you want of the world? You have come to want according to what has happened to you. What is it that you do not want from the world? What you do not want also follows from what has happened to you.”

contributing to the Hellenistic alchemical synthesis. As noted above, almost all the apparatus, procedures, substances, as well as the mythical/philosophical notions known to Zosimus and his colleagues at the beginning of the common era had been with us since at least the time of Tepe Gawra, more than 4,000 years earlier. **Of course the substances will be purified, glass and metal will allow improvements to ceramic apparatus, etc. However, in this earliest moment, just emerging from the Paleolithic, we can find almost all of the apparatus, procedures, substances and basic notions that will inform the historical development of alchemy globally up to the present.**



Part I Archaic Imagery

Evolution and Transformation

Among the major achievements of the Mesopotamian Neolithic is the domestication of the plant and animal species which form part and parcel of the agricultural revolution. Just as the imagery in the story of the wild man *Enkidu* has been shown by *Silo* to carry traces of the ceramic revolution, it is also replete with those of domestication.¹¹ **Domestication is nothing less than human intention transforming the natural order. As such it involves a total change of the human beings relationship with the world and the gods. This imagery, drawing on the raw material of Neolithic cultural achievements (notably, agriculture, irrigation, domestication, ceramics and metallurgy), permitted new intuitions of previously unthinkable ideas, in this case: *evolution and transmutation*.**

The Material Discipline, like that of the other Disciplines that we know, is a path of profound transformation. For someone on this path the Discipline is not simply one more work of internal development, but rather one of *transmutation*. That is, other possible techniques, exercises or systems of work may have as their goal the equilibrium and development of the practitioner. But even when framed as a system

¹¹ Enkidu is created as a wild creature. His domestication is one of the key elements that allow him to meet with Gilgamesh and permit the tale to unfold. Silo, *Obras Completas Volume 1* Plaza y Valdes, Argentina (2004), *Mitos Sumero-Acadios* p.361

of self-transference¹² within a larger system of internal works the Disciplines have as their aim something registered as qualitative change—as *transubstantiation*.¹³ From within the perspective of the Discipline it is tautological that “alchemy” will require a system of images related to the possibility of producing an “unnatural,” though beneficial, change. All of this imagery, and the underlying impulses they translate can be subsumed within an idea of *Evolution*; an idea that we normally associate with Darwin and the beginnings of modernity.

Evolution is a process of adaptation and change. And beginning in the Neolithic we see a growing human intervention in the transformation of nature. *The domestication of plants and animals involves not only learning to maintain wild stock but to improve them—to transform them*.¹⁴ Consider the example of wheat (*Triticum* spp). Unlike modern domestic varieties, which have plump large grains, wild wheat looks and behaves like many other wild grasses. When it is ripe the heads fall to the ground and seed future generations, but in domesticated varieties the wheat stays on the stem when it is ripe increasing its value as crop plant.

There are other important differences; for example, besides larger grains, domestic wheat has tough ears that remained intact during harvesting. There is genetic evidence that this critical change came about as a result of a random mutation near the beginning of wheat's cultivation.¹⁵ Wheat with this mutation against shattering was the only wheat harvested and so became the seed for the next crop. This wheat was much more useful to farmers and became the basis for the various strains of domesticated wheat that have since been developed. In terms of size, color, taste and hardness other domesticated plants vary even more strikingly from their wild ancestors.¹⁶

¹² L. Amman, *Op Cit* pp.94-111

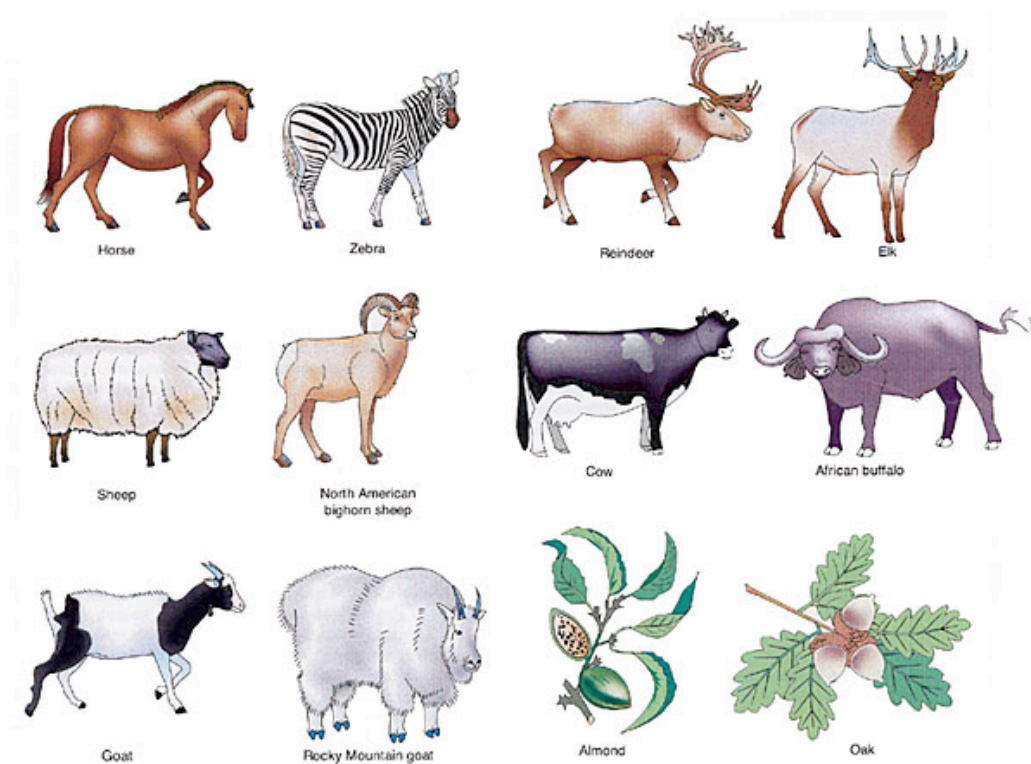
¹³ Cf. *The Four Disciplines* p.6 fn13 for a discussion of this term.

¹⁴ We are using domestication in the commonly understood sense of a process, aided by artificial selection, through which a population of animals or plants becomes more useful to, or controllable by, humans.

¹⁵ Jorge Dubcovsky, *et al*, Genome Plasticity a Key Factor in the Success of Polyploid Wheat Under Domestication *Science* 316, 1862 (2007)

¹⁶ For example, in the case of maize (*Zea Mays*) it is even difficult to see what even led to its domestication since the edible portion of the wild variety of maize is inedible since it is so small and each kernel is enclosed in a very bi-valve shell. Ears of cultivated corn are many times larger than their ancestral varieties. An even more striking case is that of the almond. Most wild almond seeds contain an intensely bitter chemical called amygdalin, which breaks down to yield the poison cyanide. Eating them could be fatal but artificial selection produced a very edible domesticated variety. There are other notable examples, like cassava or manioc, *Manihot esculenta*, the third largest source of carbohydrates for human food worldwide. The presence of cyanide precursors means that the “bitter” varieties it cannot be used in its natural state. Various multi-step procedures have been used to make the flour edible.

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The animal on left is the domesticate, the one on the right a closely related non-domesticated species.

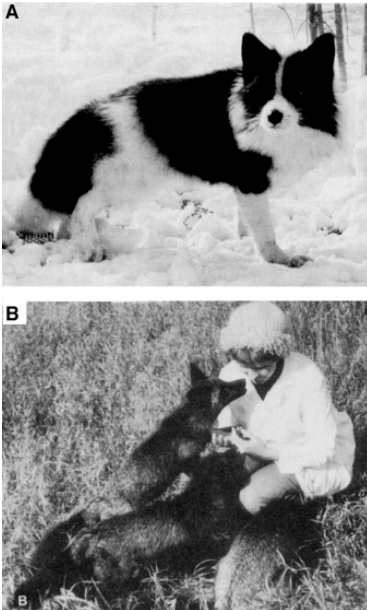
The same holds true of domesticated animals; they are not simply tame versions of wild animals.¹⁷ They have been modified in their morphology, etc – they are not simply less wary examples of a species. The process of domestication has been key to human development – but despite the enormous advantages people have been successful in domesticating very few species of plant or animal. It seems not all

¹⁷ Animal domestication is usually dated as beginning with the dog in 13,000 BCE. In 1974 Saxon reported that excavations in North Africa had revealed evidence for herd management (which might be considered partial domestication) of Barbary Sheep 5,000 years earlier BCE. *Libyca* 22 pp.49-92 as reported in Mary Settegast's *Plato, Prehistorian*, Lindisfarne Press; New York pp.36-37 (1990).

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species are apt for domestication and that besides artificial selection there are other factors at play. Whatever the combination of factors it is generally thought that such changes would take the intervention many human generations over hundreds if not thousands of years. There is interesting evidence that this is not always true.

Consider the remarkable example given in recent times by the Russian experiment in the selective breeding of foxes.¹⁸ Within only a few generations they inadvertently changed wild foxes into a dog like animal. Without intending to they totally changed the behavior as well as the appearance of the foxes they started with. The new animals were less fox-like and had the physical and social characteristics we associate with domestic dogs.¹⁹



(A) Changes in the foxes' coat color were the first novel traits noted, appearing in the eighth to tenth selected generations. Large areas of de-pigmentation similar to those in some dog breeds appear. (B) Tame foxes enjoy and seek out human contact. (From Belyaev 1979.)

¹⁸If foxes could be raised in cages their pelts could be gathered more economically than by trapping them. However the wild foxes were difficult to handle and would often damage their pelts. This led to the attempt to breed tamer, more domesticated foxes.

¹⁹ In the 1950s, Dmitry Belyaev of the Soviet Union's Institute of Cytology and Genetics in Novosibirsk, Siberia, began an experiment that involved trying to breed tamer foxes. He began with 30 male and 100 vixen (i.e. female) Silver Foxes, *Vulpes vulpes*, an animal never before domesticated. Only about 5% of the males and 20% of the females are selected to breed. The criteria for their selection was the degree of "tameness" defined as the ability of young, sexually mature foxes to behave in a friendly manner to their handlers, wagging their tails and whining. Eventually, a "domesticated elite" classification arose—these were the foxes that actually sought to establish human contact, licking the scientists like dogs would. By the tenth generation, 18 percent of the young foxes were in this elite category. By the twentieth generation, 35% were in this category. Today, over forty years after the breeding had begun, these domesticated foxes comprise from 70-80% of the test population. See Belyaev, D. K. (1979). Destabilizing selection as a factor in domestication. *Journal of Heredity* 70: 301-308. Also Belyaev, D. K., Ruvinsky, A. O., and Trut, L. N. (1981). Inherited activation/inactivation of the star gene in foxes. *Journal of Heredity*. 72: 264-274. Quoted here: <http://8e.devbio.com/article.php?id=223>

This is even more remarkable when you consider that DNA analysis confirms that all dogs, even those that superficially look fox-like, are not descend from coyotes or foxes but only from wolves, in a process that began perhaps 100,000 years ago. On the other hand wolves and foxes split from a common ancestor some 7 to 10 million years earlier.²⁰

There were revolutionary cultural as well as psychosocial implications in the domestication of the dog (and later other species of animals and plants). All of this provided fertile ground for the formation of a mental direction guided by imagery of evolution, change, and transformation. In other words, **the experiences of domestication supplied raw material for thinking certain thoughts. But even more, this imagery places human intervention as the key to transforming what nature has provided into something better.** In fact almost every aspect of what we think of as the Neolithic revolution interacted to create a particular mental direction or at least to facilitate that direction's translation into this extraordinary complex of images. It also put into motion contradictions that have not been resolved up to the present moment.

Transformation and Immortality²¹

Domestication is only one of the many breakthroughs we associate with the Neolithic. Each advance corresponds to its own system of images but also work together in forging a common mental direction. Consider for example the ceramic revolution that is so much a part of the transition from the Paleolithic to the Neolithic.²² Mud can be dried but the nature of mud is to dissolve when it becomes wet. This had been the reality and experience of clay since before the emergence of the human being. This physical behavior presents itself as the essential and defining aspect of the substance. Sun drying and even the addition of other materials like straw can make it more durable but they do not change the basic nature of the substance. These characteristics are given as part of the enduring natural order; unchanged and unchangeable since the world began. However, among the natural

²⁰ Evidence from genetic analysis confirms that the ancestors of modern dogs diverged from other wolves about 100,000 years ago. The earliest archeological evidence so far indicates dogs became the first domesticated animal no latter than 15,000 years ago. See: Vila, *et al* "Multiple and ancient origins of the domestic dog" *Science* 276: 1687–1689. This paper is available online at <http://www.kc.net/%7Ewolf2dog/wayne2.htm> Also, Lindblad-Toh K, *et al* "Genome sequence, comparative analysis and haplotype structure of the domestic dog". *Nature* 438 (7069): 803–19.

²¹ And it is in the oldest known written story that we discover Gilgamesh and his quest for immortality (for his companion Enkidu). Silo, *Obras Completas Volume 1* Plaza y Valdes, Argentina (2004), *Mitos Sumero-Acadios* p.361

²² The origins of ceramics in the sense of "the first thoroughly artificial [clay] objects—can be credited to Gravettian figurine makers at *Dolni Vestonice* around 30,000 B.P. the use of pottery vessels is so far not known to have occurred until after the global changes that accompanied the advent of the Holocene." J. Hoopes and W. Barnett in *The Emergence of Pottery* Smithsonian Institution Press, Washington and London (1995) p.2 Cf. below pp.38-39 where clay is discussed in the context of the substances used in the Material Discipline.

forces capable of suddenly transforming the world in peculiar ways there is one in particular whose characteristics proved vital: fire.²³

Over long millennia going far back to pre-human times, the imagery of fire and transformation had taken shape.²⁴ Fire transforms the dark of night into day. It transforms the raw into the cooked, the cold into the hot.²⁵ **Powerfully ambivalent, it is dangerous and all consuming, but also a source of protection and security. Fire and human intervention turned the natural order upside down. No longer is it simply a matter of a changing world—whether gradual or violent, positive or negative. The imagery made possible by the mastery of fire shaped an intuition about intention and transformation.** With the ceramic revolution it now takes on new potency and articulation. It was then we learned that the magic ability of fire could not just burn or modify, it could transform the basic nature of another substance. **In a moment whose impact on the (naïve?) consciousness is almost inconceivable, mud becomes rock. Water, is now contained by the clay which it once so easily consumed.**

With the development of metallurgy this imagery continued being perfected and amplified. And if the agricultural revolution gave rise to imagery of rebirth, the mastery of ceramics and metals provide articulation to imagery of transformation and immortality. Simple mud can be transformed into rock, and in that transformation gain immortality (no longer is it killed by water, now it has mastered water). With the smelting of copper and later bronze we see that even the most stable things i.e. rocks (ores) can be perfected becoming another kind of creature, bright, resplendent and powerful. The very notions of *evolution, and transmutation and immortality* are images born and nurtured on a series of key Neolithic technological breakthroughs involving human interventions that change “essential” aspects of the natural order.²⁶

²³ See p.35 below where *fire* is discussed under the heading of substances, also pp.57-59 in reference to fuels and furnaces under the heading of apparatus.

²⁴ The earliest evidence for the use of fire by humans comes from various East and South African sites. The evidence (which is disputed) dates this to at least 1.42 Million Years before the present. Dates for ability to produce fire vary but recent evidence pushes it back to 790,000 years ago--more than three times earlier than the previously accepted date. M. Balter Science 30 April 2004: Vol. 304. no. 5671, pp.663 – 665. The usual dates given for the production of fire are closer 25,000 to 35,000 years ago. See for example http://encarta.msn.com/encyclopedia_761563809/fire.html

²⁵ This of course reminding one of Levi Strauss's notion of raw/cooked axis that divides everything of a "natural" origin from everything "cooked" i.e. cultural, made by human beings. Levi Strauss, *The Raw and the Cooked: introduction to the science of mythology volume 1*, Harper & Row; New York (1969)

²⁶ Only two cases appear so far in the record of ancient Mesopotamia. Both are in the tale of Gilgamesh. The immortality gifted by the gods on Utnapishtim and his wife, and Gilgamesh's failed attempt to give Enkidu the plant of immortality (though let us note, there is a plant of immortality). Cf. Silo, *loc cit*

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As every apprentice of the Material Discipline learns, key to the process is the problem of resonance with the substance in transformation.²⁷ The simple attention of the craftsperson in their labor falls far short of reaching that mystery—just as the intuitions and imagery we are discussing are far from the Discipline per se.

Nonetheless, for those working in their sacred crafts²⁸ for long hours and days over fire and crucible, transforming one kind of thing into another how could phenomena of *identification* not take place? How could the craftsperson not in some way feel the process of the material being worked?^{29, 30, 31, 32} *And how could all this not give rise to that primary alchemical intuition, that there could be an art where the transformations undergone by the substance could also be undergone by the subject.*³³

²⁷ *Las Cuatro Disciplinas* where we read “El “cuerpo” que va sufriendo un proceso de transformación es la representación del operador. Por lo anterior, no basta realizar operaciones con materiales, es necesario que el operador “resuene” con ellos en un argumento de transformación”.

²⁸ As all such activities are within an archaic worldview.

²⁹ The unchanging order, where, *like begets like* is deep and old. Those who disrupt that order tend to be seen as dangerous heretics, precisely because, in some fundamental way, they challenge what is natural and given. In *The Bible* we read how pleased god was with this order. Cf. *Genesis* 1:11 thorough 1:25, where after each step in creation god looks upon the created order and sees “*that it was good.*”

³⁰ Martin Luther speaking of proofs of the existence of god says: “*The best argument that there is a God - and it often moved me deeply - is this one that he proves from generation of species; a cow always bears a cow, a horse always bears a horse, etc. No cow gives birth to a horse, no horse gives birth to a cow, no goldfinch produces a siskin. Therefore it is necessary to conclude that there is something that directs everything thus.*” *Luther's Works*, No. 5440, Fortress Press, Philadelphia (1969)

³¹ Compare this with Rumi's poem where he writes *I died as a mineral and became a plant, I died as plant and rose to animal, I died as animal and I was Man. Why should I fear? When was I less by dying?*. R.A. Nicholson, *The Mystics of Islam*; World Wisdom Books, Bloomington, p119 (2002)

³² In reference to the mechanisms of identification see the *Mental Discipline* (especially step 2) in *Las Cuatro Disciplinas (also Transcendental Meditation)*, *Psychology Notes I, II, and III* for a very complete explanation of the mechanisms that underpin such identification (and eventually the structuring of the psychological “I”), also *The Internal Landscape* for many suggestive comments on the relation of internal and external landscapes, and the configuration of meanings. Certainly the mechanisms that allow identification are rooted in the structure of the psychism itself. In this example, it is no matter if the object of the identification is our fellow human (compassion, etc) or an object. Many recent psychological experiments to explore these mechanisms do not add much more to the discussion than we can observe directly by watching a puppet show, or a ventriloquist in conversation with their dummy.

³³ “Esta es una Disciplina que trabaja con un sistema mental de fuerte alegorización y asociación. El “cuerpo” que va sufriendo un proceso de transformación es la representación del operador”. *Los Quatros Disciplinas*

Birth, Death and Rebirth

While the experiences of the Disciplines are accessible only to one who has walked that path there is no doubt that for the subject in transformation it is experienced within the ancient rhythm of birth, death and resurrection.³⁴It is a pattern that was potentially already ancient before the advances of the Neolithic. However its significance becomes clearer, and finds clearer expression and articulation, with the growing importance of the domestication of cereals and the increasingly complex social arrangements required for large-scale agriculture (irrigation, etc).

As noted above, our search for the Mesopotamian contribution to the Material Discipline does not mean we expect to find either a Discipline per se, or a process like the one we know. However, if we leave aside the precise divisions of our 12 steps for the moment and instead attend to the narrative of our Disciplinary process in the broadest terms we can trace it's 3 overarching phases, or quaterns: *Birth and Life—Death and Darkness—Resurrection and Ascent*.³⁵ This pattern lives at the very heart of our Disciplinary work. It is an argument or narrative structure that is not arbitrary and, despite its transcendental and universal nature, it is a particular expression rooted in a particular place and time—Neolithic Mesopotamia and the beginnings of agriculture.

The convergence of geographic, climactic and social conditions that gave rise to large-scale agriculture took place in an area that was highly suited to the intensive production if, and only as long as, sufficient water supply could be provided. That required extensive artificial irrigation. Building and maintaining system of canals and levies required in turn new types of social organization and led to the first known human civilization.³⁶

As well as the web of connections to technological advances the mythology of Sumer sometimes reveals the changing social situations that accompanied those changes. For example, the story of *Enkimdu* and *Dumuzi* reveals the tensions between pastoral and agricultural peoples or traditions. These tensions will continue; at times they will separate hunter-gatherers and farmers, or farmers and herds-people, or even cattle ranchers and shepherds. The images will be rearticulated in the Biblical stories of Cain and Abel, Jacob and Esau, and finally even in Hollywood's cowboy movies.

³⁴ *ibid*

³⁵ *loc cit*. These are in some sense arbitrary divisions. But as we will also see these divisions also have Mesopotamian/Chaldean roots. Cf. pp.25-29 below for more information.

³⁶ As defined by: permanent urban settlements, dwelling, writing, large-scale agricultural production, etc.

Mesopotamian Origins and the Material Discipline

In the Sumerian story *"Inanna Prefers the Farmer"* Enkimdu god of farming and of the irrigation canals, and the shepherd-god Dumuzi are both competing for the attention of the goddess *Inanna*. Her brother the Sun god *Utu*³⁷ wants her to marry Dumuzi but she prefers Enkimdu.



Inanna sings:

*"I, the maid, the farmer I shall marry,
The farmer who makes plants grow abundantly,
The farmer who makes the grain grow abundantly."*³⁸

Dumuzi the upstart pastoralist confronts the more peaceful farmer Enkimdu who attempts to resolve the situation:

*"Thou, O shepherd, why dost thou start a quarrel?
O shepherd, Dumuzi, why dost thou start a quarrel?
Me with thee, O shepherd, me with thee why dost thou compare?
Let thy sheep eat the grass of the earth.
In my meadowland let thy sheep pasture..."*³⁹

³⁷ Equivalent of the Akkadian *Shamash*.

³⁸ S.N. Kramer, *Op Cit* p102 This can be seen at <http://www.sacred-texts.com/ane/sum/sum09.htm>

³⁹ *ibid*



In the end Dumuzi wins the hand of Inanna. Their tryst will eventually lead them both into endless cycles of punishment in (and release from) the underworld.

In another poem Dumuzi (as herdsman) is connected to milk, there are references to the shattering of butter churns that corresponds to his death.

*My dream, O my sister, my dream,
This is the heart of my dream!
Rushes rise up all about me, rushes sprout all about me,
One reed standing all alone bows its head for me,
Of the reeds standing in pairs, one is removed for me,
In the wooded grove, tall (?) trees rise fearsomely all about me,
Over my holy hearth, water is poured,
Of my holy churn - its stand (?) is removed...
...The churn lies (shattered), no milk is poured,
The cup lies (shattered), Dumuzi lives no more,
The sheepfold is given over to the wind.⁴⁰*

While it forms part of the next section (*Embryology*) it is, at this point, worth touching on the relationship between this milk and semen. This is not unlikely if you consider the imagery in, for example, the poem “*The Courtship of Inanna and Dumuzi*” Where Inanna specifically reinforces this association.

*I Bathed for the wild bull,
I bathed for the shepherd Dumuzi,
I perfumed my sides with ointment,
I coated my mouth with sweet-smelling amber,
I painted my eyes with kohl.
He shaped my loins with fair hands. The shepherd Dumuzi filled my lap with cream
and milk, He stroked my pubic hair. He watered my womb. He laid his hands on my*

⁴⁰ *ibid*

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*holy vulva. He smoothed my black boat with cream. He quickened my narrow boat with milk. He caressed me on the bed. Now I will caress my high priest on the bed. I will caress the faithful shepherd Dumuzi. I will caress his loins, the shepherdship of the land. I will decree a sweet fate for him*⁴¹.

Inanna is generally recognized as the Earth (which bears fruit and becomes barren but regains its fertility). She is a deity, and possibly the first of those whom descends to the underworld leaving the world barren and returns bringing it back to life. The Earth's fertility is made possible thanks to the life giving seed/milk/water that revives her. *Unlike the north, the southern region of Mesopotamia, home of Sumer and later Babylon and Chaldea, is capable of sustaining intensive agriculture. But that's only possible with artificial irrigation.* This fact is so important to Sumer and the Neolithic revolution, that among the simplest (i.e. oldest) Sumerian words are specific words for dikes and channels.⁴²

Existence commences with the separation of the waters. The salty seawaters pertain to the monstrous *Tiamat* and these are separated from the waters, below from *Abzu* (or *Engur*) the sweet waters from the deep, i.e. the fresh lakes and marshes fed by underground streams.⁴³ Existence starts there and is supported by water, for Engur is also *Nammu* "the mother, first one, who gave birth to the gods of the universe."



Tiamat

⁴¹ *ibid*

⁴² <http://www.sumerian.org/sumerfaq.htm#s19> point 57.

⁴³ Mitos *ibid*



Nammu

Mechanical devices (trenches, dikes, levees, etc) and social organization were required to bring the water that could make fertile, could impregnate the life-giving earth with vital crops. These crops would be cut down and fields might lie fallow for a season but then life would return and growth would begin anew. There was a cycle of life and death and rebirth brought about through intentional activity. *And so a god's life purchased the life of the earth. That is the god Inanna died but the sacrifice of Dumuzi allowed her return.*

More than simple cyclicity is at issue in the wheel of life, death and resurrection. Observing natural phenomena, perhaps watching the tides go in and out or the sun rise and set and rise again, would almost inevitably through *associations of similitude*⁴⁴ have put our earliest ancestors in mind of *repetition*, of *eternal return* and given rise to images of the cyclical movement from birth to death to rebirth. For the hunter-gatherer, *cyclicity* itself (and by extension *eternal return*, etc) is fully embodied and observable in the most basic events, e.g. circadian rhythms of light and dark, breeding cycles of game animals, seasonal reappearance of particular plants, etc.

Already by the Paleolithic our ancestors had also observed cycles in more complex events, e.g. in the equinox and solstice, lunar phases, planetary orbits and the turning of particular stellar configurations. However, this imagery becomes more articulated and important with the rise of agriculture, perhaps beginning as early as the late Paleolithic (when, for example, long before becoming settled *Natufian* hunter-gatherers were collecting and storing wild grain, making bread, etc).⁴⁵ As

⁴⁴ Silo, Collected Works Vol 2, Psychology Notes also Amman L. *loc cit*

⁴⁵ Bar-Yosef, Ofer (1998), The Natufian Culture in the Levant, Threshold to the Origins of Agriculture, *Evolutionary Anthropology* 6(5): 159-177 available at <http://www.columbia.edu/itc/anthropology/v1007/baryo.pdf>

Eliade and others have pointed out such imagery takes the fore with the enormous cultural upheaval that sees agriculture become dominant in the Neolithic.⁴⁶

No doubt nature's cycles are of vital importance to all life on Earth. From, gathering and stashing food, to hibernation, there is a vast array of instinctive behaviors whose purpose is to synchronize the living beings' needs with the seasonal demands. Given their overriding implications for survival, nature's moods and fluctuations would have been carefully observed, studied, recorded and transmitted. However, while the nomad would follow the migratory route of game animals, or change the prey species with the change of seasons these have a very different implication for sedentary peoples. The seasons that see the birth and death of crops are concerns of the agriculturalist; for the hunter in temperate zones the end of summer may mean nothing more than the promise of seasonal game. And while an unusually fierce winter can mean starvation, such deprivation is not inherent in the season.

This can be seen in the extreme case of the pure hunter, i.e. one who has little or no year-round dependence on plants. We could take as an exemplary case the Inuit (Eskimo) peoples of the far north. In those most extreme climactic conditions winter is not seen as a time of death. Despite the demise of plant life, and the freezing temperatures it is a time when transportation and hunting are both easier than at other times of year. Food especially sea mammals cannot only be hunted, but they can also be stored thanks to the cold. *"The mobile nature of most Arctic foraging societies enables long distance travel in order to exploit seasonal abundance of different species - one example being the Netsilik who hunt seals out on the ice during winter, and hunt caribou and fish for salmon during the warmer months."*⁴⁷ In this frozen northern winter the limits of the white sky blend with the white of the snow

⁴⁶ "The agrarian cultures develop what might be called a cosmic religion, since religious activity is concentrated around the central mystery: the periodical renewal of the world. Like human existence, the cosmic rhythms are expressed in terms drawn from vegetable life. The mystery of cosmic sacrality is symbolised in the World Tree. The universe is conceived as an organism that must be renewed periodically – in other words, each year". Mircea Eliade, *A History of Religious Ideas: From the Stone Age to the Eleusinian Mysteries* Vol. 1, London: Collins, p.41 (1979). See also pp.66-67 where he writes: "The cult of Tammuz is disseminated more or less everywhere in the Middle East. In the sixth century, Ezekiel (8:14) cried out against the women who wept for him even at the gates of the Temple. Tammuz ends by taking on the dramatic and elegiac figure of the young gods who die and are resurrected annually....In short, the two cosmic modalities—life/death, chaos/cosmos, sterility/fertility—constituted the two moments of a single process. This "mystery," perceived after the discovery of agriculture, becomes the principle of a unified explanation of the world, of life, and of human existence; it transcends the vegetable drama, since it also governs the cosmic rhythms, human destiny, and relations with the gods. The myth relates the defeat of the goddess of love and fertility in her attempt to conquer the kingdom of Ereshkigal, that is, to abolish death. In consequence, men, as well as certain gods, have to accept the alternation life/death. Dumuzi-Tammuz disappears, to reappear six months later. This alternation—periodical presence and absence of the god—was able to institute "mysteries" concerning the salvation of men, their destiny after death."

⁴⁷ Balikci, Asen, *The Netsilik Eskimo*. United States: Doubleday, Dell Publishing Group, Inc. (1970) quoted at <http://foragers.wikidot.com/arctic-foragers>

covered ground – so even notions of up and down are transformed.⁴⁸ Winter has a very different meaning than that which necessarily accompanies the death and disappearance of the “staff of life” i.e. grain, the major source of nourishment. For the Inuit the frozen winter is the time of maximum sociability. The dwellings on the winter campgrounds house larger groups than the more solitary summer time. It is a period when storytelling, dance and festivities are used to enliven the long 24-hour night.⁴⁹



The extreme case of hunting societies like that of the Inuit (they had maintained much of their traditional culture until just over a generation ago) places the rhythm of the agriculture seasons in high relief. The sprouting, growth and death of crops followed by their reappearance occurs in a repetitive and predictable seasonal pattern. *The seasonal patterns of life, death and renewal are what are critical. It is of no importance what the seasons are, or what months they fall on.* This pattern has a number of divisions depending on the climatic zone. The Inuit for example divide the year into 6 seasons. However, in temperate climates we can easily distinguish 4 distinct seasons. We have spring (re)birth followed by summer growth then autumnal harvest and finally winter death spring (re)birth, ad infinitum.

It is important to note that the relation between season and climate and associated vital stage is not universal. The arctic north is not the only exception. For example, plants flourish in the Southern Mesopotamian spring and it is the killing heat of the summer not the cold of winter that is associated with death.

In Greece wheat was seeded in the autumn, and sprouted and grew through the wet winter. During the blistering hot summer the seed was placed in underground

⁴⁸ Cf. Silo, *op cit*, *Silo Speaks*, *The Riddle of Perception* p.583

⁴⁹ Balikci, *loc cit*

containers, and in the autumn brought out for planting. ***But no matter in which months these activities unfold in all these cases we can locate the 3 moments of: birth (life and growth); death (dissolution and darkness); rebirth (resurrection and ascent).***



At left Demeter offers ears of wheat. At right Persephone holding a torch, blesses the young man. Copy of the largest Eleusinian relief, 5th c. BCE. Greek National Archaeological museum.

This pattern holds true of nature, as well as of individual human and social life. It weaves together the primordial calendar of days and nights, lunar phases, weather, the changing seasons, the rising and falling of waterways, and of course cycles of plant growth. It also causes and incorporates the rhythm of social activities from the collective activity of building irrigation ditches, clearing them of silt, planting, sowing, etc. Interruptions in this archetypal rhythm are, literally, cosmic catastrophes. These crises are both caused and resolved by divine activity as we see in the story of Inanna/Ishtar and Dumuzi/Tammuz⁵⁰ as much as in later variants of the so-called “dying gods”.

⁵⁰ Beginning with the summer solstice came a time of mourning in the Ancient Near East as in the Aegean: the Babylonians marked the decline in daylight hours and the onset of killing summer heat and drought with a six-day “funeral” for the god. Cf. <http://en.wikipedia.org/wiki/Tammuz>



Ishtar

Embryology and Mineralogy

The way that an egg evolves into a fetus and the embryo to the fully formed child is a very specific form of development. And though it is very difficult at this late date to recognize the understanding of the male role in reproduction was not something evident for our ancestors. Like so many other images and ideas we tend to take for granted it was in reality hard won and that only after much time and careful observation.

For various peoples transiting from the Neolithic to the Age of Metals, and even in recent times, this embryological vision includes fetal/base metals that evolve within the Earth's womb until they mature into nobler minerals and finally gold.⁵¹

⁵¹ Eliade has collected many such examples. See for example, Mircea Eliade; *The Forge and the Crucible, the Origins and Structures of Alchemy*, University of Chicago Press; Chicago, IL (1962)

This kind of embryological imagery will not strike the practitioner of our art as unlikely. Each of us knows that, the marriage that gives birth to the androgyne, the Egg, the homunculus, et al, are not simply code words or colorful technical terms.⁵²



These montage images were based on my directions to the artist Katlyn Breene

It seems likely that for many long ages only the role of the mother, the bearer of new life, was recognized as playing a role in reproduction. This vision of reproduction as essentially a kind of parthenogenesis may have accompanied, or facilitated, the worldview in which matriarchy flourished. The discovery of the function of the male seed may have gone hand in hand with the domestication of food crops, concerns about breeding, knowledge of paternity and the development of patriarchy. It is likely this new knowledge was in fact a key component in the erosion of the old cosmic, and psychosocial order.⁵³

⁵² see *hierosgamos* below

⁵³ The vast increase in the proportion of weapons excavated in the late Paleolithic, the absence of any signs of violent death in the most ancient remains, the lack of defenses at pre-Mycenaean Crete all make one wonder at the implications and extent of that reordering. See for example, Mary Settegast, *Plato, Prehistorian*: Lindisfarne Books (2000)

Evidence for a Babylonian origin of alchemy has previously been tied to embryological notions put forth by Eisler in 1925 CE.⁵⁴ He had based his insight on an interpretation of the word, *ku-bu*; a term which appears in Assyrian chemical texts discovered in the excavation of king Assurbanipal's great library at Nineveh.⁵⁵ Others had read the term as having embryological meaning, as some kind of fetus, abortion or even demon. In the context of these tablets Eisler read it as *ore* or *mineral* making a direct link between ores and embryology.

Eliade quotes the translation thus:

*When thou settest out the [ground] plan of a furnace for 'minerals' [ku-bu], thou shalt seek out a favorable day in a fortunate month, and thou shalt set out the [ground] plan of the furnace. While they are making the furnace, thou shalt watch [them] and thou shalt work thyself [?] [in the house of the furnace]: thou shalt bring in embryos [born before time]... ...Thou shalt kindle a fire underneath the furnace and thou shalt put the 'mineral' into the furnace. The men whom thou shalt bring to be over the furnace shall cleanse themselves and [then] thou shalt set them to be over the furnace.*⁵⁷



Eisler felt these were not ritual instruction to place embryos (perhaps as sacrifices) in the furnace. Rather that they showed a kind of equivalence, where ore was the same as embryo, and that these lines indicated that the Babylonians were working with this image of *the maturation and perfecting of metals*. In other words with a key

⁵⁴ Eliade, *op cit* p.19

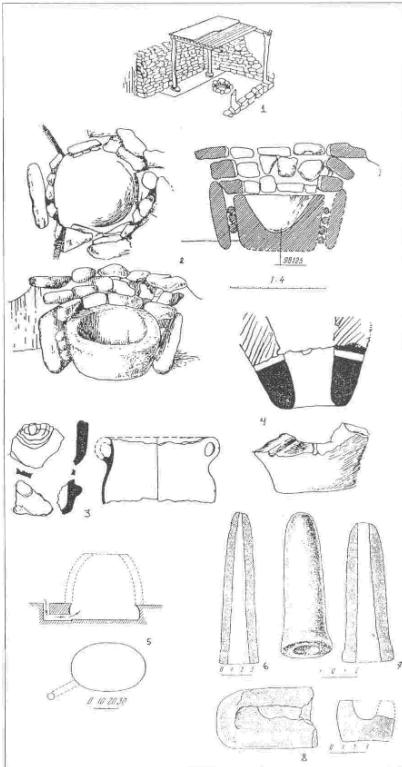
⁵⁵ Assurbanipal ruled from 669 BCE to circa 631 directly before the 11th or Chaldean dynasty

⁵⁶ While the tablets in question may have come from Assurbanipal's library they very likely date back to a much earlier time. For example, the same library give us tablets containing the Babylonian story of creation, the *Enuma Elish* which is estimated to date from around 1,800 BCE. There (IV, 136, line 3) the term *ku-bu* is used to describe the body of Tiamat; likening her to an embryo or fetus. And so it is, Tiamat's body is the embryo of the world and gives rise to the cosmos thanks to *Marduk's* rending her apart. Silo, *Obras Completas Vol 1, Mitos Asiro-Babilonicos* pp.374-381

⁵⁷ Eliade, *op cit* p.71

alchemical image – *the possibility of intervening in nature and speeding up, as it were, natural time*. This image is two-fold. On one hand, over time minerals or ore bodies, like embryos in nature's subterranean womb, are nurtured and develop. On the other, humans can intervene to speed up nature's geo-embryological pace. This last point is key. It is an image that continues to work through out the history of Alchemy and in our own *Material Discipline*.

Eisler's argument is essentially philological and turns on the interpretation of the meaning of the term *ku-bu*.⁵⁸ But it's not the only, or even the most important evidence pointing to an archaic origin for this system of images. As far back as we have records for mining and smelting practices we find evidence of an embryological vision of *mineral life*. The metallurgical practices take the fetus and mature it further in the refiners fire turning rocks into brilliant, useful and potent metals. These images of embryology, birth and growth are intrinsic to the Material Discipline and the historical Alchemy.



Reconstruction of Room III, or copper-melting workshop, of Amiranis Gora (Chubinishvili 1971: Table XXIV, 1)

⁵⁸ Forbes tells us "We have similar texts relating the offering of sacrifice to embryos by Assyrian glassmakers in the hope that these incomplete beings might assist him during his experiments." R.J. Forbes, *Studies in Ancient Technology*, Vol. 1 Leiden, E.J. Brill (1955) p.128. As this makes clear, doubts about the term *ku-bu* meaning ore do not necessarily put in doubt the association of embryo and ore.

Sacred Marriage

Within the steps of the Material Discipline the process begins with what might legitimately be called a union of opposites. This conjunction results in the birth of an androgynous child. Similar imagery is repeated in various ways and levels is linked to images of “the seed and the egg”, “the mystery of fertilization”, the “male and female,” all of them rooted in Neolithic achievements regarding domestication of plants and animals. These images converge in the imagery of the “Sacred Mating” of the *hieros gamos*.⁵⁹



This key ceremony in ancient Mesopotamia involved the “ritualized public sexual union between the king and *hierodule*⁶⁰ (or so-called ‘*sacred prostitute*’)”⁶¹. The term *hieros gamos* is used generally to refer to the union between two divinities, or between a human being and a god or goddess, or between two human beings (raised to sacred status).⁶²

⁵⁹ Hieros Gamos from the Greek *ιερός γάμος*, or Hierogamy *ιερογαμία*, both meaning “holy wedding”.

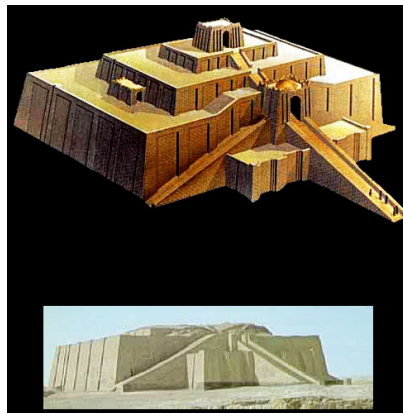
⁶⁰ From the Greek *ιεροδούλη* (*ιερών* “temple” + *δούλη* “female slave”), a temple slave in the service of a specific deity, often with the connotation of religious prostitution. The priestesses of Inanna/Ishtar were known to be hierodules, or *nadītu* in the native Sumerian language. Cf. F. Apfell Marglin, the entry *Hieroduleia*, And K.W. Bolles, *Hieros Gamos*, vol. VI of *The Encyclopedia of Religion*, ed. M. Eliade, *et al.*, New York (1987), also S.N. Kramer, *Cuneiform Studies and the History of Literature: The Sumerian Sacred Marriage Texts*, *Proceedings of the American Philosophical Society* 107 (1963), pp. 485-527.

⁶¹ Karen-Claire Voss, *The Hierosgamos Theme in the Images of the Rosarium philosophorum*; published in *Alchemy Revisited: Proceedings of the International Conference on the History of Alchemy at the University of Groningen, 17-19 April 1989*, ed. by Z.R.W.M. von Martels. E.J. Brill: Leiden (1990)

⁶² S.N. Kramer, *The Sacred Marriage Rite: Aspects of Faith, Myth, and Ritual in Ancient Sumer*, Bloomington (1969) pp.49-66

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Most interpretations of the original *hieros gamos* of Mesopotamia see it as a union in which, by virtue of their participation, the human partners became divine. It is maintained that the priestess who took part in this ritual became the goddess Inanna—as in Roman Catholic theology, where during the Eucharist, bread and wine are transubstantiated into the body and blood of Jesus Christ—an image rooted, as noted earlier, in the emergent technologies of Neolithic Mesopotamia. It is an example of what might be considered an example of a more general category that we could call “*replacement*”.⁶³ It is believed that in Mesopotamia, “the *hierosgamos* was thought to insure the well-being of the king, the prosperity of the people, and the continued fertility of the land” through the reenactment of the union of Dumuzi and Inanna (within the temple on top of the Ziggurat).^{64 65 66}



⁶³ While it is outside of the focus of this study this more general idea seems worth mentioning as a promising theme of investigation.

⁶⁴ Akkadian *ziqqurrat*, from *zaqāru* "to build on a raised area." A temple tower of ancient Mesopotamia having the form of a pyramid of successively terraced levels. There are 32 known examples dating from the 3rd millennium BCE to 6th century BCE.

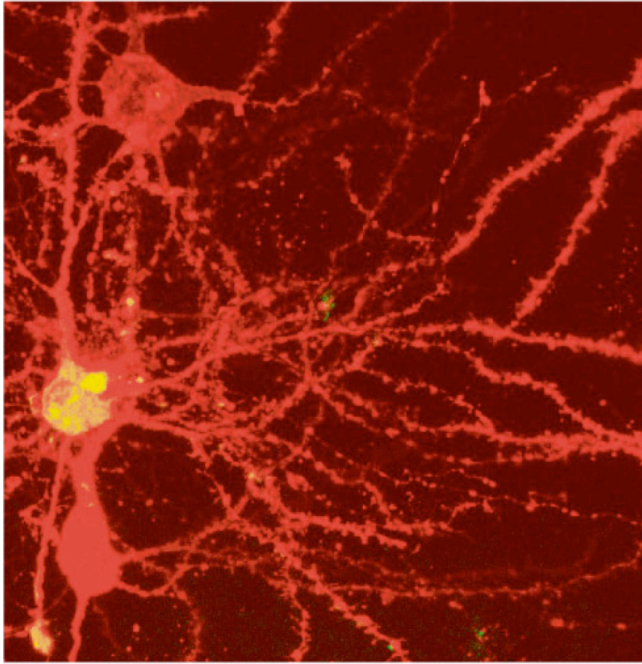
⁶⁵ Voss, *ibid*

⁶⁶ cf Silo, *Obras Completas, Mitos Sumerio* fn15

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Microcosm/Macrocosm

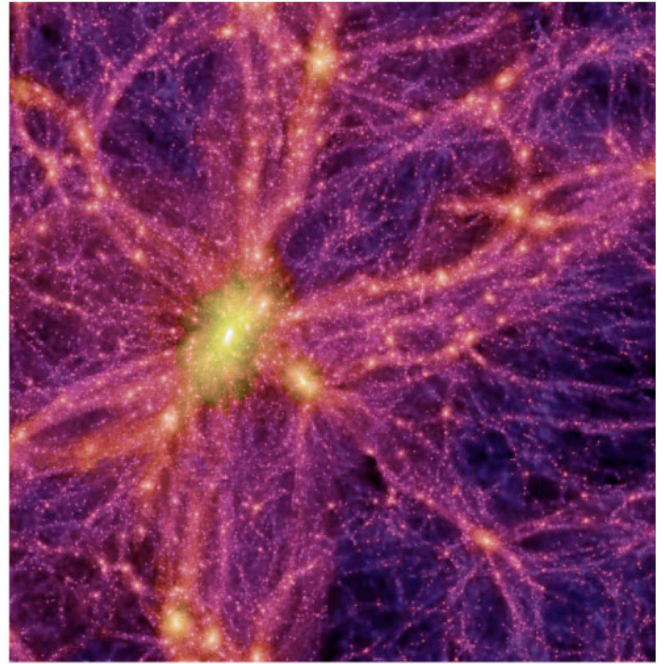
One is only micrometers wide. The other is billions of light-years across. One shows neurons in a mouse brain. The other is a simulated image of the universe. Together they suggest the surprisingly similar patterns found in vastly different natural phenomena. *DAVID CONSTANTINE*



Mark Miller

Mark Miller, a doctoral student at Brandeis University, is researching how particular types of neurons in the brain are connected to one another. By staining thin slices of a mouse's brain, he can identify the connections visually. The image above shows three neuron cells on the left (two red and one yellow) and their connections.

Source: Mark Miller, Brandeis University; Virgo Consortium for Cosmological Supercomputer Simulations; www.visualcomplexity.com



Virgo Consortium

An international group of astrophysicists used a computer simulation last year to recreate how the universe grew and evolved. The simulation image above is a snapshot of the present universe that features a large cluster of galaxies (bright yellow) surrounded by thousands of stars, galaxies and dark matter (web).

The New York Times

If the process we know follows the 3 phases (i.e. *Birth, Death, Rebirth*) outlined earlier, it is a journey that is possible thanks to a number of basic registers translated into images that seem rooted, less in cultural particulars than in the structure of the human being. Nonetheless, they cannot be removed from their original cultural matrix and their subsequent historical accretions. It seems that it is not until the Arabic Alchemy of the middle ages that we find the famous maxim from the Emerald Table of Hermes which proclaims: “...as above so below.”⁶⁷

⁶⁷ The earliest known version of the so-called *Emerald* or *Smargdina Tablet of Hermes* is found attached to manuscripts dated between 650 and 830 AD. These appear appendices to the *Kitab Ustuqus al-Uss al-Thani* (*Second Book of the Elements of Foundation*) attributed to Jabir ibn Hayyan, and the *Kitab Sirr al-Khaliqa wa San'at al-Tabi'a* ("Book of the Secret of Creation and the Art of Nature"). It is not clear that they are from the same period as these texts (or predate them). It may simply be that they were appended at a later date. The oldest example that is dated with certainty is part of the text is the *Kitab Sirr al-Asrar*, which claims to be a letter on the role of the king written from Aristotle to his student Alexander the Great. Cf. Read, J. *Prelude to Chemistry* G Bell and Sons, London (1936) p.53, also <http://www.golden-dawn.com/eu/UserFiles/en/file/pdf/ontablet.pdf>

However, the idea that the Macrocosm (e.g. Heaven) is reflected in the Microcosm (e.g. Earth) has much deeper roots. In some sense the origin of this intuition, like many others we have been looking at, is a direct expression of mechanisms of the human psychism in general and the associative pathway particular.⁶⁸ This seems homogenous with our subject, involving as it does a Discipline that is profoundly allegorical.⁶⁹

In the case of Sumer the earliest writings reveal the centrality of the relationship between the heavens and the Earthly realms. That relationship is reflected in many ways but above all as a conjunction (and hence separation) between the world above and that below. Every aspect of the divine hierarchy and celestial relationships is reenacted in the human social world. This reflection of the divine world in the human/natural world is key to the Sumerian cosmology; whether it is in how the dwelling of the gods are reflected in the temples and cities (first in simpler dwellings and later in the towering ziggurats) or in how social relationships recapitulate divine relationships. The entire celestial pantheon is reflected in the Earthly ruling classes and their relationships.

The same concern with the relationship between the microcosm and macrocosm can also be seen in the careful observation of celestial phenomena (eclipses, phases of the moon, meteors and comets) as well as weather phenomena. Omens of all sorts were so important that in Assurbanipal's library they made up the largest number of texts on any subject.⁷⁰ However, it was not just heavenly phenomena that were omens of the fate of the king and the land. Everything and anything could bear the message of the gods.

In practice that would most often mean that things out of the ordinary could be omens, while the repetition of that set of circumstances would presage the same events. And so from the earliest times specialized hereditary priests, called *Baru*, kept records of much more than phenomena in the sky. Predictions based on hepatoscopy (liver reading) are the oldest known form of divination and perhaps the most widespread but there is even a collection of omens and their meanings referred to the behavior of ants.⁷¹

⁶⁸ Silo, *Obras Completas Volume 1*, Plaza y Valdes Mexico (2002) *Psicologia 1*

⁶⁹ Los Cuatros Disciplinas, Disciplina Material, p.2 "Esta es una Disciplina que trabaja con un sistema mental de fuerte alegorización y asociación..."

⁷⁰ Lester Ness, doctoral dissertation, *Astrology and Judaism in Late Antiquity*, <http://shangri-la.0catch.com>

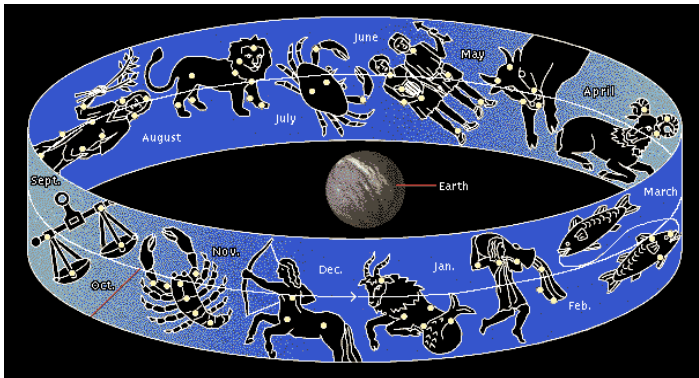
⁷¹ *ibid*

Mesopotamian Origins and the Material Discipline



Sheep's liver in clay. 14.6 cm across. British Museum

The proto-astronomy and proto-astrology practiced by the Sumerians was impelled by their astral theology and their vision of microcosm and macrocosm. This conception equated the gods with particular planets (and also with particular cities). These celestial observations began to be developed into more sophisticated astronomical and astrological systems by the Babylonians and especially the Chaldeans (Neo-Babylonians). These discoveries passed on to Greece and later formed part of the Alexandrian synthesis. It is there that both astrology and alchemy would take on the basic shape they would maintain for millennia.



Babylonian concern with such observations was accompanied by attention to problems of timekeeping and calendars. The Babylonian mathematical system was sexagesimal i.e. base 60 as opposed to our general use of base 10⁷². The Babylonian system is still visible in our circle of 360 degrees, etc. The case of the circle is

⁷² There are of course specialized uses of other base systems. The most obvious is base 2 in the binary logic of computers.

important in this context because it becomes the divisions of the zodiac and the horoscope.⁷³ And this Zodiac is the first attempt we know of to create a map or coordinate system of the sky.⁷⁴



Zodiac Beit She'an Valley Israel 6th century CE

These celestial observations were made because they were important phenomena and because of what they revealed about the mundane sphere. Up to and throughout the Sumerian period these astrological observations were not about every individual or event. They were always tied to the fate of the king and city/state. They went on taking a more wide-ranging and general role until, by the time of the Chaldeans, there was an elaborate astronomy, ample astronomical records and astrology. But by this time astrology was used to reveal, not only the fate of kings or the city/state, but of any individual.

⁷³ The horoscope represents a stylized image of the sky at a given moment and from a particular place. Horoscope from the Greek *horoskopos/horoskopoi* i.e. "marker of the hour" or "a vision of the hour". Astronomically it is a representation of the motion of certain constellations along the ecliptic, i.e. the apparent path of the Sun as it passes through the ecliptic divided into twelve signs.

⁷⁴ Cf. Silo, *Obras Completas* 1 Mitos Sumerio, fn 5,6,7. The etymology of the term zodiac is disputed. Most maintain that it derives from the Latin *zōdiacus*, and the Greek *ζωδιακός* [κύκλος], which would mean "circle of animals." The fact that the zodiacal signs Libra, and Aquarius are not "animals" may support the notion that it derives from the Sanskrit *sodi*, denoting "a path", as we see in the Greek *hodos* (and hence *hodoscope*?) The names of the (9) signs in Hindu astrology are not too far from the Greco-Babylonian signs.

The links between metallurgy (or proto-alchemy) and astrology is complex, manifold and persistent. The earliest unequivocal reference to the correspondence between the seven planets and metals is uncertain but the link to Mesopotamia seems inescapable, at least in as much as the planets or stars are equivalent to gods. If the linking of planets and metals doesn't originate with the Chaldeans (625-539 BCE) it certainly takes shape with them.⁷⁵ As Forbes has it, "*We also find metals being connected with gods or stars more particularly in Neo-Babylonian (Chaldean) times.*"⁷⁶ Bringing the specific theme of astro-theology back to the more general discussion of the relation between the celestial and mundane worlds in historical alchemy he concludes, "*The correlation between gods and stars is already quite common and thus gradually the 'universal sympathy' principle of the later alchemists grows.*"⁷⁷

Conclusions regarding Origins of Systems of Imagery

It is important to note by way of conclusion that the historical relationship between Mesopotamian and later ideas is multifaceted and tangled. These relations are not unique causes, even where they may be in some sense, causes. They are concomitances embedded in a complex system of relations. Nonetheless, where the systems of images we have been describing are not causal they still provide an important and early layer of the growing copresence that will inform later theories, imagery and systems of interpretation.⁷⁸

If Jaspers is correct that the projection of intention is the *primary delusion* it only states part of the case.⁷⁹ Reflecting, as they do, the deep reality of the human being as "*the maker of meaning*"⁸⁰ there will always arise notions of sympathy, correspondence, associative based superstitions of all kinds, sympathetic and contagious magic,⁸¹ a full-blown doctrine of signatures⁸² or even a complex theoretical system like Kabbalah.⁸³

⁷⁵ The specifics of the correspondence between the metals and planets changed but "The association of the sun, moon and the five nearer planets with the seven metals was firmly established nearly two thousand years ago. The concept of seven planets probably dates back to the eighth or ninth centuries B.C., possibly as a result of certain Chaldean influences." M.P. Crosland *Historical Studies in the Language of Chemistry*, Dover Phoenix Editions (2004) pp.79,80

⁷⁶ Forbes *ibid* p.128

⁷⁷ Forbes *loc cit*

⁷⁸ As noted earlier p2 and fn 2 above the roots of much of this imagery is to be found in the associative structure of the psychism itself.

⁷⁹ Karl Jaspers, *General Psychopathology*, University of Chicago; (1963) p98

⁸⁰ Silo, *Collected Works Volume 1, External Landscape VII:3* p46

⁸¹ J. G. Frazer, *The Golden Bough*, Chapter 3 Section 1 The Principles of Magic (1922) available at <http://www.sacred-texts.com/pag/frazer/gb00301.htm>

⁸² cf. for example J. Boehme, *Signature of all Things*, Dent & Sons, London (1912) available here: <http://www.sacred-texts.com/eso/sat/sat00.htm>

⁸³ cf. for example, G. Scholem, *Kabbalah*, Penguin; London (1978)

Part II Substances, Apparatus and Procedures

Substances

We will now turn to the basic substances that we use in our discipline. Some of these chemicals, minerals and metals were used in ancient Mesopotamian crafts, others in pharmacology, or food preparation, etc. In some cases we will be looking at substances for which there is a great deal of evidence. In other cases we are interested in exploring whether technologies existed that, at least theoretically, would have allowed the production of substances not normally thought to exist so early in our history. This would include, for example, the mineral acids. We will look at what's known about the availability and history of the substances, and in some cases of their precursor chemicals (e.g. alum, saltpeter, and sal ammoniac).

Fire

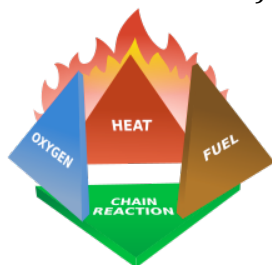
Our existence as corporeal beings demands the presence of many substances in precise measure and form (e.g. water to drink, air to breath). However, in some sense fire has a special place in unlocking our technological possibilities. Other animals, eat and drink. They don't utilize fire. The realization of the possibilities given by the mastery of fire marks a trajectory, which as we have seen in the first part of this study, implies much more than material development. Neither solid, liquid, nor gas, fire is not only key to those change but also has an essential mysterious quality. Somehow the *strangeness* of all things, whether water or a tree or a turd is made more evident in the burning flickering quasi-plasma of *vulgar fire*.⁸⁴

Synthesizing various definitions of fire one arrives to something like; "*a body of hot incandescent gas*" or perhaps, "*fire is the rapid oxidation of combustible materials with a resulting release of heat, light, and reaction products*". Some refer to fire as a *plasma*, the so-called 5th state of matter, even though rigorously speaking most of it is insufficiently ionized to be considered a plasma.

The process familiar in our Material Discipline involves the use of at least six types of fire. These include *vulgar fire* in a number of forms and intensities, e.g. the *Wheel of Fire*, the Bunsen, etc. We also use a range of "ovens" from the egg itself, to the incubator. And there are various heating and drying apparatus (in an earlier era these might work with banked fires, or for lower temperatures the use of reflected heat, *sand baths*, etc.). We also see occasional tools like the *bain Marie*, and the *incubator*. But besides these various apparatus (discussed below) there are also other forms of fire that are key to the process, e.g. the *mineral acids*, and in general *our fire* (*sophic fire*, *the fire of the wise*, etc.).

⁸⁴ The flames will present in a variety of colors depending on the fuel and the temperature of the fire. When organic fuel burns the coolest part of the fire is white, increasing temperature burns yellow. Above the yellow region, the color changes to orange, and lastly red.

On various occasions Silo has mentioned a number of points that could help to formulate an ample study on fire. This is not the occasion for that. Instead we will simply note some basic physics and history of this “substance”. As previously mentioned, fire is defined in various ways but recent studies tend to include four points, in the definition e.g., “*Fire is caused when sufficient oxidizer and material that is flammable, combustible or both is subject to enough heat to ignite and perpetuate itself*”. These four elements which, are necessary for every fire, (oxidizer, fuel, heat and chain. reaction) are often called the fire tetrahedron⁸⁵.



fire tetrahedron

At the end of the 20th Century estimates for human use of fire largely ignored the crucial distinction between the artificial maintenance of fire and its purposeful production. Most archaeological surveys of fire usage focus on the remains of fires excavated at *Swartkrans* in South Africa and *Chesowanja* in Kenya. These indicate human controlled fire dating back some 1,500,000 to 1,900,000 years.⁸⁶ However, not everyone agrees with this assessment. Some argue that these could be the remains of natural wildfires. The demand for “indisputable proof” in the form of hearths or rings of stone is unlikely, and in any case such expectations may be unreasonable for many reasons. However, at the 2004 annual meeting of the *Paleoanthropology Society* a report was presented by researchers about the *Gesher Benot Ya'aqov* site in Northern Israel with very strong evidence of fires (and hearths) made by *Homo erectus* between 790,000 and 690,000 years ago.⁸⁷ The widespread use of fire (perhaps indicating mastery of production as well as preservation) may be dated to less than 200,000 years ago.

Water

The famous formula H^2O describes a chemical substance with very interesting and in many ways importantly unique characteristics. It is a tasteless, odorless and liquid at sea level pressures and through a wide range of Earth's normal surface temperatures. The ability of chlorophyll-based life forms to survive underwater is thanks to the transparent quality of the liquid that allows a broad spectrum of light to penetrate.

⁸⁵ According to wikipedia more exotic flames are possible beyond those requiring oxygen, for example hydrogen burning in a chlorine atmosphere will produce a flame, as will other combinations such as fluorine and hydrogen and hydrazine and nitrogen tetroxide.

⁸⁶ Goudsblom, Johan *Fire and Civilization*. London: Penguin Books (1992), p.17

⁸⁷ <http://news.bbc.co.uk/1/hi/sci/tech/3670017.stm>

Since oxygen atoms are negative in relation to hydrogen, water molecules have a *polar* structure. These weak interactions between the poles of each molecule have a net effect of giving water a high surface tension. Surface tension plays a key role in capillary action that allows water to move up narrow tubes against gravity—key to the survival of every vascular plant. The polar nature also divides substances into *hydrophilic* (*that mix with water*) and *hydrophobic* (*like the fats and oils that don't mix well with water*).

Water has sometimes been called *the universal solvent* because of its ability to dissolve many substances including salts, sugars, acids, alkalis, and some gases. The hydrogen bonding between the molecules means that it has very high *specific heat capacity*⁸⁸ and *heat of vaporization*.⁸⁹ These properties allow water to moderate Earth's climate by limiting temperature fluctuations. Another vital property of water comes from the fact that it is 9% less dense when it freezes. Hence ice floats on water, which in turn allows life to flourish. If it weren't the case, ice would sink and lakes and oceans freeze from the bottom up.⁹⁰ Instead even in the arctic oceans life goes on beneath the frozen cap. Essential to life, and inherently linked to the deepest allegories, it is no surprise that water is also central to much mythology, cosmology and cosmogony.⁹¹ Water appears in our process in various forms, *Vulgar*, *Bi-distilled*, *Dense*, etc.

For ancient Mesopotamian cultures the division between types of water is the prototype of all differentiations and the primal act of creation. This system of images will be carried forward and it later appears in Genesis 1:7 where, as the King James translation has it, "*And God made the firmament, and divided the waters which were under the firmament from the waters which were above the firmament: and it was so.*" So we find in the Babylonian *Eminu Elish* the distinctions begin with the separation of two intermingled cosmic principles – *Apsu* (*Sweet Water*) and *Tiamat* (*Salt Seas*).^{92, 93} Later, with *Marduk's* bisection of the water serpent Tiamat, a second division occurs that creates the world.

As Silo tells the tale, "*He cut her cadaver lengthwise as if it were a fish, raising one of its pieces up to the sky. He placed it under lock and key with a guard over it to prevent the waters it held from escaping. Then, crossing through the spaces, he inspected the*

⁸⁸ Specific heat is the measure of the amount of heat required to raise the temperature by a particular interval.

⁸⁹ The amount of energy required to convert the substance to vapor.

⁹⁰ This physical and chemical information is mostly drawn from Wikipedia.

⁹¹ As Lao Tzu reminds us in a very different context "Water is the highest good..." cf. Chapter 8 Tao Te Ching

⁹² Silo *Mitos Raices* in *Obras Completas* loc cit

⁹³ It is intriguing to consider that the geography of the marsh lands of Mesopotamia produce a landscape of formation where earth and water are not clearly separated but intermingle, however the vital distinction of sweet and salt water can never be ignored. Cf. H. Frankfort, *Kingship and the Gods*; University of Chicago Press (1978) p.234

regions thereof, and, measuring the abyss, he established his dwelling upon it. In this way Marduk created the heavens and the Earth and established their limits".⁹⁴

Historical alchemy is replete with instructions for the use of many types of water including, *sweet water, salt water, river water, dew*, etc. Nonetheless, even with the presence of distillation apparatus, albeit rudimentary ones, the use of bi-distilled water might seem unlikely. How much more unlikely would seem the production of *dense water*? However the use of repeated distillation is fundamental to many of the processes mentioned in the earliest records we have (mostly in reference to perfumery).⁹⁵ There is no *a priori* reason to dismiss the possibility that these substances *could have* been produced. And in fact the many repetitions of distillation that form a part of the recipes make it seem almost inevitable.

Earth

Worn away from igneous rock and most often carried off by the same running water that eroded it, clay is usually found in riparian deposits. Its primary constituents are tiny crystalline particles of *feldspar*, which are composed mostly of highly refractive *alumina* and *silica*. When moist, these thin crystals can easily slide by each other and form a plastic material. When dry they lock together and become rigid. As the material is washed along it picks up other organic and mineral particles that give clay its range of colors and qualities. When there is too great a proportion of non-plastic material the clay loses its particular quality and is what we call mud.⁹⁶

The abundance and qualities of clay means it almost certainly played an important role in the earliest (i.e. pre-ceramic) technologies. Among its many functions it was likely used, as it was in more recent times, both as paint and medicine. It was also almost certainly used in *wattle and daub* type construction.^{97, 98}

Like the biblical Adam, and Rabbi Loew's golem, Enkidu was made from earth—and so was Sumer.⁹⁹ With no great abundance of adequate wood, or stone (unlike Egypt for example) kiln, or sun-dried clay was a major construction material.^{100, 101} Even writing emerged as a system of impressions on clay tablets.

⁹⁴ Silo *ibid*

⁹⁵ M. Levey, *Chemistry and Chemical Technology in Ancient Mesopotamia*; Elsevier Publishing, Amsterdam (1959) p.143

⁹⁶ D. Schmandt-Besserat, *The Use of Clay Before Pottery in the Zagros*, Expedition, (Winter 1974) p.11

⁹⁷ *Ibid*

⁹⁸ Used for perhaps 6 millennium, "*wattle and daub*" is a way of making walls—a woven lattice of wooden strips called *wattle* is *daubed* with a sticky material usually made of some combination of wet soil, clay, sand, animal dung and straw.

⁹⁹ "*Mesopotamia is a land of mud and mudbrick architecture.*" P.R.S. Moorey, *Ancient Mesopotamian Materials and Industries*; Clarendon Press, New York, (1994) p.303

¹⁰⁰ "They provide a very acceptable substitute for stone when moulded and exposed to the intense summer heat of the plain (it can reach 50° in Babylonia in the shade) for appropriate length of time or better still when kiln-fired." *ibid*

The tricks of turning clay to ceramics represent great discoveries, essential for the so-called Neolithic revolution. The first firings of clay were not made in kilns or ovens, but in open bonfires that could reach up to 800° C for short periods of time.¹⁰² To increase the affect of the firing, clays were mixed with sand, crushed shell, or other materials to open the body texture and allow moisture to escape. Coarse clay also minimized shrinkage and hence breakage.

The earliest kilns were pit or trench-kilns—basically holes or trenches dug into the ground and covered with fuel. **The earliest known objects made from fired clay are not utilitarian, they are figurines like the so-called *Venus of Dolní Věstonice*, a female figure dating to between 30 and 25,000 BCE.**¹⁰³ The first ceramic vessels we have evidence for are those made by the *Jōmon* people of Japan some 10,000 years later.¹⁰⁴ The term *Jōmon* refers to the markings on their pottery, made by sticks wrapped with cord. There is recent evidence of Chinese ceramic vessels dating to about 10,000 BCE.¹⁰⁵

Glass

Not only was the volcanic glass obsidian used in the Paleolithic but by no later than 14,000 BCE it was already traded over long distances. A number of early obsidian trade routes have been reconstructed. The first is from southeast Turkey to Iraqi Kurdistan. The second is from central Turkey through the Taurus to the middle Euphrates and the northern Levant.¹⁰⁶ Present evidence seems to indicate that the first true glass, in the sense of melted silicate cooled in a manner that ensures it doesn't crystallize, was produced in Mesopotamia, northern Syria or Egypt.¹⁰⁷ The earliest examples that we have of objects made from glass are from the middle of the third millennium BCE. These were made primarily with Silica (from sand), lime (i.e. calcium oxide, CaO) and an alkali¹⁰⁸.

¹⁰¹ "I must also reveal what use they made of the earth dug from the moat, and how they constructed the wall. While they were digging the moat, they took the clay thus excavated from it and made it into bricks, and when they had molded a sufficient number, they baked the bricks in kilns. Then using hot bitumen as mortar, they built up the banks of the moat and stuffed reed mats in between at intervals of every thirty layers....". Herodotus, *The Histories* 1.179 in *The Landmark Herodotus*; London (2007) p.97

¹⁰² for a more detailed discussion cf. fn 161 below

¹⁰³ ed by W.K. Barnett and J. W. Hoopes, *The Emergence of Pottery*, Smithsonian, Washington D.C. (1995) p.2

¹⁰⁴ *ibid* p.11

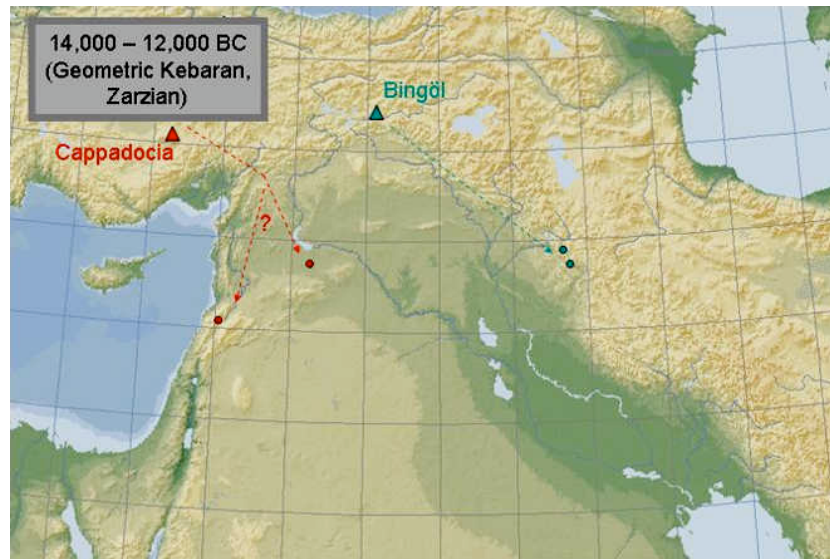
¹⁰⁵ Zhang Chi, *Documenta praehistorica* XXIX, <http://arheologija.ff.unilj.si/documenta/pdf29/29chi.pdf>

¹⁰⁶ <http://www.archatlas.dept.shef.ac.uk/ObsidianRoutes/ObsidianRoutes.php>

¹⁰⁷ Moorey, *op cit* p.167

¹⁰⁸ D. Klein and W. Lloyd, *The History of Glass*, Little, Brown and Company, London (1993) p.11

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Obsidian routes from other sources, e.g. around Lake Van and in Transcaucasia, are not shown¹⁰⁹.

The Egyptians (and Syrians) used soda ash derived from *halophile* (i.e. salt-loving) plants that grow near the sea as their alkali. Of course, these are predated by examples of *faience* and glazed materials.^{110, 111} The late Bronze Age (1,500 to 1,200 BCE) saw great advances in glass making in Egypt and throughout Western Asia. The cultural collapses at the end of the Bronze Age put a halt to glass making but by the 9th Century BCE techniques for making clear glass were discovered in Syria and Cyprus. The earliest extant instructions for making glass are from the library of King Ashurbanipal about 250 years later.¹¹² Egyptian glass making however, does not seem to have recovered until Ptolemaic Alexandria. The first evidence of blown glass does not appear until the first Century BCE.

Glass did not replace clay vessels and apparatus until almost modern times. For millennia, a protective clay exterior was used to cover fragile, and valuable glass in order to guard it from damage by heating or other forces. This practice was continued until the 20th Century CE as illustrated in the case of the glass Alembic

¹⁰⁹ <http://www.archatlas.dept.shef.ac.uk/ObsidianRoutes> This website's map information is drawn from M.-C. Cauvin et al., *L'obsidienne au Proche et Moyen Orient: du volcan à l'outil*, Archaeopress, Oxford (1998)

¹¹⁰ Faience in this sense is a glass like substance made primarily from sintered ground quartz and a glaze. It is unrelated to the modern usage, where it is a name for pottery with a shiny white glaze produced by tin-oxide. (Moorey, *ibid*).

¹¹¹ Glaze is a layer of glass on the surface of faience or ceramic. Alkaline glazes use a soda or potash flux to modify melting temperature. Lead glazes do the same with a lead flux. Either of these can be modified with tin oxide. Alone it turns the glaze white. In combination with another metal-oxide it makes the glaze opaque. (Moorey *ibid*).

¹¹² Ashurbanipal (Akkadian: *Aššur-bāni-apli*, " 685 BC E to 627 BCE, the last great king of the Neo-Assyrian Empire. He established the first systematically organized library in the ancient Middle East at Nineveh.

pictured here which originally coated in clay was “collected in 1975, along with a cucurbit from the alchemist *Azad Manesh* who was operating at the time in Isfahan, Iran.”¹¹³



Mercury

Today considered a *transition metal* with an atomic number of 8, *mercury* derives its atomic sign Hg from its Greek name *hydrargyros* i.e. *liquid silver*. Its other common name, *quick* (i.e. living) *silver* translates the Latin, *argentum vivum*. It is occasionally found either as a native metal, most often in the form of *cinnabar* (HgS) but also as a constituent of other minerals like *corderoite* and *livingstone*.¹¹⁴



Cinnabar

There are ancient Babylonian tablets that record recipes and techniques related to perfumery, etc. But the oldest complete book on proto-chemistry or metallurgy

¹¹³ F.L. Holmes and T. H. Levere, *Instruments and Experimentation in the History of Chemistry*, Massachusetts, Institute of Technology (2000) p.11

¹¹⁴ Mercury is an extremely rare element in the Earth's crust, having an average crustal abundance by mass of only 0.08 parts per million. However, because it does not blend geochemically with those elements that constitute the majority of the crustal mass, mercury ores can be extraordinarily concentrated considering the element's abundance in ordinary rock. The richest mercury ores contain up to 2.5% mercury by mass, and even the leanest concentrated deposits are at least 0.1% mercury (12,000 times average crustal abundance).
[http://en.wikipedia.org/wiki/Mercury_\(element\)](http://en.wikipedia.org/wiki/Mercury_(element))

Theophrastus of Eresus' 4th Century BCE "De Lapidibus" or "On Stones" dates from thousands of years later. After a few paragraphs discussing cinnabar Theophrastus notes (in paragraph 60, of the 69 comprising this work) a mechanical process for extracting mercury from cinnabar. He explains that the mineral must be ground with vinegar in a copper mortar and pestle. There is a reference in *Pliny's* (23-79 CE) *Natural History* where he describes a method of sublimation where cinnabar is heated in an iron shell, decomposes and the resulting quicksilver condenses onto a convex lid. Finally, as with the 5,000 year old still from Tepe Gawra (see below, pp55-60) the final product is collected by wiping it off from the lid.

Aristotle is the first of the classical authors to mention mercury and there are references to samples found in Egyptian tombs dating from 1500-1600 BCE.^{115, 116} The extraction of mercury from cinnabar is not a complex process. Besides the chemo-mechanical method noted by Theophrastus, it is normally extracted, as per Pliny's note, by heating the mineral in the air and condensing the vapor.¹¹⁷

As Levey relates, the techniques noted by the later Muslim alchemists for sublimating Mercury from Cinnabar would have been technologically possible for the Sumerians. He also notes the Babylonian word for Mercury (*IM.KAL.GUG*) derives from *IM.KAL* i.e. soot and means Soot/Sublimate of the red.¹¹⁸ And considering that mercury appears both as a constituent of minerals like Cinnabar but also as in its elemental form – and given its extraordinary characteristics it was almost certainly known from very early times, at least in some geographic regions.

Sulfur

Today *Sulfur* (*sulphur*, also called *brimstone*) is considered a *multivalent nonmetal* with an atomic number of 16. This yellow crystalline substance can be found as a pure element as well as a constituent in sulfide and sulfate minerals like *pyrite* (iron sulfide), *cinnabar* (mercury sulfide), *galena* (lead sulfide), *stibnite* (antimony sulfide), etc. The simplest form of extracting Sulfur, the so-called *Sicilian Process*, is very straightforward and was used in volcanic regions when sulfur was present in rocks. Kilns were built on a sloping surface and the sulfur was loaded into and on top of them. The sulfur was ignited and the heat melted it. The molten element flowed down the sloping hillside and was collected in wooden buckets. Distillation was used to further purify the remaining material.¹¹⁹

We don't know when sulfur was first used or recognized as an important element but given its distinctive color, smell and other attributes it was likely very early on.

¹¹⁵ Aristotle, *Meteorology* IV.8

¹¹⁶ J.M. Stillman, *The story of Early Chemistry* Appleton, London (1925) p.9

¹¹⁷ The equation for this extraction is $\text{HgS} + \text{O}_2 \rightarrow \text{Hg} + \text{SO}_2$.

¹¹⁸ Levey, Martin *Chemistry and Chemical Technology in Ancient Mesopotamia*, Elsevier Publishing, Amsterdam (1959) p.36

¹¹⁹ <http://en.wikipedia.org/wiki/Sulfur>

We know that Sulfur was a common ingredient in Assyrian pharmacy and ritual preparations.¹²⁰



Galena



Stibnite

Iron

Iron is a *transition metal* with the atomic number 26 and the symbol *Fe* because of its Latin name *ferrum*. Iron is a group 8 and period 4 element. It is one of the few *ferromagnetic* elements. Along with nickel, Iron is the most abundant metal in metallic meteorites, and in the dense metal core of our planet. Iron is the most abundant element on Earth, but only the fourth most abundant element in the Earth's crust. Most of the iron in the crust is found combined with oxygen as iron oxide minerals such as *hematite* and *magnetite*. On the other hand, 1 in 20 meteorites consist of the unique iron-nickel minerals *taenite* (35–80% iron) and *kamacite* (90–95% iron)¹²¹.



hematite



iron meteorite

Although rare, meteorites are the major form of natural metallic iron on the earth's surface and the source for the iron used during the Paleolithic and early Neolithic.¹²² Of course, one cannot overlook the importance of the celestial origins of this already extraordinary (in terms of strength, weight and magnetic characteristics) material.

¹²⁰ Levey, *op cit* pp.127, 128

¹²¹ <http://en.wikipedia.org/wiki/Iron>

¹²² Mircea Eliade, *The Forge and the Crucible*; Rider, London (1962) pp.19-26

Copper

Copper is a *transition metal* with the atomic number 29 and the symbol *Cu* from its Latin name *cuprum*. In the Roman era, copper was principally mined on Cyprus, hence the origin of the name of the metal as *Cyprium*, "metal of Cyprus", later shortened to *Cuprum*. Native copper is one of the few metals to naturally occur as an un-compounded mineral. It is a ductile metal with excellent electrical conductivity. Earth's crust consists of 63 parts per million (ppm) of copper. In its pure state it's easily bent and has a color that, with the exception of gold, is otherwise unknown in metals, which are normally silvery white. Interestingly copper can also have germicide affects and can be used for that purpose in medical ambits.¹²³

Copper was the most widely used and cheapest metal in Mesopotamia. At least up to the Chaldean period, when iron became less expensive than copper. Having been used for at least 10,000 years, its historical usage is probably only preceded by gold and meteoritic iron. The earliest known copper artifacts are some 50 objects discovered at *Cayonu Tepesi* in Southeastern Turkey that date to the late 8th millennium BCE.¹²⁴ Like the findings in *Çatal Höyük* (about 6000 BCE) these are native copper and there are no signs of smelted copper. The earliest evidence of smelted copper in this region is from *Can Hasan* in central Anatolia (about 5000 BC).¹²⁵ But smelted copper artifacts have been discovered (a copper chisel) in a chalcolithic site at *Prokuplje* in Serbia.¹²⁶ These finds pre-dates *Can Hasan* by 500 years. The earliest well preserved copper smelting kiln dates from about 3,500 BCE. Located in the *Timna Valley* some 30km north of the *Gulf of Eilat* it is simply a small pit that would have been fed air with goatskin bellows.¹²⁷

There was already a substantial trade in copper coming from *Dilmun*, other Persian Gulf islands and *Ur* no later than the early years of the third millennium BCE.^{128,129} In the 2nd and 3rd millennium copper also came from *Anatolia*.^{130,131}

¹²³ <http://en.wikipedia.org/wiki/Copper>

¹²⁴ J.D. Muhly, *The Beginnings of the Use of Metals and Alloys*, MIT Cambridge (1988)

¹²⁵ P. R. S. Moorey *op cit*; also <http://en.wikipedia.org/wiki/Smelting>

¹²⁶ <http://metalurgija.org.rs/mjom/vol12/No%202-3/2Sljivar.pdf>

¹²⁷ <http://www.mfa.gov.il/MFA/History/Early%20History%20%20Archaeology/Archaeological%20Sites%20in%20Israel%20-%20Timna-%20Valley%20of>

¹²⁸ Forbes *op cit* p.196

¹²⁹ "...here he indicates that a great deal of copper was imported into Sumerian cities from Dilmun, Magan and Meluhha, all located south of Sumer. In the east Tigris mountainous area Kimash is mentioned as a source of copper for the merchants." "Henri Limet, *Le Travail & Mdal au Pays de Sumer*; Paris (1960) pp.85-99; Quoted in Marilyn Kelly-Buccellati, *Trade in Metals in the Third Millennium: Northeastern Syria and Eastern Anatolia* in the work *Resurrecting the Past*, edited by P. Matthiae et. al., Nederlands Historisch-Archaeologisch Instituut Te Istanbul, (1990) fn 29, p.125 This chapter is available as a pdf at <http://128.97.6.202/attach/Kelly-Buccellati%201990%20Trade%20Metals.pdf>

¹³⁰ Forbes *ibid* p.197

¹³¹ For a more recent and more ample study of this subject cf Marilyn Kelly-Buccellati *ibid* pp.117

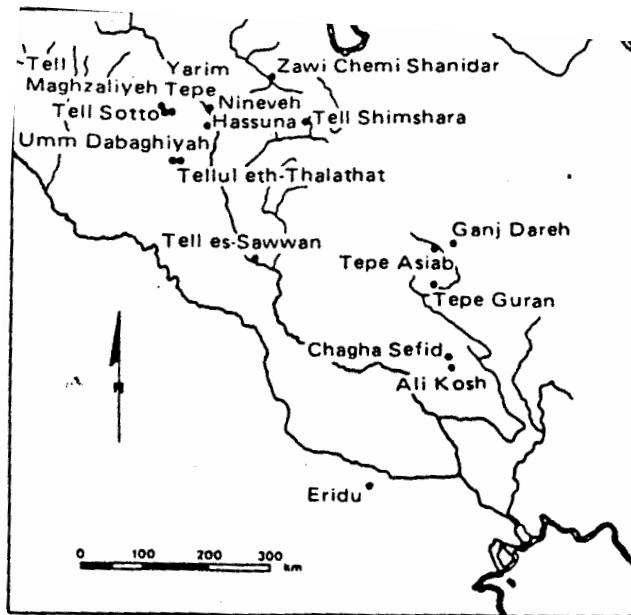


Figure 1.5 Mesopotamian sites with early copper finds (before 5000 B.C.). After A. M. T. Moore, in *Advances in World Archaeology* (Academic Press, 1985), vol. 4, 39, fig. 1.21.

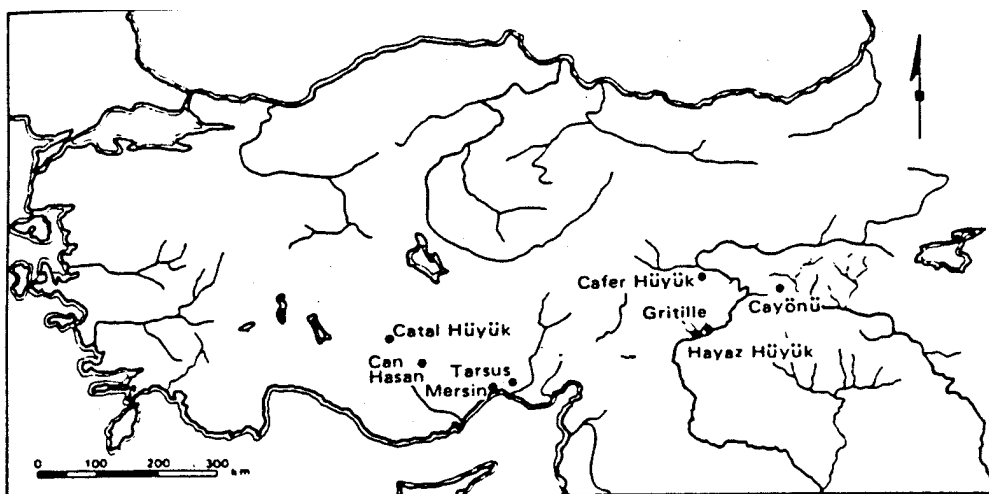


Figure 1.4 Anatolian sites with early copper finds (before 5000 B.C.). After A. M. T. Moore, in *Advances in World Archaeology*, (Academic Press, 1985), vol. 4, 28, fig. 1.16.

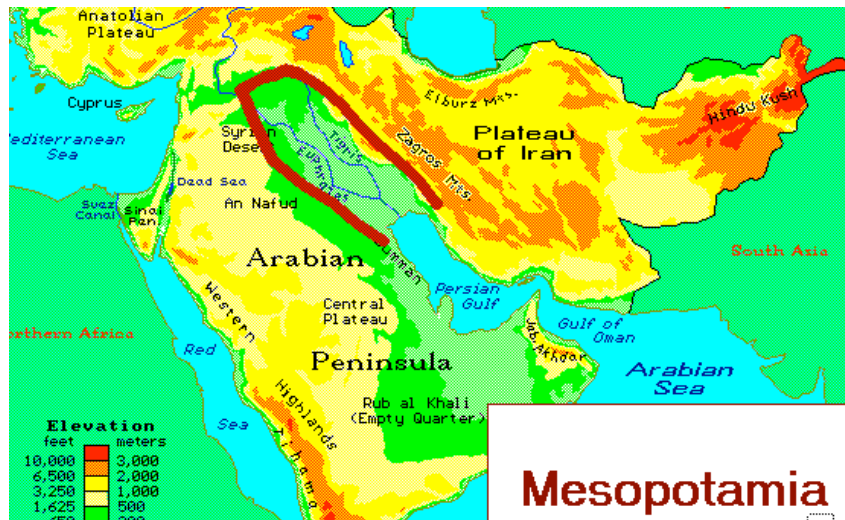
Map from Muhly op cit pp.6,7

Traces of copper mining were discovered in 1968 at *Rudna Glava* in Serbia. Evidence indicates that after exhausting the native copper the miners turned to veins of *malachite* (copper carbonate) that they exploited until reaching 20 meters and hitting ground water. It is thought that this site is representative of copper mining in the Balkans in the period from 4500-4000 BCE. There is also a site at *Ai Bunar*, in

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southern Bulgaria, that's thought to be even older. It's estimated that at this mine approximately 20,000-30,000 tonnes of rock were excavated yielding one tenth that amount of *malachite* and *azurite* and in the end producing somewhere around 500-1000 tonnes of copper.¹³²

The early metal trade routes were based on even earlier (i.e. pre-copper age) trade.



*"In Syro-Mesopotamia interregional exchange networks developed early; by the fifth millennium obsidian was traded along the major trade routes from Anatolia southward. This long-distance exchange was stimulated in the north by the vast differentiation in the environment from the mountainous, resource-rich areas of eastern Anatolia via the vast, flat, rain-fed, fertile plains of northeastern Syria to the alluvial, irrigated plains of the south. This differentiated, but complementary, distribution of resources facilitated the development of an interdependent long distance trading network"*¹³³.



malachite



azurite

¹³² Bronze Age Silver and Gold <http://www.geology.ucdavis.edu/~cowen/~GEL115/115CH6.html>

¹³³ Marilyn Kelly-Buccellati *ibid* p.125

Tin

Relatively scarce, tin appears in the Earth's crust with a frequency of about 2 ppm. It's a *post-transitional metal* with the atomic number 50 and the symbol *Sn* from the Latin *Stannum*. Tin is most often smelted from the mineral *cassiterite*, where it occurs as an oxide, SnO_2 . *Cassiterite* and other tin bearing minerals are almost always found in granite. Tin's high specific gravity and corrosion resistance means that most of it is extracted from deposits found downstream from the primary lodes. Because of its low melting point tin can easily be smelted from *cassiterite*.



Cassiterite

Tin has both special importance and raises particular problems. On one hand it is key to making tin-copper alloy bronze. On the other hand no tin has been found in the zone in question. Bronze objects exist there from the 4th millennium BCE, most of these are arsenical rather than tin alloyed bronzes. But it's not until around 2,700 BCE that bronze appears in greater quantity and with a higher ratio of tin. The source of the copper is more easily understood. There are local deposits. However the source, or sources, of the tin remain uncertain.¹³⁴

The source of this tin has been sought as far afield as Cornwall in the United Kingdom – something that remains a possibility. Ancient mid-Eastern texts refer to tin coming from the East. Some people have claimed that the source should be sought in Thailand. Bronze artifacts are found there dating from 3600 BCE. Atomic absorption spectroscopy has determined that they contain 2.5% tin indicating that it's an intentional alloy. Other perhaps more likely sources of tin include: Turkey, Lebanon, the Caucasus, and Iran. Another possible source was more recently discovered in Afghanistan. There is some evidence that tin could have come from the Harrapan civilizations of India's Indus Valley.¹³⁵ There are major deposits closer to Mesopotamia, in the desert North East of Aswan. On the other hand the Egyptians did not alloy copper with tin until sometime after 2000 BCE.

¹³⁴ S. Cleuziou and T. Berthoud, *Early Tin in the Near East*, *Expedition* (Fall 1982) p.14 cf also <http://www.geology.ucdavis.edu/%7Ecowen/%7EGEL115/115CH4.html>

¹³⁵ *ibid* pp.16, 17

Wherever the source or sources laid research has left us with very clear picture of the enormous range of Mesopotamian trade routes. For example, cloves *Eugenia aromatica* dated 1700 BCE have been discovered in what is now Northern Syria. These must have come, directly or indirectly from the *Molucca Islands* off the coast of Indonesia.¹³⁶

Lead

A *post-transition metal* with the Latin name *plumbum*, lead has the symbol *Pb* and the atomic number 82. *Pb* is an abbreviation of its Latin name which was applied to all soft metals; originally it was *plumbum nigrum* (literally, "black *plumbum*"), where *plumbum candidum* (literally, "bright *plumbum*") was tin. Lead is relatively common with the Earth's crust containing about 12 ppm. Native (i.e. metallic) lead does occur in nature, but it is rare. Lead is usually found in ore with zinc, silver and (most abundantly) copper, and is extracted together with these metals. The mineral ores of lead are most often *galena* (PbS), which contains 86.6% lead and *cerussite* (PbCO₃).



cerussite

Because it is widespread, easy to extract and easy to work with, lead has been widely used for thousands of years. Metallic lead beads dating back to 6400 BCE have been found in *Çatalhöyük*. In the early Bronze Age, lead was used with antimony and arsenic. Lead is mentioned in the book of Exodus (15:10).¹³⁷

Antimony

A *metalloid* with the Latin name *stibium* (from the word for "mark") Antimony has the symbol *Sb* and the atomic number 51. Antimony is quite rare with estimates of its abundance in the Earth's crust range from 0.2 to 0.5 ppm. In its elemental form it is a silvery white, brittle, fusible, crystalline solid that exhibits poor electrical and heat conductivity properties and vaporizes at low temperatures. Antimony resembles a metal in its appearance and in many of its physical properties, but does not chemically react as a metal. Antimony and some of its alloys are also unusual in that they expand on cooling.¹³⁸

¹³⁶ D. T. Potts, *Mesopotamian Civilization the material foundations*; Athlone, London (1997) p.269

¹³⁷ <http://en.wikipedia.org/wiki/Lead>

¹³⁸ This is also true of gallium, bismuth and of course water.



Antimony

Pliny the Elder distinguishes between male and female forms of antimony. He says *"In the same mines in which silver is found, there is also found a substance which, properly speaking, may be called a stone made of concrete froth. It is white and shining, without being transparent, and has the several names of stimmi, stibi, alabastrum, and larbasis. There are two kinds of it, the male and the female. The latter kind is the more approved of, the male stimmi being more uneven, rougher to the touch, less ponderous, not so radiant, and more gritty. The female kind, on the other hand, is bright and friable, and separates in laminæ, and not in globules"*.¹³⁹

Some have interpreted the male form as the sulfide, and the female form as native metallic antimony.¹⁴⁰ There are numerous references to the use of the natural sulfide of antimony, stibnite, as medicine and a cosmetic. In the early centuries of this era we find for example a saying of Muhammad that: "Among the best types of *collyrium*¹⁴¹ you use is antimony (*ithmid*) for it clears the vision and makes the hair sprout."¹⁴² However, it is uncertain as to whether references to antimony as an eye cosmetic in the ancient world do in fact refer to the element of interest to us. Analyses of ancient Egyptian eye-paint do not show the presence of antimony in any meaningful amounts.¹⁴³ In any case it is more likely that the antimony used in the ancient world was from the relatively rare occurrences of native metal found in

¹³⁹ Pliny, *Natural history*, 33.33; *The Natural History*. Pliny the Elder. Translator, John Bostock, London. Taylor and Francis, Red Lion Court, Fleet Street. (1855) online at <http://www.perseus.tufts.edu/cgibin/ptext?doc=Perseus%3Atext%3A1999.02.0137&query=head%3D%232348>

¹⁴⁰ as mentioned at <http://en.wikipedia.org/wiki/Antimony> fn2

¹⁴¹ i.e. eyewash or eye medicine

¹⁴² *Sunan Abu-Dawud* (Ahmad Hasan translation), Book 32, Number 4050. *Sunan Abu-Dawud* is a collection of sayings and actions attributed to Muhammad (such sayings compose the *sunnah*, the reports of these are called the *ahadith*). This collection was assembled by the 9th century CE Afghan born Abu-Dawud (Abu-Dawud Sulaiman bin Al-Aash'ath Al-Azdi as-Sijistani. available online at <http://www.muslimaccess.com/sunnah/hadeeth/abudawud/032.html>

¹⁴³ P.R.S. Moorey, *Ancient Mesopotamian Materials and Industries*, Clarendon Press, New York, (1994) p. 241

limestone or marble deposits.¹⁴⁴ There are such deposits in mines in present day Iran, Kurdistan and Transcaucasia.¹⁴⁵

Antimony can be found as a trace element in ancient Mesopotamian bronzes. It is found in association with ores. Like arsenic, in small quantities it has a hardening affect on copper. There are also a small number of purported antimony metal artifacts that have been discovered. One is a metallic antimony tablet, another was said to be part of a Chaldean vase of pure antimony dated to around 3,000 BCE.¹⁴⁶ There have also been finds of beads, and other small ornaments made from pure antimony as well as alloys. **There are great difficulties in working with antimony and some have seen these objects as pointing to a “lost art of rendering antimony malleable”.**¹⁴⁷

Silver

A *transition metal* with the Latin name *argentum* (from the Greek: *ργήντος* - *argēntos*, gen. of *ἀργήεις* - *argēeis*, "white, shining"). Silver has the symbol *Ag* and the atomic number 47. It is very ductile (i.e. it can be reshaped without fracturing) and slightly harder than gold. It has a white metallic luster that can be polished to a great extent. It is the most electrically and thermally conductive of all the metals. It is also the whitest and the one with the highest optical reflectivity overall. Silver plays important roles in a wide and diverse range of activities, e.g., photography (silver halides are photosensitive), medicine (it has antibiotic and antiviral properties) and art (silver nitrate is used to stain glass yellow).¹⁴⁸ Silver is rarely procured in its native state and most often produced in the smelting of other ores, notably the lead mineral galena (PbS), which contains 86.6% lead. Other common varieties are cerussite (PbCO₃).¹⁴⁹

Slag heaps from Asia Minor and the Aegean indicate that silver was being separated from lead as early as the 4th century BCE. Silver ornaments and vases were found at Troy, and in the 19th Dynasty of Egypt. They may well have been made from native

¹⁴⁴ Some claim that the preparation of metallic antimony from stibnite was first carried out by Geber (721-815 CE). However, Berthelot and others argue that this was not the case. Vannoccio Biringuccio, gave the first European description of a technique to isolate antimony in his 1540 CE *De la Pirotechnia* – though Agricola is often given the credit. It has also been claimed that, this was preceded by Basil Valentine in his *Triumphal Chariot of Antimony* (c. 1540). However, the date and identity of Valentine is disputed. Gottfried Wilhelm Leibniz (1646–1716) investigated the identity of Valentinus (a monad?) and decided it was a pseudonym of Johann Thölde (1565–1614) the Englishman who was supposedly translating texts that were miraculously discovered when lightning shattered their hiding place, a pillar of St. Peter's Abbey, at Erfurt in Germany. *Triumphal Chariot of Antimony* is available here <http://www.archive.org/details/triumphalchariot00basirich>

¹⁴⁵ *ibid*

¹⁴⁶ Though this claim continues to today Moorey (*loc cit*) notes that this, was recognized as a misidentification as early as 1887.

¹⁴⁷ *op cit* p242

¹⁴⁸ <http://en.wikipedia.org/wiki/Silver>

¹⁴⁹ <http://weber.ucsd.edu/~dkjordan/arch/metallurgy.html>

silver. However, ore must be smelted to refine silver in quantity, and this cannot have been an easy process to apply on a large scale. Nevertheless, copper smelting was well advanced during the Bronze Age, and silver and lead were being produced (presumably by similar methods) in some quantity in Armenia and Anatolia, both Sumerians and Assyrians traded for it. After the fall of the Hittites, the Assyrians record looting large quantities of silver in raids into the mountains of Anatolia around 880 BC.¹⁵⁰

Mineral Acids

-Nitric Acid is widely thought to be the first intentionally produced mineral acid. We find its production explained in the 13th or early 14th Century CE *De inventione veritatis* attributed to *Geber* (pseudo-Geber).¹⁵¹ This recipe involves the distillation of vitriol,¹⁵² saltpeter (potassium nitrate KNO₃),¹⁵³ and/or alum.^{154, 155} In an example of mechanisms that should interest anyone who has tried to sort through the texts of traditional alchemy we find that 3 centuries later the recipe (attributed to *Raymond Lull*) has added, to no obvious purpose, *sale nitro et cinabrio*.¹⁵⁶ The addition of *sal ammoniac*¹⁵⁷ would have produced *aqua regia*.¹⁵⁸

-Sulfuric Acid has a more disputed history. Some place its origins as concurrent with that of Nitric Acid. Others say it was 2 or 3 hundred years later. Most histories of chemistry indicate that, in any case, it was not widely known before approximately 1600 CE when *Johann Van Helmont* produced it through the distillation of green vitriol (ferrous sulfate) and burning sulfur. A process for its synthesis by burning sulfur with saltpeter in the presence of steam was first noted by *Johann Glauber* in the 17th century. As the saltpeter decomposes, it oxidizes the sulfur to SO₃, which combines with water to produce sulfuric acid.

The old names for Sulfuric acid, *oil of vitriol* or *spirit of vitriol*, point to its derivation from the mineral compounds collectively known as *Vitriol*.^{159, 160} *Green Vitriol*

¹⁵⁰ Bronze Age Silver and Gold <http://www.geology.ucdavis.edu/~cowen/~GEL115/115CH6.html>

¹⁵¹ Ladislao Reti, *How Old is Hydrochloric Acid*; *Chymia no. 10*, University of Pennsylvania Press, Philadelphia (1965) p.11

¹⁵² Appendix E

¹⁵³ Appendix F

¹⁵⁴ Geber, *The Book of the Invention of Verity or Perfection*, Chapter XXIII in *The Work of Geber* edited by E. J. Holmyard; London & Toronto (1928) p.223

¹⁵⁵ Appendix G

¹⁵⁶ Reti op cit p.14

¹⁵⁷ Appendix H

¹⁵⁸ Editor's comment in his translation of Georgius Agricola *De Re Metallica*, Dover; New York (1950) fn 21, p460

¹⁵⁹ See Appendix E

¹⁶⁰ In *L'Azoth des Philosophes* attributed to Basilius Valentinus this is presented as an (retroactively formed) acronym for *Visita Interiora Terrae Rectificando Invenies Occultum Lapidem* i.e. 'Visit the interior of the earth and rectifying you will find the secret stone'.

contained *iron (II) sulfate heptahydrate*, $\text{FeSO}_4 \cdot 7 \text{H}_2\text{O}$. Heated it decomposes to Iron oxides, water and sulfur trioxide which in turn combine producing Sulfuric Acid¹⁶¹. *Blue Vitriol*, contains *copper (II) sulfate pentahydrate*, $\text{CuSO}_4 \cdot 5 \text{H}_2\text{O}$. These compounds decompose as with Green Vitriol but this time to Copper oxide. Preparations like these have been ascribed to alchemists including the 12th-century Arab *Abu Bekr al-Rhases* and the 13th-century German *Albertus Magnus*.

-Hydrochloric Acid has a history that is usually seen as beginning toward the end of the 16th Century CE. and *Basil Valentine*.¹⁶² He is usually credited with the first written reference in a recipe for the preparation of an *aqua caustica* by the distillation of vitriol and common salt. However, as early as 1875 evidence was presented that these references were written “after and not before Paracelsus.” Other candidates include *Battista Della Porta* in 1589 (using salt and bricks, and another recipes using vitriol and sal ammoniac), *Libavius* in 1595, *Van Helmont* sometime before 1646 (using common salt and dried potter’s clay), *Glauber* 1648 (used green vitriol and alum and in 1658 to salt and oil of vitriol).

There are also older descriptions of processes purportedly for other purposes but that could produce hydrochloric acid. For example, in *Biringuccio’s Pirotechnia*¹⁶³ (published in 1540) there is a recipe for dyeing involving vitriol, alum, sal ammoniac, and cinnabar (or verdigris). These were distilled in an alembic. The presence of cinnabar, as in the Pseudo-Lullian Nitric Acid recipe mentioned above, would likely not interfere with the production of the acid. In *De Re Metallica*, Agricola gives a recipe for *Aqua Valens* (Parting Water) that involves that also might have produced hydrochloric acid.^{164, 165}

Hydrochloric acid would also have been generated in the process of *cementation* used to purify gold.¹⁶⁶ There are other clues pointing to, at least, the potential generation of hydrochloric acid before Glauber, et al in the 17th century CE.

Another recipe of Geber – or pseudo Geber (circa 1300 CE) involves mercury “...heated in the presence of salt, alum and/or ferrous sulfate, the hydrochloric acid generated will react with the quicksilver and its chloride will sublime in form of thin white needles. I cannot believe that from among the old alchymists who repeated this experiment... there was not one who was tempted to investigate what would happen if

¹⁶¹ In a similar way one could begin from Iron Pyrite (iron disulfide, FeS_2) which would be heated in air to yield iron (II) sulfate, FeSO_4 , which then oxidized by further heating in air would form iron (III) sulfate, $\text{Fe}_2(\text{SO}_4)_3$, which when heated to 480°C would decompose to iron (III) oxide and sulfur trioxide, which passed through water would yield sulfuric acid.

¹⁶² Cf. above fn 144

¹⁶³ Biringuccio *Pirotechnia* Cambridge University Press, Cambridge (1966) p.382

¹⁶⁴ *aqua valens* was *Parting Water* because it was used to *part* silver from gold.

¹⁶⁵ *Reti loc cit*

¹⁶⁶ Cementation involves the gold being beaten into paper-thin leaves. These would have certain substances (e.g. salt and vitriol or alum) sandwiched between them. The laminated sheets were heated and hydrochloric acid generated.

one or the other components were omitted...if quicksilver is left out a clean stream of gaseous hydrochloric acid is generated just as in the experiment described for the first time by Glauber in 1648."¹⁶⁷

Summary regarding Substances

It is clear that the basic substances used in our process would have been available from Sumerian times. As we will see, the distillation techniques available from earliest times (e.g. Tepe Gawra) could well have allowed for the production of the three mineral acids – theoretically at least. The next step would involve practical proof that it is doable, something our previous work with the *cisne* partially confirms. Of course, in any case even if we show in practical terms that this is possible, it in no way provides any evidence that it was in fact done.

In terms of the other substances that are important for this discussion, we should note the various forms of water and fire. The question of the forms of fire, beyond that of *Our Fire* (already discussed) will be examined in our discussion of apparatus rather than substances. We will deal with those substances whose early use is even more speculative (e.g. electricity) in the same way—that is, in the discussion of apparatus, or procedures, rather than substances. As for the various forms of water we will only point out that distillation, even in a rudimentary form using retorts alone, guarantees the production of one of the necessary forms of water. The other unique form does not even require this much technology. *It should be kept in mind that this question of varieties of water is framed within the context of Mesopotamia where everything begins with the separating of waters*¹⁶⁸.

Apparatus

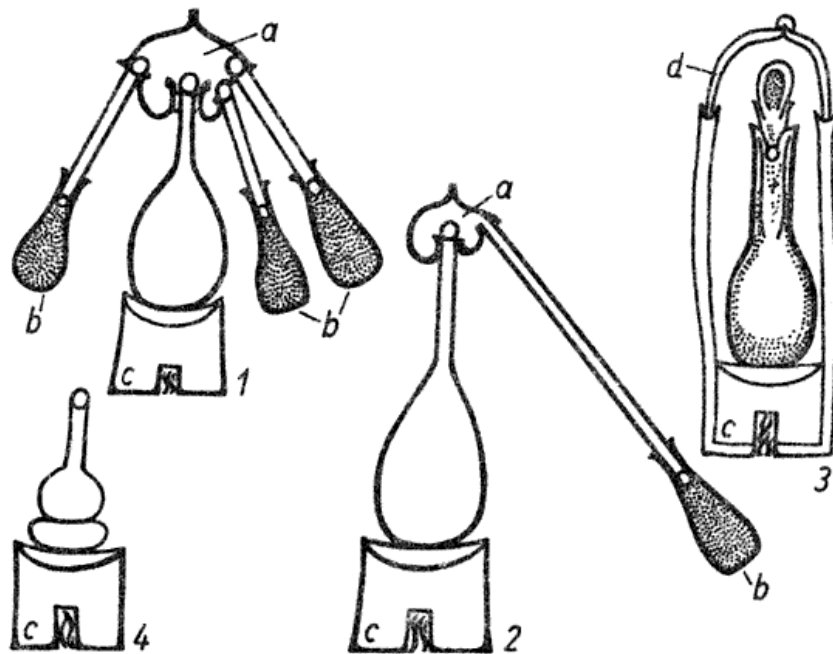
As pointed out earlier, almost all of the apparatus, substances and procedures known to the Arab and Medieval alchemists were already in use (certainly in a more primitive form) in Neolithic Mesopotamia. Some will object that distillation, for example, was unknown until the 8th or even 12th Century C.E. And indeed this was the orthodox historical notion until very recently when the information included below about early Mesopotamian distillation was finally accepted. Others will argue that the mineral acids, weren't known until for example, around 800 AD when Jabir ibn Hayyan (Geber) recognized the mineral acids. However, once you have distillation – even with the most primitive of apparatus—there are in principle no insurmountable barriers to the distillation of these 3 acids as well as other acids and other substances (including, as we know well, spirits of wine).

¹⁶⁷ Reti op cit p.16

¹⁶⁸ Cf. pp.34-36 above



Jabir ibn Hayyan



In the pre-metallurgical epochs we will find tools, containers and apparatus of various types of wood, stone, bone, and ceramic. There will also be glass from extremely ancient times in the natural form of obsidian.¹⁶⁹ By the 4th millennium BCE ceramic vessels were coated with a glaze made from crushed quartz. These are the first known examples purposely-manufactured glass. The technique appears in both Mesopotamia and Egypt.¹⁷⁰

¹⁶⁹ The site known as *Kaletepe Deresi 3*, in what is now central Turkey, was discovered in the summer of 2000. Ancient volcanic activity in the region had generated a number of obsidian intrusions, which throughout prehistory attracted humans to the area. Archaeologists say that the mineral industry at the site shows technologies and behaviors related to extraction and manufacture through the Lower and Middle Paleolithic. Cf. Ludovic Slimak, *et al*, *Kaletepe Deresi 3 (Turkey): Archaeological evidence for early human settlement in Central Anatolia*, *Journal of Human Evolution*, Volume 54, Issue 1 (2008), pp.99-111

¹⁷⁰ CF. pp.37-39 above

The apparatus, procedures and substances in use before the Alexandrian synthesis would have been drawn from a range of craft and domestic technologies: ceramics, metallurgy, pharmacy, cooking, etc. Obviously the ceramic revolution made available a much wider range of robust apparatus. Besides storage containers (mostly ceramic) there were also those meant to be heated. Other containers were designed for specific chemical processes known at the time. These procedures include extraction, sublimation and as we have mentioned, distillation. Our major source for information about these early chemical technologies—as in the earlier report on Mesopotamian distillation—remains the works of Levey¹⁷¹ and Forbes.¹⁷²



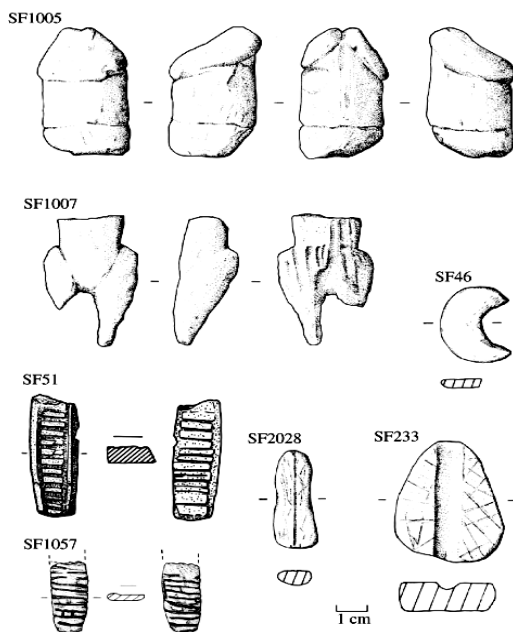
a variety of Sumerian containers

¹⁷¹ Martin Levey *Chemistry and Chemical Technology in Ancient Mesopotamia*, Elsevier, Amsterdam 1959, and his articles in *Chymia: Annual Studies in the History of Chemistry* Vols 1-12 (1948-67)

¹⁷² especially R.J. Forbes 9 volume *Studies in Ancient Technology*

Mortars and Pestles

There are many examples of both Neolithic and Paleolithic grinding devices of all types. Grinders and mills were, and continued to be, made of stone especially when they were intended for the processing of hard material like mineral ores or glass. Levey tells us that there are excellent examples of mortars (*abanNA*) and pestles (*amittu*) from Tepe Gawra.¹⁷³ In some cases these are definitely pre-Neolithic. Further south in the Levant we find some examples interesting for their design as much as their age. The penis shaped pestles and accompanying mortars from the archeological site known as WF16 discovered in 1996 and situated a few hundred km south of Jericho.¹⁷⁴ The association of the mortar and pestle with the male and female sex organs, the lingam and yoni (i.e. in both a secular and sacred sense), is widely reported.



Penis shaped pestle from WF16

For example, “Explicit sexual imagery is found on stone artifacts and bowls from the Northwest of America from 5000 years ago to the nineteenth century. In the Old Testament, Job (31:9–10) uses a mortar and pestle grinding grain as a metaphor for sex. Among the Shona people of Zimbabwe, domestic artifacts are imbued with sexual meanings on the basis of their shape; Shona men were believed to become impotent if they sat upon a mortar (Jacobsen-Widding 1992). In modern day Jordan, the language of cultivation is replete with sexual associations; the name for the stole of the ard being the same as that for penis, and the relationship between the ard and the land

¹⁷³ Martin Levey, *ibid*

¹⁷⁴ Steven Mithen, et al; *Sexual Symbolism in the Early Neolithic of the Southern Levant: pestles and mortars from WF16* 2005 Oddelek za arheologijo, Filozofska fakulteta - Univerza v Ljubljani

*being seen as similar to that between men and women (Palmer 1998). With regard to food itself, Camporesi's (1993, p. 16) study of nineteenth century Italian peasant society described bread as the 'most grandiose sexual metaphor ever invented'.*¹⁷⁵

Sieves

Ceramic (earthenware) strainers are known from before the 3rd millennium BCE. Some of these devices would have been covered with a wool or hair strainer. This sort of filtration is mentioned in pharmaceutical texts dating back to 2200 BCE. Another approach to filtration involved putting the solution requiring filtering into an unglazed clay container. This, in turn was placed in a larger glazed container. The filtrate would pass through the unglazed ceramic's pores and pass into the glazed storage container.¹⁷⁶ In a similar way, even today in certain regions potable liquids are kept in unglazed pitchers and the water evaporating through the pores keep the liquid cool.

Furnaces

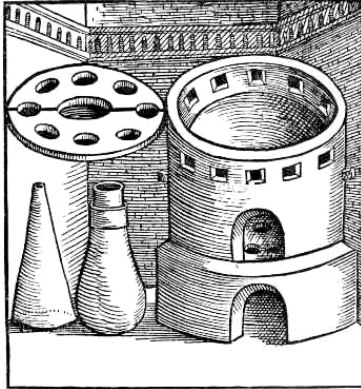
Levey draws on the writings about ancient Mesopotamian perfumery, glassmaking and other crafts to make clear that they were already using a enormous range of techniques, substances and more or less specialized apparatus. He also notes that the Mesopotamians clearly differentiated between types of fire.¹⁷⁷ They used a variety of small, portable furnaces depending on the situation. Some were used for heating materials and others for boiling liquids, distillation, for use in perfumery, etc. There are samples dating back to the 4th millennium BCE. These are made of clay and generally shaped like a tower or house approximately 70 to 95 cm in height. They had draft holes (often triangular) cut out of them and also a stokehole or opening at the bottom for fuel. This entrance would have also served as an air inlet. Rather than a grate, the round top could hold a round bottom pot, which was the typical form as we see in the example of the distilling pots from Tepe Gawra (see below pp. 56-58). Such furnaces persist through prehistoric Europe well into the middle ages and can be seen in the *mustauqads* of the Arab alchemists world.¹⁷⁸ See further illustrations below (pp.58-59).

¹⁷⁵ Steven Mithen, *Did farming arise from a misapplication of social intelligence?* Philosophical Transactions of the Royal Society *Biological Science*. (2007) April 29; 362 1480: 705–718
<http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2346509>

¹⁷⁶ Levey, *op cit* pp.14-15

¹⁷⁷ Levey *Op Cit* p.20

¹⁷⁸ Levey *Op Cit* pp.22-23



Medieval Arab portable hearths

Larger kilns, furnaces and ovens of various kinds were known from very early on. Of course the oldest type of kiln (in terms of its function) is the bonfire. Even today an expert potter using these most primitive ovens can create fine ceramics, by carefully keeping the fuel (grass, wood or dung), and the flames from direct contact with the objects being fired.¹⁷⁹

There are images that show domed kilns topped by short exhaust chimneys (too short to have supplied draft), they look very similar to modern brick kilns.¹⁸⁰ Many other types and forms of furnaces were used in ancient Mesopotamia. *“Domed furnaces were widespread in Mesopotamia, with the earliest examples of domed construction going back to the prehistoric Tell Halaf period. In fact the beehive-shaped oven is still used...”*¹⁸¹ Glass kilns came in both a domed form and the so-called *KURI SA SIKNAT ENDIT-PEL-SA* the furnace with a floor of eyes¹⁸². There were also annealing ovens that worked at lower temperatures. Of course by the late 5th millennium BCE and the beginning of the *Chalcolithic* (Copper Age), there were also smelting furnaces.

By 5000 BCE most kilns could have fired to a maximum of between 850 and 1050° C. but in at least one case (Samarra) it is calculated that they were reaching temperatures of approximately 1,100° C.^{183, 184}

¹⁷⁹ K Hesseberg *The Complete Potter: Sawdust Firing*, University of Pennsylvania (2002) p.78

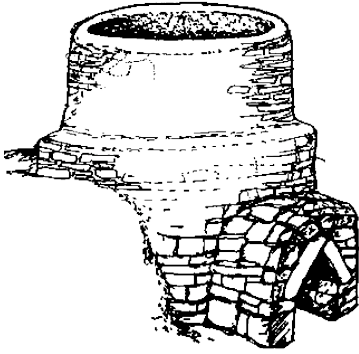
¹⁸⁰ Levey loc cit

¹⁸¹ Levey op cit p.26

¹⁸² These eyes were the holes that allowed glass to be gathered and also reheated. It “was the founding furnace (‘that where the workmen work’).” Davison, et al, *The Conservation and Restoration of Glass*, Elsevier, Oxford (1989) p.136

¹⁸³ Moorey op cit p.150

¹⁸⁴ The attained temperatures are in dispute. Compare the measurements made by Masahiro Baba and Masanori Saito (Japan) of the Institute of Egyptology at Waseda University, Tokyo their figures were based on measurements using a bonfire, a bonfire in a pit, a mud covered bonfire and a simple updraft kiln with a separate hearth and firing chamber. They recorded temperatures of less than 800°C, 800°C, 950°C and 870°C respectively. However, we don’t know anything about the fuels that were used. These figures should be compared with Silo’s in *Collected Works Vol 1, Universal Root Myths: Sumerian-Akkadian Myths*, Latitude Press fn 2 p.317



Fuel

Regarding the fuels used in Mesopotamia, Levey refers to a description in a 7th Century BCE text on glass; if it is typical the preferred fuels of the time were *willow* and *mulberry* and *styrax* or other resinous woods. Resinous fuels in general produce higher temperatures; compare for example, *pine* at 5085 calories or *fir* at 5035 compared to *oak* and *ash* at 4620 calories and 4711 respectively.¹⁸⁵ Further to the South East in early Iron Age Palestine (i.e. 2nd millennium BCE) fuel was probably primarily dung and some imported charcoal as well as the same dried shrubs and bushes used in the same region today.¹⁸⁶ Moorey on the other hand notes that straw and dung supplemented wood, and that potters in the Near East still use a range of fuels to reduce the burning of expensive wood, and charcoal. These supplements include: agricultural waste, sawdust, and bones.¹⁸⁷

¹⁸⁵ Ian Greogory, *Kiln Building*, A&C Black, London 2001 p.14

¹⁸⁶ Levey op cit p.21

¹⁸⁷ Moorey op cit p.144

Procedures and Apparatus

Obviously it is difficult, if not impossible to separate procedures, from the apparatus used to carry them out. And vice versa. There can be no doubt that almost every procedure and apparatus involved in the Material Discipline can be found in some form by the early Neolithic. Many of them can be found much earlier. And many remain unchanged for thousands of years and often to the present day. Of course the existence of archeological evidence for the particular apparatus needed for a specific procedure does not in any way imply anything beyond the possibility of the procedure being known and used.

From the earliest Neolithic, ovens, pots, containers of all sorts as well as grinders, mills, mortars and pestles, sieves and other devices for purification, separation (e.g. of wheat and chaff), mixing and storing were used in cooking, perfumery, pharmacy and diverse chemical processes (e.g. tanning, dyeing, making glue, etc). While the corresponding procedures may seem simple and self-evident at this date, they represent hard won knowledge accumulated since the appearance of our earliest tool using ancestors. As we have noted below, it seems that there are even apparatus for very specialized chemical process, like distillation, and sublimation that date from approximately 3500 BCE.

As noted earlier in the discussion of mercury on p37 above, it seems quite certain that the Sumerians were familiar with the procedure and apparatus for sublimation. Levey supplies persuasive linguistic evidence when he notes that the Babylonian word for Mercury (*IM.KAL.GUG*) derives from *IM.KAL* i.e. soot and means Soot/Sublimate of the red.¹⁸⁸

The following information appeared in my previous report on the earliest examples of distillation.

Levey argues for the origins of Arabic chemical/alchemical techniques in a line going back to Mesopotamia¹⁸⁹. He says that while written knowledge came into this synthesis from the Greeks the techniques were transmitted in craft/sciences from very early Mesopotamia. He illustrates this argument with research on the excavations at Tepe Gawra.

-Tepe Gawra

The number of architectural remains from these early periods at Tepe Gawra makes it one of the most important sites of N Mesopotamia. The name Tepe Gawra (tē'pē gourā') comes from the Kurdish words meaning "great mound." This site is located in N Iraq, 24 km NE of Mosul. In 1927 the archaeologist Ephraim Speiser discovered

¹⁸⁸ Levey, Martin *Chemistry and Chemical Technology in Ancient Mesopotamia*, Elsevier Publishing, Amsterdam (1959) p.36

¹⁸⁹ Many published in the now defunct review *Chymia: annual studies in the history of chemistry*, University of Pennsylvania Press.

it to be the site of ancient settlements. In all, 24 levels and sublevels were unearthed; they date from the 5th millennium B.C.E. to the 2d millennium B.C.E.

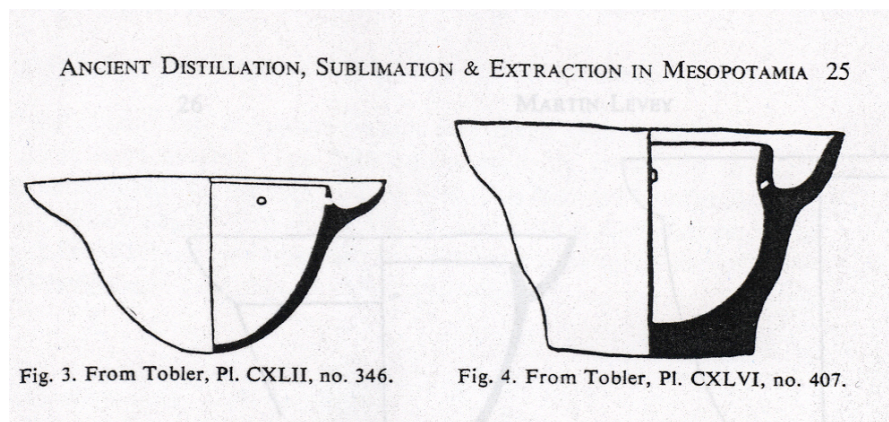
The levels are numbered from top to bottom. Interestingly the upper levels were not very distinctive; apparently they show a type of civilization less advanced than that found in the lower levels. In the lower levels the chronological sequence of the Halafian (c.5000 B.C.), Al Ubaid (c.4100–3500 B.C.), and Jemdet Nasr (3500–3000 B.C.) periods is well represented. The three monumental temple remains on an acropolis of the 13th level represent the finest architecture at the site.

-Distilling and Extracting

Among the fragments of earthenware pots excavated from levels ix-a and ii (dating to approx 3500BCE) were samples of peculiar double-rimmed pots. Prof. Martin Levey (Pennsylvania State University) assembled the fragments of these pots (in the 1950s ??) and claimed that they represented the oldest stills known. He could find no other pots of this type described at any other sites (anywhere.)

In fact Levey describes two sub-types of this pot. One has a solid inner rim; he says this was a distillation apparatus. The other has holes in the inner rim that would allow it to drain. This second type is, according to Prof. Levey, an extraction apparatus. The working of the apparatus is described in some Akkadian perfumery texts (from much later than these pots, dating to 1200 B.C.E.) and corresponds to the working of similar apparatus described much later by Muslim alchemists, pharmacists and perfumers.

The extraction apparatus (with holes in the inner rim) is shown in these two drawings.

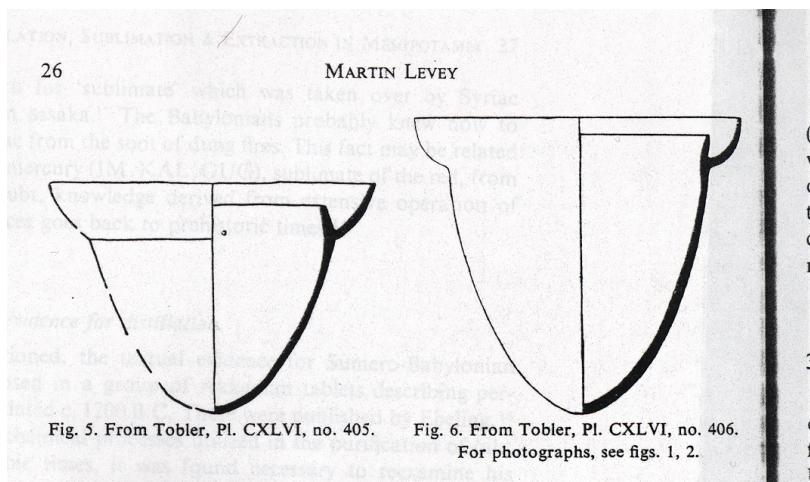


The pot shown in fig.3 is 256 X 496 mm. It is from stratum xi-a. The other is 71 X125 mm and was found in a gram in layer xi. Levey says that perfumers used the type of pot in fig 3 for aqueous, or oil extraction. The raw botanical (or zoological) material was placed in the channel between the rims. In the bottom was the solvent, whether water or volatile oil. The whole device fitted into an oven (described below) and covered. The vapor would condense on the cooler lid and run down into the trough

where it would act on the raw material. This condensate would fall back into the pot through the holes in the inner rim, setting up a process of continuous extraction (like in the soxhlet.)

The second pot is unusually small and also has a flat bottom, which is unusual for these pots. Levey thinks that this pot was heated not with fire but by surrounding it in dung.

Levey says that the distillation apparatus were a more evolved form of these pots. Here are the drawings and photos of the reconstructed pots.



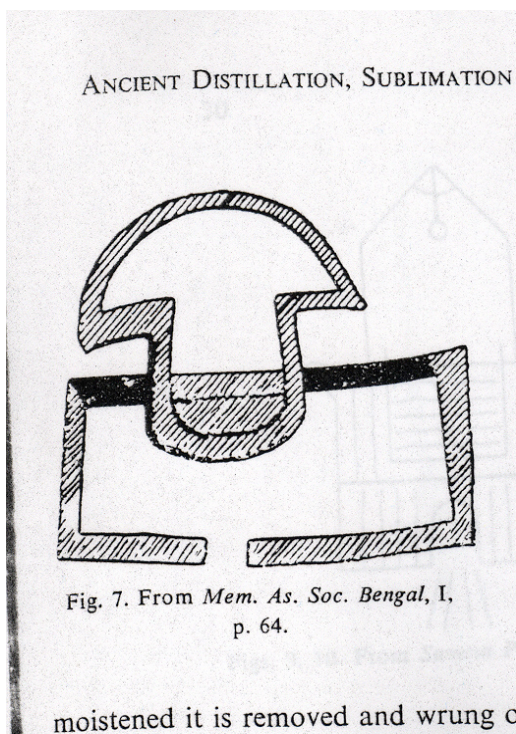
The pot in fig. 5 (from level xi) is 365 X 535 mm. The other is from level ix and is 480 X 530 mm. The channel could hold 2.1 liters of liquid the inner pot 37.3 liters. Levey comments that in actual distillation they would only be $\frac{1}{2}$ or $\frac{1}{3}$ full. Short horizontal scratches apparently made by some kind of spatula mark the channel. Levey notes that these apparatus would require great care, in for example, making sure that the lids and trough (channel) were kept cool in relation to the boiling liquid. He says, "*this did not cause too great a problem to the ancients since, by the 2nd millennium B.C., the Mesopotamians had learned to exert great care in their chemical technological operations*". He notes that this problem (insufficient cooling) was a problem much later for the Muslim alchemists and he quotes Al-Razi to this effect.

In practice the distillation would take place in many repetitions; over and over again a cloth would be used to wipe up the liquid from the channel between the rims. He claims that there are examples of similar approaches to distillation used much later. He cites the example of Alexander of Aphrodisias (c. 200 C.E.) who describes how seawater is boiled and the sweet water obtained by suspending sponges so that the vapours of the liquid condense on them and are absorbed.

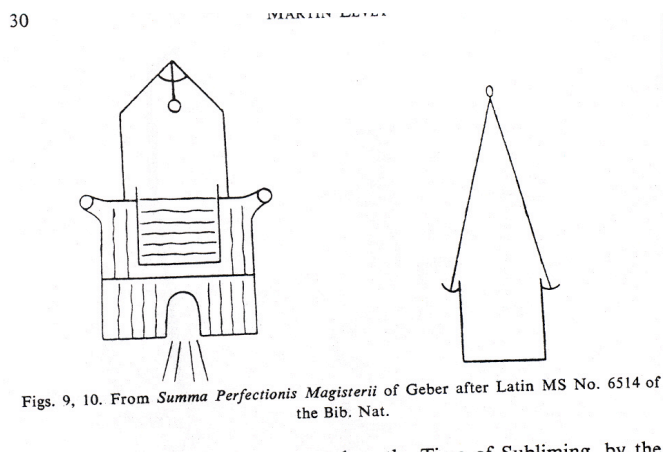


Figs. 1, 2. Two views of Tepe Gawra pot c. 3500 B.C. Photographs courtesy University Museum, Philadelphia.

He also notes 2 similar techniques used in Arab alchemy. He quotes an example from Al-Razi (c. 900 C.E) that involves the use of wool in the upper part of a two-stage apparatus to absorb the sublimate. From time to time the liquid would be extracted from this wool. He also gives an example that used the apparatus shown here. It has a wide brim or ridge with a trough all around it to retain the sublimate condensing on the cooler lid and returning down into this channel.



In the following diagrams from Geber he says we have further examples of apparatus based on this principle. In each of them a channel catches the condensed material falling from the (cooler) lid.



Levey says that the round bottom pots fit into a base, which was the oven. It would be constructed so that the heat would come up to the level of the liquid in the pot. This would allow maximum heating of the liquid and minimum heating of the lid. The following figures show (fig. 11) such a device from level xi and (fig. 12) a latter device of the Muslim alchemists.

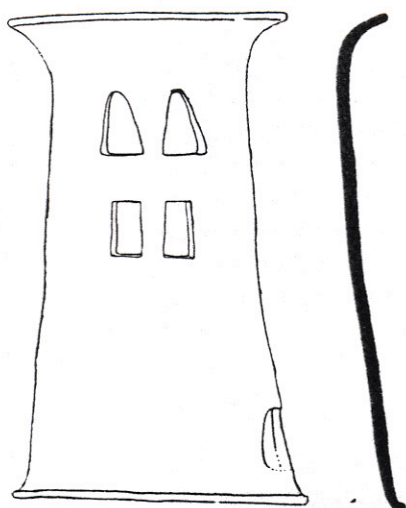


Fig. 11. From Tobler, Pl. CXLVIII, no. 435.

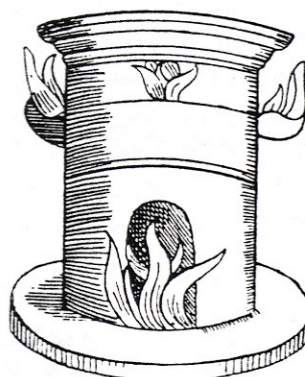


Fig. 12. From Geber's *Artis Chemicæ Princeps* (Basle: 1552).

To this previously reported information I would like to add the following observations based on the work of Needham et al.

While those working in our Material Discipline can verify, even the simplest retort, including the Tepe Gawra still, can allow the distillation of *spirits of wine* (ethanol). After many decades during which historians of technology believed that alcohol could not have been distilled until the invention of condensers allowed the cooling of the distillate. There was some dissent but this was the view one would find until very recently in any text on the history of science. Then in 1980 as part of this debate Anthony Butler and Joseph Needham published a study in which they experimentally compared the efficiency of four early stills (retorts).¹⁹⁰ Of course there were some who still ignored the evidence that distillation of wine spirits was possible even with the most primitive of alembics.

Ancient Understanding of Electricity

Just as academics assumed that distillation of *aqua ardens* (*burning water* or *water of fire*) from wine was impossible before the 12th Century CE, they have ignored or underplayed the interest that the ancients had in what we would now consider electromagnetic phenomena. Though very late by our standards, even the existence of the 13th Century CE work of *Petrus Peregrinus* (*Peter* or *Pierre* of Maricourt) on magnets makes evident the lack of basis for such assumptions.¹⁹¹ It is difficult to

¹⁹⁰ A. Butler, J. Needham, *An Experimental Comparison of the East Asian, Hellenistic and Indian (Gandharan) Stills in Relation to the Distillation of Ethanol, and Acetic Acid*. *Ambix: the journal of the society for the history and philosophy of science* Vol XXVII Number 2 (July 1980) p.69

¹⁹¹ Petrus Peregrinus de Maricour, *The Letter of Petrus Peregrinus, on the Magnet A.D. 1269*, Translated by Brother Arnold, McGraw Publishing; New York (1904) available at <http://www.archive.org/details/letterofpetrusp00pieriala>

imagine that the most brilliant, observant and thoughtful minds of ancient times would not turn their attention to phenomena as wondrous as magnetism, lightening, St. Elmo's Fire and other luminous electrical atmospheric phenomena (aurora borealis, ball lightening, etc.), the shock of electric-fish like the torpedo ray, and electrostatic effects especially—in the eponymous case of amber (i.e. *Elektron* in Greek hence our word *electricity*). Of course the ancients had no reason or underlying theory to unite these seemingly disparate phenomena. In fact such unifying notions would have to wait until the 19th Century CE and the work of Faraday, and Maxwell. However, while Thales of Miletus (circa 624 BCE to 46 BCE) is credited with the “discovery” that amber can attract light objects it seems unlikely that others would not have noticed this as well as other examples of static electricity. But besides the mysterious “magical” qualities they share, there's nothing that would have made electrical and magnetic phenomena seem related to each other. And while Maxwell had not yet shown how electricity and magnetism were aspects of electro-magnetism it was evident that both magnets (towards iron) and amber (to various small, light objects) exercised some kind of attraction over a distance.

If magnetism was thought to have begun with Gilbert in 1600 CE, Electrolysis is usually thought to have begun 200 years later with Alessandro Volta's “voltaic pile”.¹⁹² However there are other possibilities.

Parthian Batteries

In 1938 *Wilhem König*, a German archeologist and Director of the National Museum of Iraq, uncovered a curious item among the institutions collections. It was a relic originally uncovered in a dig near *Khuyut Rabbou'a* outside of Baghdad.¹⁹³ Dating back perhaps two millennia, it consisted of a (13 cm) clay jar containing a copper cylinder that encased an iron rod. Tests indicated that it had contained an acidic agent, such as vinegar or wine.

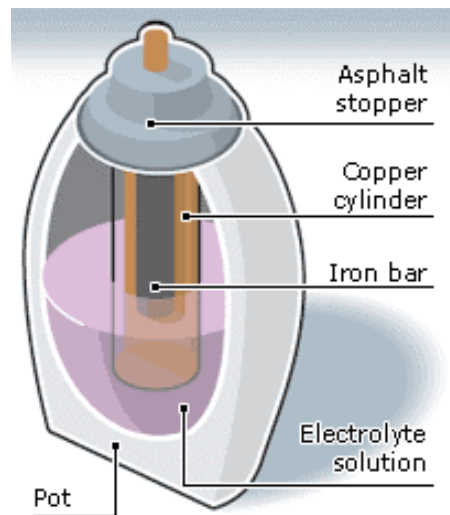
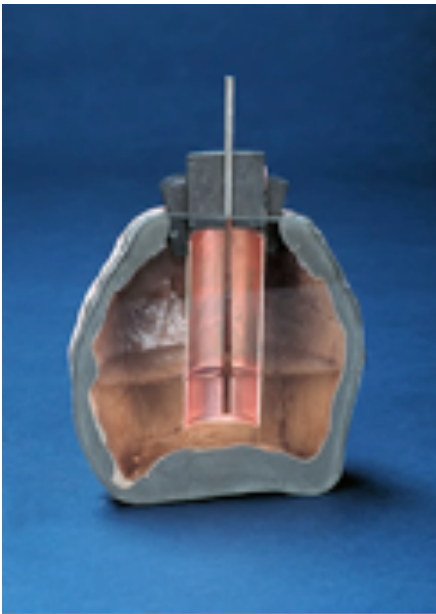
¹⁹² The “original battery” it generated electric current and consisted of discs of silver and zinc with salt-water soaked paper stripes sandwiched between them.

¹⁹³ Sources disagree on many points. For example, some claim he excavated the batteries and others that they were in the museum's collections.

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Since a battery (or voltaic pile) consists of dissimilar metals (electrodes) and an electrolyte (ion carrying solution, like an acid) *König* conjectured that this was indeed an ancient voltaic pile and this device came to be known as the *Baghdad* (or *Parthian*) *Battery*.



He further suggested that the battery was used around 200 BCE for electroplating objects with gold. While all this is far from certain and there are alternative explanations, various later studies have come to the same conclusion: that this is a galvanic cell capable of delivering between 1 and 5 volts, a number that could be increased by wiring a number of such batteries in series.¹⁹⁴ In any case, given the required technologies such batteries could have been built in the early Neolithic (using native i.e. unrefined metals, like sidereal iron). This of course does not imply that these batteries existed that early or even that the so-called Baghdad Battery

¹⁹⁴ My own tests indicate that a copper wire and an iron nail inserted into a lemon will generate between .45 and .47 volts

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were used for such purposes. It is only one more indication that the apparatus, substances and procedures taken up by historical alchemy and continued even into the Material Discipline were *potentially* available even as early as the beginning of Mesopotamian civilization.

The technological breakthroughs that form part of the so-called Neolithic revolution arose in the same conditioning ambit as the imagery they made them possible and which they in turn enabled. This imagery opened the way for new thoughts, new intuitions and of course new technologies. But key from our perspective, they opened the way for those currents of images, ideas, intuitions and practices that become the historical alchemy and our own Royal Art.

Appendix A

Timeline (dates are only approximate)

NOMADIC HUNTERS - 18,000 to 10,500 BCE

The *Kebaran* were nomadic hunters and gatherers in the Levant and Sinai. They used microlithic tools of all kinds but lacked specialized grinders and mortars that appear later in the Near East and are so important in the kitchen, the workshop of perfumer and healer and of course in another moment that of the alchemist.

Some consider the Kebarans as Paleolithic others as *Mesolithic*. But in general it's agreed that they were a hunter-gatherer culture that existed after the last Ice Age and before the *Neolithic*. Unlike other cultures of the time they were not too affected by the retreat of the ice and the loss of *megafauna*.

EARLY FARMING COMMUNITIES - 10,500-5,000 BCE

10,500 BCE The *Natufian* hunter-gatherers are thought to be descendents of the *Kebarans* and lived a nomadic existence in the same area. Though they were nomadic hunter-gatherers there is material evidence that they harvested wild cereals in what are today Syria and Lebanon. This seems to imply that the production of bread predates *sedentarism*. Since we will later see beer being made from malt (i.e. sprouted grain) they may have also had alcoholic beverages (beer, mead, etc) made from intentionally fermented grain or honey fermented in stone (or leather or wood?) containers. While they had not adapted a settled lifestyle they did build and make use of permanent sites. Perhaps these had a religious purpose function possibly they acted as grain depots. Perhaps they served a combination of these functions.

The Natufians are currently the earliest people known to transition from hunting and gathering to farming. It's thought that severe long-term drought caused by the so-called *Younger Dryas*, a sort of small ice age, forced them to abandon traditional hunting grounds and start farming in a settled fashion.

With the end of the Ice Age around 10,000 BCE the Neolithic revolution had begun. This involved the spread and development of agriculture the domestication of various plants and animals starting with sheep in the North Tigris Valley. Houses were built from reeds or mud-brick and grouped in villages where they tended their crops. They built granaries to store their grain, and they began developing a token system to record trade and accounts.

9,000 BCE End of the Ice Age; domesticated sheep in the North Tigris Valley. Beginning cultivation of wild wheat and barley and domestication of dogs and sheep; inaugurating of change from food gathering to food producing culture - Karim Shahr in Zagros foothills. This is also the period of the oldest level excavated

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to the present at *Göbekli Tepe* ("Hill with a Belly"). It is a site built on the highest point of an elongated mountain ridge about 15km northeast of the town of Sanliurfa in southeastern Turkey. It is a complex and sophisticated pre-Neolithic site thought to have been constructed by hunter-gatherers more than 11,500 years ago. There was another smaller site (*Nevali Cori*) but it was inundated by the construction of the Ataturk Dam.

7,700 BCE Çatal Huyuk in Turkey; obsidian mined for tools; fertility cult indicates use of domesticated cattle.

7,500 BCE Extensive settlement at Jericho, weaving, fortification, remains of cultivated cereals.

7,000 BCE Pottery begins. At Jarmo, oldest known permanent settlement: crude mud houses, wheat grown from seed, herds of goats, sheep, and pigs.

6,500 BCE Copper used in Turkey for trinkets; a dugout canoe used in Holland.

6,200 BCE Copper smelting and textiles at Çatal Huyuk

6,000 BCE Farming in Macedonia; pottery plentiful. Migrations of northern farmers settle in region from Babylon to Persian Gulf. Hassuna culture introduces irrigation, fine pottery, and permanent dwellings; dominates culture for 1000 years, develops trade from Persian Gulf to Mediterranean.

PRE-SUMERIANS 5,500-3,500 BCE

5,500 BCE Irrigation agriculture in the foothills of the Zagros mtns.

5,000 BCE Use of copper in Macedonia begins. Ubaidians develop first divisions of labor, mud brick villages, first religious shrines. Small temple at Eridu – earliest example of an offering table and niche for cult object.

4,500 BCE Invention of the plough

4,000 BCE Semitic nomads from Syria and Arabian Peninsula invade southern Mesopotamia, intermingle with Ubaidian population. Temple at Tepe Gawra built setting style for later examples

SUMERIAN PERIOD 3,500-1,900 BCE

3,500 BCE Sumerians settle on banks of Euphrates. Temple at Eridu – ziggurat prototype

3,300 BCE Writing begins in Sumer; wheeled vehicles and wheel-made pottery, sailboats, and animal-drawn plows in Sumer; agriculture reaches Ireland.

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3,000 BCE Democratic assemblies give way to kingships, evolve into hereditary monarchies.

2,800 BCE Akkadian conquest of Diyala region. Introduction of pictographs to keep administrative records. 3-D statues, e.g. Warka head. White Temple - ziggurat traditional design. Temple at Tell Uqair - mosaic decorations. Cuneiform land sales formal contracts. Eridu and Kish - simple palaces. "Standard of Ur" - war-peace plaque, religious statues, gold and silver artifacts buried in tombs of Ur. Sumerians of Abu Salabikh - first poetry.

2,700 BCE Agriculture reaches China; royal inscriptions appear in Sumer; Sumerian script used in Akkad; Sumerian fashions used in Mari. Gilgamesh, hero of Sumerian legends, reigns as king of Erech

2,500 BCE Writing in Mari (Sumerian script); keeping of daily accounts in Sumer; the pyramids completed. Lugalannemudu of Abab unites city-states that vie for domination for 200 years

2,400 BCE Writing in Assyria (Sumerian script).

2,350 BCE Sargon I of Agade, first known empire.

2,300 BCE Copper common in Sumer; writing in the Indus valley (local script).

2,250 BCE The fall of the Dynasty of Sargon. Ur-Nammu founds Ur's 3rd. dynasty; dedicates ziggurat at Ur moon-god Nanna, sets up early law code. Gudea, Prince of Lagash, art and literature under royal patronage flourish, magnificent statues produced in his honor.

2,112 BCE Gutian invasions

2,100 - 2,000 BCE Supremacy of Ur on lower Mesopotamia

2,100 BCE The laws of Ur-Nammu of Ur, the earliest preserved law book.

2,000 BCE Elamites invade and destroy Ur.

BABYLONIANS AND ASSYRIANS 1,900-330 BCE

1,900 BCE The *Epic of Gilgamesh* is redacted from Sumerian sources and written in the Semitic language. Though Gilgamesh was Sumerian, his *Epic* is Babylonian. Amorites from the Syrian Desert conquer Sumer. Sometime in the next 400 years "Abraham" leaves Ur.

1,800 BCE The Old Babylonians using a duodecimal system (a system based on 12 and 6) to measure time and are employing advanced mathematical operations, such as, multiplication, division and square roots. Hammurabi ascends the throne in Babylon.

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- 1,750 BCE Hammurabi brings most of Mesopotamia under his control. Hammurabi of Babylon rules most of Mesopotamia; financial transactions in Sumer and Accad now commonly in silver.
- 1,600 BCE Hittite invasion from Turkey ends Hammurabi's dynasty
- 1,500 BCE Assyria conquered by Hurricanes from Anatolia. Bas-relief of baked brick appears as dominant art form - Karaindash Temple.
- 1,400 BCE Kurigalzu assumes Babylonian throne
- 1,200 BCE Hebrews begin conquest of Canaan (it will take about 100 years)
- 1,200 BCE Nebuchadnezzar I expels Elamites.
- 1,100 BCE King Tiglath-Pileser I leads Assyria to new era of power. Iron, introduced originally by Hittites, is used extensively in Assyria for tools and weapons.
- 1,050 BCE Philistine invasion of Canaan. Samuel the last of the Judges asked to select a King.
- 1,000 BCE Assyrian empire shattered by Aramaean and Zagros tribes. Assyrian decline halted by Adadnirari II.
- 900 BCE Assurnasirpal II builds magnificent new capital, Calah, replacing old capital of Assur, present day Nimrud.
- 800 BCE Tiglath-Pileser II creates great empire extending from the Persian Gulf to the borders of Egypt. Sargon II builds new capitol at Dur-Sharrukin.
- 722 BCE The Assyrians conquer Israel. Kingdom of Judah survives.
- 705 BCE Assyrian King Sennacherib builds a new capital in Nineveh and builds a library of Sumerian and Babylonian tablets. Sennacherib manages to subdue the entire region of western Asia.
- 660 BCE Assurbanipal extends empire from Nile to Caucasus Mountains. Sennacherib's son, Esaraddon, rebuilds Babylon.
- 612 BCE Chaldeans overthrow Assyrians and destroy Nineveh. Chaldean (Neo-Babylonian) period begins.
- 600 BCE Nebuchadnezzar II rules Neo-Babylonian Empire. Builds his main temple, the Esagila in honor of Marduk, whose ziggurat is widely thought to be the famous "Tower of Babel", mentioned in the Old Testament Bible. According to some this is also the time of Zoroaster and the beginning of Zoroastrianism.
- 586 BCE Nebuchadnezzar II takes Jerusalem, "The Babylonian Exile" begins.

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500 BCE Cyrus the Great, Persian warrior and statesman, conquers Babylon

334-330 BCE Conquest of Persia by Alexander the Great. Alexander the Great enters Babylon; final fall of the Persians and Mesopotamian dominance over the region; beginning of Hellenistic period. Alexander the Great dies of fever in Babylon at the Age of 33.

Appendix B

INANNA PREFERS THE FARMER <http://www.sacred-texts.com/ane/sum/sum09.htm>

From Stuart Noah Kramer, *Sumerian Mythology* Revised Edition, University of Pennsylvania Press, Philadelphia [1944, revised 1961]

This charming agricultural myth, [The text is reconstructed from *SEM* 92-93 and *SRT* 3 fn 90] which I have entitled "Inanna Prefers the Farmer," is another example of the Cain-Abel motif. The characters of our poem are four in number: the seemingly ubiquitous Inanna; her brother, the sun-god Utu; the shepherd-god Dumuzi; the farmer-god Enkimdu. The plot is as follows. Inanna is about to choose a spouse. Her brother Utu urges her to marry the shepherd-god Dumuzi, but she prefers the farmer-god Enkimdu. Thereupon Dumuzi steps up and demands to know why she prefers the farmer; he, Dumuzi, the shepherd, has everything that the farmer has and more. Inanna does not answer, but Enkimdu, the farmer, who seems to be a peaceful, cautious type, tries to appease the belligerent Dumuzi. The latter refuses to be appeased, however, until the farmer promises to bring him all kinds of gifts and--here it must be stressed the meaning of the text is not quite certain--even Inanna herself.

The intelligible part of the poem begins with an address by the sun-god Utu to his sister Inanna:

"O my sister, the much possessing shepherd,
O maid Inanna, why dost thou not favor?
His oil is good, his date-wine is good,
The shepherd, everything his hand touches is bright,
O Inanna, the much-possessing Dumuzi . . . ,
Full of jewels and precious stones, why dost thou not favor?
His good oil he will eat with thee,
The protector of the king, why dost thou not favor?"

But Inanna refuses:

"The much-possessing shepherd I shall not marry,
In his new . . . I shall not walk,
In his new . . . I shall utter no praise,
I, the maid, the farmer I shall marry,

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The farmer who makes plants grow abundantly,

The farmer who makes the grain grow abundantly."

A break of about twelve lines follows, in which Inanna continues to give the reasons for her preference. Then the shepherd-god Dumuzi steps up to Inanna, protesting her choice--a passage that is particularly remarkable for its intricately effective phrase-pattern:

"The farmer more than I, the farmer more than I, The farmer what has he more than I?

If he gives me his black garment, I give him, the farmer, my black ewe,

If he gives me his white garment, I give him, the farmer, my white ewe,

If he pours me his first date-wine, I pour him, the farmer, my yellow milk,

If he pours me his good date-wine, I pour him, the farmer, my kisim-milk

If he pours me his 'heart-turning' date-wine, I pour him, the farmer, my bubbling milk,

If he pours me his water-mixed date-wine, I pour him, the farmer, my plant-milk,

If he gives me his good portions, I give him, the farmer, my nitirda-milk,

If he gives me his good bread, I give him, the farmer, my honey-cheese,

If he gives me his small beans, I give him my small cheeses;

More than he can eat, more than he can drink,

I pour out for him much oil, I pour out for him much milk;

More than I, the farmer, what has he more than I?"

Follow four lines whose meaning is not clear; then begins Enkimdu's effort at appeasement:

"Thou, O shepherd, why dost thou start a quarrel?

O shepherd, Dumuzi, why dost thou start a quarrel?

Me with thee, O shepherd, me with thee why dost thou compare?

Let thy sheep eat the grass of the earth,

In my meadowland let thy sheep pasture,

In the fields of Zabalam let them eat grain,

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Let all thy folds drink the water of my river Unun."

[paragraph continues] But the shepherd remains adamant:

"I, the shepherd, at my marriage do not enter, O farmer, as my friend,

O farmer, Enkimdu, as my friend, O farmer, as my friend, do not enter."

[paragraph continues] Thereupon the farmer offers to bring him all kinds of gifts:

"Wheat I shall bring thee, beans I shall bring thee,

Beans of . . . I shall bring thee,

The maid Inanna (and) whatever is pleasing to thee,

The maid Inanna . . . I shall bring thee."

And so the poem ends, with the seeming victory of the shepherd-god Dumuzi over the farmer-god Enkimdu.

Appendix C

Genesis 4:1-16 (King James Version)

<http://www.biblegateway.com/passage/?search=Genesis%204:1-16;&version=9;>

1And Adam knew Eve his wife; and she conceived, and bare Cain, and said, I have gotten a man from the LORD.

2And she again bare his brother Abel. And Abel was a keeper of sheep, but Cain was a tiller of the ground.

3And in process of time it came to pass, that Cain brought of the fruit of the ground an offering unto the LORD.

4And Abel, he also brought of the firstlings of his flock and of the fat thereof. And the LORD had respect unto Abel and to his offering:

5But unto Cain and to his offering he had not respect. And Cain was very wroth, and his countenance fell.

6And the LORD said unto Cain, Why art thou wroth? and why is thy countenance fallen?

7If thou doest well, shalt thou not be accepted? and if thou doest not well, sin lieth at the door. And unto thee shall be his desire, and thou shalt rule over him.

8And Cain talked with Abel his brother: and it came to pass, when they were in the field, that Cain rose up against Abel his brother, and slew him.

9And the LORD said unto Cain, Where is Abel thy brother? And he said, I know not: Am I my brother's keeper?

10And he said, What hast thou done? the voice of thy brother's blood crieth unto me from the ground.

11And now art thou cursed from the earth, which hath opened her mouth to receive thy brother's blood from thy hand;

12When thou tillest the ground, it shall not henceforth yield unto thee her strength; a fugitive and a vagabond shalt thou be in the earth.

13And Cain said unto the LORD, My punishment is greater than I can bear.

14Behold, thou hast driven me out this day from the face of the earth; and from thy

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face shall I be hid; and I shall be a fugitive and a vagabond in the earth; and it shall come to pass, that every one that findeth me shall slay me.

15And the LORD said unto him, Therefore whosoever slayeth Cain, vengeance shall be taken on him sevenfold. And the LORD set a mark upon Cain, lest any finding him should kill him.

16And Cain went out from the presence of the LORD, and dwelt in the land of Nod, on the east of Eden.

Appendix D

Genesis 25, King James Translation

<http://av1611.com/kjbp/kjv-bible-text/Ge-25.html>

Then again Abraham took a wife, and her name *was* Keturah.

2 And she bare him Zimran, and Jokshan, and Medan, and Midian, and Ishbak, and Shuah.

3 And Jokshan begat Sheba, and Dedan. And the sons of Dedan were Asshurim, and Letushim, and Leummim.

4 And the sons of Midian; Ephah, and Ephher, and Hanoah, and Abida, and Eldaah. All these *were* the children of Keturah.

5 And Abraham gave all that he had unto Isaac.

6 But unto the sons of the concubines, which Abraham had, Abraham gave gifts, and sent them away from Isaac his son, while he yet lived, eastward, unto the east country.

7 And these *are* the days of the years of Abraham's life which he lived, an hundred threescore and fifteen years.

8 Then Abraham gave up the ghost, and died in a good old age, an old man, and full *of years*; and was gathered to his people.

9 And his sons Isaac and Ishmael buried him in the cave of Machpelah, in the field of Ephron the son of Zohar the Hittite, which *is* before Mamre;

10 The field which Abraham purchased of the sons of Heth: there was Abraham buried, and Sarah his wife.

11 And it came to pass after the death of Abraham, that God blessed his son Isaac; and Isaac dwelt by the well Lahairoi.

12 Now these *are* the generations of Ishmael, Abraham's son, whom Hagar the Egyptian, Sarah's handmaid, bare unto Abraham:

13 And these *are* the names of the sons of Ishmael, by their names, according to their generations: the firstborn of Ishmael, Nebajoth; and Kedar, and Adbeel, and Mibsam,

14 And Mishma, and Dumah, and Massa,

15 Hadar, and Tema, Jetur, Naphish, and Kedemah:

16 These *are* the sons of Ishmael, and these *are* their names, by their towns, and by their castles; twelve princes according to their nations.

17 And these *are* the years of the life of Ishmael, an hundred and thirty and seven years: and he gave up the ghost and died; and was gathered unto his people.

18 And they dwelt from Havilah unto Shur, that *is* before Egypt, as thou goest toward Assyria: *and* he died in the presence of all his brethren.

19 And these *are* the generations of Isaac, Abraham's son: Abraham begat Isaac:

20 And Isaac was forty years old when he took Rebekah to wife, the daughter of Bethuel the Syrian of Padanaram, the sister to Laban the Syrian.

21 And Isaac intreated the LORD for his wife, because she *was* barren: and the LORD was intreated of him, and Rebekah his wife conceived.

22 And the children struggled together within her; and she said, *If it be so*, why *am* I thus? And she went to inquire of the LORD.

23 And the LORD said unto her, Two nations *are* in thy womb, and two manner of people shall be separated from thy bowels; and *the one* people shall be stronger than *the other* people; and the elder shall serve the younger.

24 And when her days to be delivered were fulfilled, behold, *there were* twins in her womb.

25 And the first came out red, all over like an hairy garment; and they called his name Esau.

26 And after that came his brother out, and his hand took hold on Esau's heel; and his name was called Jacob: and Isaac *was* threescore years old when she bare them.

27 And the boys grew: and Esau was a cunning hunter, a man of the field; and Jacob *was* a plain man, dwelling in tents.

28 And Isaac loved Esau, because he did eat of *his* venison: but Rebekah loved Jacob.

29 And Jacob sod pottage: and Esau came from the field, and he *was* faint:

30 And Esau said to Jacob, Feed me, I pray thee, with that same red *pottage*; for I *am* faint: therefore was his name called Edom.

31 And Jacob said, Sell me this day thy birthright.

32 And Esau said, Behold, I *am* at the point to die: and what profit shall this birthright do to me?

33 And Jacob said, Swear to me this day; and he sware unto him: and he sold his birthright unto Jacob.

34 Then Jacob gave Esau bread and pottage of lentiles; and he did eat and drink, and rose up, and went his way: thus Esau despised *his* birthright.

Appendix E

Information is taken primarily from *Vitriol in The History of Chemistry*

By Vladimor Karpenko and John A. Norris

Vitriol

There are Sumerian word lists dating from around 600 BCE where types of *vitriol* are listed according to their color. However, the word *vitriol* derives from the Latin *vitreus*, 'glass' and refers to the glassy appearance of the sulfate salts. These included copper(II) sulfate (blue vitriol), zinc sulfate (white vitriol), iron(II) sulfate (green vitriol), iron(III) sulfate (vitriol of Mars), and cobalt(II) sulfate (red vitriol). All of these can form as secondary minerals through the weathering of these metallic sulfide deposits. Besides, vitriol or occasionally *atrament* these sulfides were generally referred to as *pyrites* during antiquity.

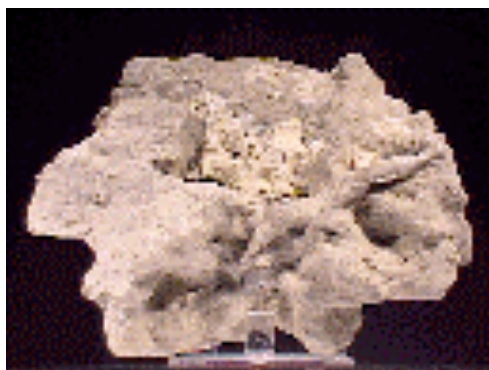
Today they would be called *sulfates of divalent metals*. In the first century of this era the Greek physician *Dioscorides* and the Roman naturalist *Pliny the Elder* both discuss *vitriol* found around the copper deposits on Cyprus they describe dripping vitriol accumulating into white dripstones in caves, mine tunnels, and along the sides of the pits they dug. They also mention artificial vitriol obtained from both naturally occurring and artificially prepared solutions of these sulfates. Dioscorides indicates that vitriol was considered as a mineral genus encompassing a number of varieties that he distinguishes according to their origins. The association of vitriol with copper ores meant it was considered to be a cupriferous substance. Hence the Greeks gave it the name *chalcanthon*. The importance of vitriol in historical alchemy is highlighted in the alchemical motto, *Visita Interiora Terrae Rectificando Invenies Occultum Lapidem* that is a sort of acronym meaning *Visit the Interior of the Earth and Rectifying You Will Find the Hidden/Secret Stone* (first found in Basil Valentine's *L'Azoth des Philosophes*).

Appendix F

Saltpetre

Information on Saltpetre is taken primarily from Wikipedia

Saltpeter or more correctly Saltpetre refers in modern usage to *Potassium Nitrate* (KNO_3). The etymology is uncertain and is said to derive from the Latin *sal petrae* either from, i.e. *salt stone* or possibly *stone of Petra*. It is also known as *nitrate of potash*, and *nitre* (or *niter* in the U.S) and in the European food labeling system is E252.



nitre

Like much ancient chemical terminology the term *nitre* has a long history of being applied to various chemicals and minerals, including sodium nitrate (sodium nitre or cubic nitre), sodium carbonate and potassium carbonate. *Nitre* shares an underlying etymology with *natron* the ancient term for sodium and the Hebrew for *néter* meaning *salt derived ashes*. It's thought that it was used as, or with, soap. As it says in the Book of Jeremiah (2:22) "*For though thou wash me with nitre, and take thee much soap . . .*" Not surprisingly the meaning of the biblical term *neter* is disputed. Some believe it refers to *sodium carbonate*. There is also a Greek term *ἀφρόνιτρον* " meaning "*foam of nitre*" which appears in records of transactions as "for the baths".

The mineral *nitre* occurs as a clear to white crystal usually found in caves and caverns. It is formed from deposits of bat guano or the accumulation of liquids containing potassium and nitrates from other sources.

Dung-heaps provided a significant source of the substance. A typical procedure involved making it by mixing manure with either mortar or wood ashes, earth and adding straw or other organic materials. This was then formed into a compost pile typically with dimensions of 1.5 X 2 X 5 meters. The heap was kept moist with urine and covered. Turning the material often, and leaching it with water approximately once a year encouraged decomposition. The nitrates contained in the leachate were combined with wood ash and the resulting potassium nitrates were crystallized and refined for use, often for gunpowder.

Urine was another source of saltpeter for gunpowder. Urine and straw would be allowed to process for months and then water was used to remove the accumulated salts. Finally the leachate was filtered through wood ashes and allowed to sun-dry.

The earliest known recipe for this kind of filtering appears in the 13th century book *al-Furusiyya wa al-Manasib al-Harbiyya* (*The Book of Military Horsemanship and Ingenious War Devices*), by the Syrian Hasan al-Rammah. He describes the use of *Potassium Carbonate* (in the form of wood ashes) to remove *calcium* and *magnesium* from the potassium nitrate.

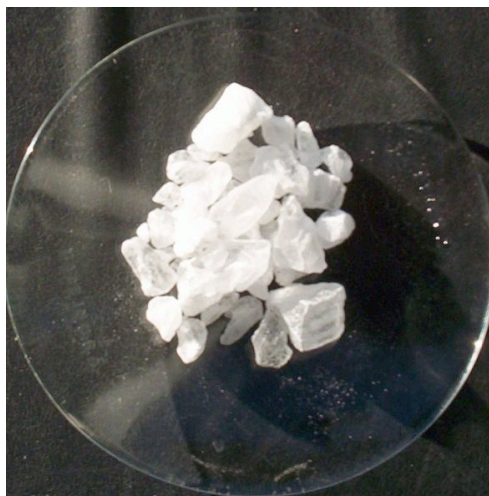
Appendix G

Alum

Information on Alum is taken primarily from Wikipedia

Alum can be used to refer to both a particular chemical compound (*hydrated aluminum potassium sulfate* $\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$) and a class of compounds known as *alums* ($\text{AB}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$). Besides potassium aluminum sulfate, or potash alum, there is another form used in cooking, *sodium aluminum sulfate*. This form is an ingredient in commercially produced baking powder. Despite its long history in food preparation in large doses it is toxic.

Pliny in his *Natural History* and *Dioscorides* give almost identical accounts of *alumen*. Various substances referred to by this name were used in dyeing and medicine. All of them share the common characteristic of being astringent. While the term may have referred to various chemicals, certain ruins on the island of Lesbos leave no doubt that by the 2nd Century CE there was an established process for producing alum from the mineral *alunite* also known as *alumstone*.



alum



alunite

Appendix H

Sal Ammoniac

Information on Sal Ammoniac is taken primarily from Wikipedia

Considered a rare compound Sal Ammoniac the natural or mineralogical form of ammonium chloride (NH_4Cl). Composed of white to yellow-brown crystals it is often associated with native sulfur, and alum it occurs around volcanic fumaroles, burning coal seams and in guano deposits. The importance of Egypt in the history of this substance can be seen by its name, which comes from the Greek ἅλς ἀμμωνιακός, that is *hals ammoniakos*, salt of Ammon.

Besides playing a small role in cooking (certain kinds of cookies and candies) sal ammoniac or ammonium chloride finds many uses: to clean the tips of soldering irons, and as a flux for solder, an ingredient in shampoo, plywood (in the glue) a nutrient media for yeast and other microorganism, in cleaning products, cattle feed, and cough medicine (it is an expectorant). It is also used in explosives, various medical procedures and zero on the Fahrenheit scale is determined by placing the thermometer in a mixture of ice, water, and ammonium chloride.

It also continues to be of importance in metallurgy. It improves the quality of metals prepared in open crucibles. Even today, in order to purify gold or silver, jewelers and metal smiths add *potassium carbonate* (*cream of tartar*) to a borax-coated crucible containing the molten metal. It is then air-cooled and re-melted with a one-to-one mixture of powdered charcoal and *sal ammoniac*.



sal ammoniac crystals

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