[This is from What Painting Is *(New York: Routledge, 1998). This was originally posted on www.jameselkins.com. This version is unillustrated: some illustrations are on the website. The alchemical symbols have dropped out of this file. See the website for context, other material from the book, and for contact information for the author. (September 2009).]*

2

How to count in oil and stone

These are glimpses of what it's like to struggle with materials without knowing their proper names or their chemical properties. Alchemical and artistic thinking take place outside modern chemistry, but that is not all there is to the difference between studio art and the science of materials. Painting also takes place off to one side of counting and basic math, in a realm where numbers don't behave the way we were told they do in elementary school. To move farther into the alchemical state of mind, we have to move farther back down our own educations: first forgetting what little of college or high school chemistry we might remember, and then going back to elementary school and erasing the ground–level memory of classes in addition and subtraction. Alchemy and studio art exist, you might say, on the first–grade level: they depend on intuition and naïveté, and they are ruined by secure knowledge. This has nothing to do with the supposed split between the right brain and the left brain, and it does not mean that interesting painting cannot also have a high scientific content (though that is unusual).[i] What it means is that painting depends on a sense of materials and numbers that could not survive even the simplest question from a second–grade teacher. In painting, one plus one is not necessarily two.

It makes sense that artists should count differently than scientists, because painting itself does not have much to do with counting.[ii] If paintings could count, they would just say the

number one over and over: each painting would insist on its own uniqueness, because no mark can be like any other, and no picture can duplicate another. Photographs, xeroxes, and prints inhabit a different world, where images come in "editions," "copies," or "multiples." A painting or drawing, on the other hand, always counts the number one. It is unique, and so is every mark on it. As every artist knows, a single brushmark can never be retrieved: if it is painted over, it is gone, and no matter how many times the same hand passes over the same inch of canvas, the mark can never be reproduced. Every mark is a different beginning: one, one, one… and so on forever.

Still, there is a sense in which counting happens in painting. It has to do with the way that marks exist together, so that they make sets and groups. If an artist paints a Cadmium Yellow streak, and then a Chromium Green blotch next to it, the two marks exist together on the canvas and make a set. There is no way to tell in advance how they might relate to one another: the green might balance the yellow, or harmonize with it, or pull away from it, or overwhelm it. But whatever relation they have, it is not the relation that one number has to another. Each mark is unique: the yellow is not one and the green is not two, and they do not add to make two or any other number. Looking at them, you would not be tempted to count "one, two." So even though it's possible to look at the canvas and count two marks, that goes against everything that paint does. Instead they form a set or a group or a composition that consists of two unique elements, two ones, existing together and making something new, which is another one. Paint adds like this:

$$1 + 1 = 1.$$

The three ones are not exactly the same, since the first is a yellow, the second a green, and the third something unnamable and new. So really the equation would have to look more like this:

$$1 + \mathbf{1} = \mathbf{1}.$$

Obviously the math we learn in school isn't going to help in thinking about painting. But there is a mathematics that can describe what happens here: it is the ancient art of numerology, and it begins—significantly enough—at the same moment that Western mathematics begins, with Pythagoras in the sixth century B.C. From there it finds its way through alchemical and mystical texts up to the present day. We still feel the last shudders of it whenever we think twice about the number 13, or wonder if 666 might not have special meaning after all. To a rationally minded modernist, numerology is nothing more than a pastime or a silly leftover of medieval—or rather,

preclassical—superstition. But a tremendous amount waits to be written about numerology, because even the greatest mathematicians have had hunches and feelings about numbers. It is a commonplace among academic number theorists that as the properties of different numbers become more familiar, they take on personalities of their own. Once Srinivasa Ramanujan Aiyangar, perhaps the most important mathematician of the century, was visited by a friend who remarked that the day was not especially propitious since the license plate of the taxi that had brought him to Ramanujan's house had the number 1729—"Not a particularly interesting number." Ramanujan's face lit up, and he said, "On the contrary! 1729 is the smallest number that is the sum of two different cubes two different ways: $1729 = 12^3 + 1^3$ and $1729 = 10^3 + 9^3$." Ramanujan "knew" the number, and that kind of acquaintance is not irrelevant for mathematics, because it will lead a mathematician to make other discoveries. Ramanujan could have added, for instance, that 1729 is also the sum of 865 and 864 and the difference of their squares 748,225 and 746,496. Numbers unfold their peculiarities to people who think about them as individuals, instead of as anonymous markers on a notched line leading to infinity. Numerology can also be found in philosophy and the humanities, with their nearly mystical interest in twos and threes. The philosopher Hegel started that obsession by insisting that nature counts by adding a thesis to its antithesis, and subsuming both in a synthesis; and even today postmodern theorists shy away from "reductive dualities" and search for ideas that call for larger congregations of numbers. They tend to mistrust any idea that comes packaged as a "dualistic" choice, or a "Hegelian" triad. In all cultures, numerology has had little to say about larger numbers: except for the important ones (666, 1000), numerologists are mostly interested in numbers under twenty or so. There is a certain truth to the habit of sticking to smaller numbers, since the unaided human mind can rarely hold more than three or four ideas at once. (According to the psychoanalyst Jacques Lacan, the numbers zero to six are a special key to the psyche because the unconscious can't count beyond six.[iii]) The basic idea of this book is a duality (painting and alchemy), and as I write I might be able to keep a half–dozen of its themes in my head at once. But no one except the odd number genius has theories that depend on 1000 or 1729 ideas. Numerologists are right to remain faithful to the normal capacities of the mind. Dualities may be reductive, but they are entirely reasonable quantities for understanding the world.

In the case of the two dabs of color, the combination is not two, exactly, but it is a new object that has the feel of the number two: it is what the numerologists called a dyad. Numerologists do not count "1, 2, 3, 4" but "monad, dyad, triad, tetrad" or "oneness, twoness, threeness, fourness" or "singleness, doubleness, tripleness, quadrupleness," or "unary, binary, ternary, quaternary"; and they do so because it helps preserve a sense of the uniqueness of each "number." In the end, a quaternity is still four—but it is a much richer four than the ordinary number four, because it has within itself much of the meaning of oneness, twoness, and threeness. This kind of numerology is not antiscientific (I am not speaking about superstitious or astrological numerologies), but it is extra–scientific: it exists alongside mathematics, neither contradicting it nor helping it in any easily describable fashion. And it is hardly an unimportant or marginal way of thinking: everything is counted according to numerological meanings *except* the abstract numbers of mathematics. It is trivially true that a mother, father, and daughter make three people, but it is much more important, and more profound, that they make a family—that is, they are a triad that is another unity. Paint mimics people in that way.

Alchemists cherished individual numbers, lavishing them with allegorical meaning and searching for their intrinsic significance. Each number was treated separately and differently than the others, so that the endless number line was transmuted into a collection of different *kinds* of objects rather than a sequence in the mathematical sense.[iv] Alchemical numerology ascribes personalities to numbers, and sometimes it goes farther and even gives them weight and body as if they were physical substances. The Renaissance mystic John Dee, spiritual alchemist and personal astrologer to Queen Elizabeth I, alludes to this in his willfully strange book *The Hieroglyphical Monad*. Mathematicians, he says, treat numbers as if they are "abstracted from things corporeal, and… remote from sensual perception." They would be astonished to see that "in our work" numbers are "concrete and corporeal… and that their souls and formal lives [*animas, formalesque vitas*] are departed from them so as to enter our service."[v] Dee's numbers are nearly living beings: they have hidden meanings, personalities, and even bodies, and their bodies have incorporeal souls. This is why alchemical numerology is suited to painting: it does not stop short at the vague intuition that numbers have characters, but it tries to bring them to

life. Like the substances that the alchemists studied, these numbers have spirits and souls. Only the thinnest veil separates them from clay and gold and fire.

There is a word, *hypostasis,* that describes what happens when fluids and stones seem to have inner meaning, and when numbers come alive. Properly speaking, it is a religious concept: Jesus was the hypostatic incarnation of the Word of God into the ordinary substance of a human body, meaning that he was spirit that became flesh.[vi] A hypostasis is a descent from an incorporeal state into ordinary matter, or in general an infusion of spirit into something inert. It can describe the feeling that numbers have "souls and formal lives," and it can explain the notion that two fluids, mingling in a bottle or on a canvas, are somehow expressing a state of mind.

Hypostasis is the feeling that something as dead as paint might also be deeply alive, full of thought and expressive meaning. One moment paint is nearly nothing, an excuse for some historian to write about the influence of Florence on Siena, or the difficulties of realistic painting —and then suddenly it is also there in all its stubborn weight and thickness, clinging to the canvas, gathering dust, wrinkling with age. Ordinarily paint is a window onto something else, a transparent thing that shimmers in our awareness as we look *through* it to see what the painter has depicted: but it is also a sludge, a hard scab clinging to the canvas. The art historian Hubert Damisch said it best when he titled one of his books *The Cadmium Yellow Window.*[vii] A painted window can be brilliant with light—think of Matisse's open windows, with their curtains blowing in the warm ocean air—but it is always also a closed plaque, a heavy mineral deposit that is stubbornly and absolutely opaque. And when it is merely paint, it begins to speak in an uncanny way, telling us things that we cannot quite understand. It seems to be infused with moods, with obscure thoughts, and ultimately—in the language of alchemy and religion—with soul, spirit, and "formal life." From that moment on, it never stops speaking. Like alchemists, painters are bound up in hypostatic contemplation: paint seems irresistibly to *mean,* as if the littlest dab must signify something. It never speaks clearly because—as any sober scientist or humanist will tell you—every meaning is a projection of the viewer's inarticulate moods. Substances are like mirrors that let us see things about ourselves that we cannot quite understand. And in painting there is another element in the equation, which suddenly makes the feeling of meaning tremendously interesting: the paint was laid down by an artist who also had hypostatic feelings about paint, and so it is also possible to interpret those feelings in pictures instead of just

imagining them. The most reliable way to do that—if anything this tenuous and personal can be called reliable—is to look at the marks as evidence of the motions of the painter's body, as I have done with Monet. It is also possible for paint itself to have meaning as it works against itself, over and under itself, on the canvas—as it does in Dubuffet's portrait. All of this is speculative, and most of it is useless to cold art history, but it is the fertile hallucination that makes paint so compelling. Paint is like the numerologist's numbers, always counting but never adding up, always speaking but never saying anything rational, always playing at being abstract but never leaving the clotted body.

1

To begin counting, it is best to start with one. The Bible opens with a primal unity: In the beginning all elements were a single chaos. Alchemists often speak about the world around them as if it were still that ancient chaos "without form," and they imagine their purpose to be the regathering of the fallen parts of the world into a new unity. The "All in all" (*omnia in omnibus*), a favorite alchemical invocation, is an attempt to compensate for the bewildering variety of the world, by swirling every conceivable object into the first undifferentiated unity. *Omnia in omnibus* also gestures toward the interconnection of all things, as if to say, Even though there are two marks, or an infinity of marks, they are only a single mark.[viii] The perfectly fused substance is the unwavering goal of alchemy, and it is also alchemy's starting point: just as the world began in a single chaos, so it will end in an impeccable perfection.

The best name for this congealed perfection is the monad. To Dee, the number one known to arithmetic is only an example—an "outward sign"—of the fundamental carrier of "unary" meaning, the monad. Its special unity is the property of the philosopher's Stone, goal of the entire alchemical *opus*. In that sense the monad is neither one nor any other number. It is a quality (*virtus*) that engenders the whole of Nature. Pythagoras was interested in harmonies between numbers, and some of the discoveries ascribed to him are at the foundation of mathematics; but he also apparently thought the first ten numbers were a kind of cipher for the universe, all beginning and culminating in the number one. He is credited with inventing the *tetraktys,* a pyramidal arrangement of points:

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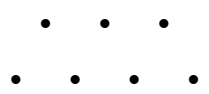


The monad at the vertex is followed by a dyad, a triad, and a tetrad, all adding to ten. This schema was taken to have fundamental affinities with the structure of the world, the harmonies of music, and the basic properties of numbers. It does not so much add to ten as culminate in the "denary," which repeats the monad again on a higher level. Alchemical thought moves up and down this sequence: one thing becomes two, which becomes three, and four, and then the four coalesces and shrinks back into the three, the two, and the one. The idea that the monad is a fundamental source rather than a number is probably due to Johannes Trithemius, who is credited with the proverb "Unity is not a number, but it gives rise to all numbers."[ix]

The monad is dark because it cannot be clearly understood. It is inhuman, or rather, it is prehuman. Even sexuality is undefined before the number two. Pythagoreans identified odd numbers with maleness, since they are "hard to divide," and even numbers with femaleness, since they are "easy to separate."[x] The number one was considered to be "both male and female at once," because "it alone is both even and odd": that is, it can be added to an odd number to make an even number, or to an even number to make an odd number. In contemporary mathematics, this does not make sense, since any odd number, added to an odd or even number, will produce an even or odd number. But the idea is that one is itself not a number. Pythagoreans defined an odd number as one that can only be divided into two unequal parts, one even and the other odd. Hence one is not yet a number, but a source of numbers. For the same reason an even number is one that can be divided into two equal parts and also two unequal parts, so that two is also not yet a number, but a source of numbers. So the number one is chaos, "formless and void," undivided, before sexuality itself.

If there is a monad in painting, it is the shapeless, formless masses of oils, waiting to be distilled and separated into grades, or the endless rocks in the earth, waiting to be exhumed, purified, and ground into pigments. The monad is all paint, before it is separated into individual paints, and long before it is injected into tubes, squeezed onto palettes, separated into piles of colors, regimented along the color wheel, and teased into figures and landscapes. Those are all divisions, moving down the *tetraktys* toward infinite variety. In poetic terms, the paint monad is the perpetual implacable enemy of every painter, because it is the meaningless formless mindless

raw stuff out of which something must be made. The paint has to be divided from itself to be useful. There has to be distance between parts of the paint: between yellow and red, and then between yellow and orange, and then between yellow and yellowish orange. There have to be distinctions of mass and medium: between sticky and runny, sticky and smooth, sticky and tacky. Those divisions are not infinite, as they are in mathematics, but they go by twos, threes, and fours. The most colors than any artist has on the palette is twenty or thirty: after that, they begin to resorb into a grey continuum, and the battle against the monad is lost. (A few painters had more intricately subdivided palettes. Seurat's was a gridwork of tints and hues, made in strict compliance with his pseudoscientific color theory. But those cases belong in the archives of pathology, and few painters have felt compelled to take such artificial steps.) After the paint has been divided from itself, and its primal mass has been splayed into the colors of the spectrum, then it needs to be recombined, placed together with itself on the canvas. In the end, the paint is once again a single mass. The monad splits into the dyad, and the bifurcations continue, and then gradually slow, and fuse, until the last gaps are closed and the paint returns to itself, reunified and perfected.

The best emblem of the monad is the famous alchemical *ouroboros,* the snake with its tail in its mouth. One of its many names is "Unity of Matter," and another is *Omnia in Omnibus*. It was first illustrated in a Greek alchemical treatise, and it flourished during the renascence of alchemy in the seventeenth century.[xi] In popular mythology, the snake clenches its tail in its fangs in order to roll quickly downhill, but the original ouroboros has a more violent purpose. One seventeenth–century writer put it this way, comparing the ouroboros to the mythical Polyps who cannibalized themselves:

> An atrocious hunger forced the famished Polyps to gnaw at their own legs,
> And it taught men to feed on human flesh.
> The dragon bites its tail and swallows it,
> Taking most of itself for food.
> Subdue the dragon by hunger, prison, and the sword, until
> It eats itself, vomits, dies, and is born again.[xii]

In this poem the ouroboros not only bites itself but eats "most of itself," decaying in the alchemical vessel until it dissolves into "vomit." Taming the ouroboros by "hunger, prison, and

the sword" means destroying it by sealing it up and heating it (the sword is a symbol of fire) until it ingests itself—in other words, putting it in a pot and cooking it until it is mush. Some alchemists tried to give exact interpretations: one thought the dragon is the blackness that remains at the bottom of a vessel when everything else has been boiled away, and the last thickened water around it was its tail, so that the two could be coagulated together into something new.[xiii] Another said that the dragon is mercury, and the tail is salt, and when they are heated they become "the ash that is within the ash" (*cinis qui est in cinere*), capable of sending out a life-giving rain and coming alive once more.[xiv] But no matter how it is glossed, the ouroboros that eats itself is an unforgettable image of the continuous recirculation of the monad: it begins as one thing, attacks itself, falls into its own mouth, and then—when nothing is left except the bloody mouth, and the intestines are inverted in an impossible topology—it vomits out its own chewed insides. That pool of flesh is the monad again, even more rigorously single. The ouroboros is the relentless search for perfect self–coincidence that dogs alchemical thinking.

These thoughts of horrible destruction and partial sexuality are threads that run through alchemy. They are the inescapable result of giving bodies and souls to numbers: after all, what could be more monstrous, more formidably inhuman, than the number one itself, the birthplace of the universe and the moment of its destruction?

2

After one comes two. Two is really all painting needs: a color or a texture, and something that can stand opposite to it. The history of painting is full of pictures that take their energy from the primordial contrast of light and dark: a brilliant angel bursts in on a saint who studies in the darkness; a woman sits alone in a dim room, looking at her reflection by the light of a guttering candle. Just as many pictures make use of the less fundamental contrasts between warm and cool, above and below, smooth and rough. The twentieth–century painter Adolf Gottlieb finally reduced all those possibilities to the elementary contrast of two shapes. Above, a smooth and glowing reddish sphere; below, a hacked and splintered black tangle of paint.[xv]

The dyad is universal, and rarely achieves such a pitch of drama. In everyday occurrence it is just one mark to the side of another, or a green near a yellow. Any two marks are a dyad. From the Venetian Renaissance onward, painters have made use of a convenient contrast

between warm and cool in order to paint as efficiently as possible. A Venetian painter might begin by laying down a thin reddish–brown undercoating, the *imprimatura,* over the whole surface of the canvas. Then, to paint a sky, he would cover the imprimatura with translucent layers of cool paint—say Ultramarine Blue, mixed with Lead White. The hills would be warm by contrast—say a tan Ochre. The object was never to let the two clash into a child's version of sky and ground, but to keep the reddish–brown imprimatura visible so that it could soften and blend them into a common background. The miracle of the method is that it is so simple: even a few careless marks will make a convincing landscape if the viewer steps back far enough to let the colors soften and merge. Colorplate 4 is a small detail from a seascape.[xvi] The artist, Alessandro Magnasco, is a wonderful and eccentric painter from the time of the alchemists. He was captivated by scenes of failing light and engulfing darkness, and his paintings often have spectral lights flashing in deep twilight. This is the crucial portion of one painting, where a warm sky meets a cool, windy sea. Everything above this passage is scudding clouds and sunset glow, and everything beneath is dark turmoil. The earth is in tumultuous disarray: waves are whipped up, trees lash back and forth, the weather is changing. Originally the painting would have been even wilder, but like so many paintings it was relined (the canvas was removed and a fresh one put in its place), so much of the paint has been pressed flat.[xvii] (Relining is a very common procedure, and it is a fair guess that most major paintings done before the twentieth century have been relined. Ask the staff in the museums you visit which are which, and you will be able to see how much damage was done. In the case of Magnasco's painting, it helps to imagine a more corrugated and less glossy surface.)

[Ed: insert colorplate 4 so that it faces the following passage.

There is no ¶ break here.]

Underneath the layers of paint is a light tan imprimatura, visible just to the left of the boat among the flecks of white foam. It's important to see the imprimatura first: when artists set out to copy paintings, they search for the places where the imprimatura is most obvious, so they can match its original color. Here it is clearest to the left of the rudder, where there is an especially strong line of white sea–spray. Just underneath the spindrift is the neutral brown of the imprimatura, left entirely uncovered. Once you have seen it, the color of the imprimatura shines through everywhere: it tints the entire middle third of this detail, softening the colors into a mirage of

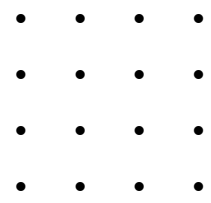
mists and vapors. For the sky Magnasco used a warm tone—Lead White, with touches of Naples Yellow, blue, Vermilion, and browns—and for the sea, a cool tone—Ultramarine, with touches of browns. (Magnasco was not one of the painters who used only a few colors. This is real polychromy: within the small compass of this detail, there is purple on the hill, and an orange just above the boat; the painting has perhaps a dozen pigments in all.)

The warm sky descends onto the horizon, and the cool sea rises up toward it. They do not meet in a line but in a blur, and they cross and overlap. There is some blue–green underneath the rose paint of the sky, and also blue–green over the sky color: at the left, closer to the horizon, are five or six hairstreaks of blue lying on the rose. In the ocean, the two basic tones are much more tangled, and sky colors come flooding down over the roughened horizon, as if the air could dilute the ocean, or the ocean could evaporate into the sky. Near the center of this detail, there are two very thick, short horizontal strokes, one a fingerbreadth above the other: the upper one is rose, and the lower one blue. Even at the bottom where the darkness is swallowing the light, Magnasco has put faint swirls of sky–color into the wet ocean–color. When painters work this way, they tend to have two brushes in their painting hand at once, one for each color. That way they can switch back and forth with the speed of a thought, alternating until the two colors are perfectly mingled. One of Magnasco's biographers called this method painting "by dabbing" (*dipingere di tocco*), and there are quick touches and streaks throughout the picture.[xviii]

Even in this little extract from one painting, there is an uncountable complexity of marks—a diaphanous conversation between light and darkness, one that can never end because the two are as inextricably woven as waves of light. At the same time the painting is beautifully simple, because it is easy to say what the paint is about. In a single phrase: it is light, talking to darkness—a dyad.[xix]

Because the dyad is one thing with another thing, side by side, it has also been called the "source of distance and inequality." Before there were two things, nothing could be separate from anything else, and nothing could be unequal. With the dyad, all that changes. "Distance and inequality" are the words of Iamblichus, an author credited with the best treatise on numerology, the fourth century A.D. *Theology of Arithmetic*. Iamblichus also thinks that the dyad has no shape: it is not yet quite an object in its own right, as three, four, and the other numbers are. The reason has to do with the way the Greeks arranged numbers into grids and piles of dots, which

they called “triangular numbers,” “square numbers,” and so forth. Sixteen, for example, is a square number:



By that logic, the dyad has no shape, since it is only a dotted line with two dots:

Because the dyad does not command an area of any sort Iamblichus calls it “indefinite and formless.”[xx] Like the monad, it is a singleness, but it appears also as a doubleness. The alchemists, always looking for sexual parallels, saw in that halfway condition an incomplete sexual fusion: what is double is either on the way to becoming one, or on the point of dividing into numberless pieces.

This is the discourse that lies behind the founding alchemical pair of sulfur and mercury. At least from the time of Arabic alchemy, and in the West from the twelfth century, sulfur was paired with mercury as the two fundamental constituents of matter.[xxi] The beginnings of that idea are lost, just as the origins of trichotomy and tetratomy.[xxii] In most Western alchemy sulfur and mercury are known by long lists of synonyms that at first make the treatises bewildering to read. The two are called—in a list made by a modern scholar—“Osiris and Isis, sun and moon, Sol and Luna, brother and sister, masculine and feminine, active and passive, giver and receiver, seal and wax, fixed and volatile, wingless lion and winged lioness, lion and eagle,” sun-tree and moon-tree, yellow and blue.[xxiii] Sulfur is also oil, crocus, soul, and “all–nature,” and mercury is phlegm (meaning distilled liquid).[xxiv] In Indian alchemy the list of synonyms is just as large, and it is called the Twilight Language (*sandhya bhasya*).[xxv] Learning those undependable names is part of the novice’s initiation into alchemy, and it quickly becomes clear that no meaning is the single best one.

The dyad is fundamentally male and female, but it is also every conceivable opposite that belongs together: knowledge and ignorance, good and evil, Gnostic light and darkness.[xxvi] The key is that the opposites are true to the principle of opposition: they are not some arbitrary pair like salt and pepper, set up by convention, but the concept of pairing itself: sulfur is to mercury

as husband is to wife. One flies (meaning it can be boiled off), and the other sits (heat does not move it). One burns, the other does not. One is porous, the other is not. One can be smashed, the other cannot. In each case the qualities of sulfur and mercury complement one another and make a perfect union, so that the dyad is never an arbitrary pair. It can represent anything in the world, but it is always the universal underlying principle of opposition.

Two marks, side by side on a canvas, make a dyad. Something about them is closed or finished, and they seem to create a universe between them. This is true of any two marks, whether they are painted on paper or etched into a rock face. Any two marks, seen together and without any distractions, will appear complete in themselves, as if they were a whole language in two words. "Male" and "female" may be the deepest names we can give to them, but any will do. And as Iamblichus says, the dyad will also appear unequal or unstable. Merely because the marks are different they will conjure the thoughts of separation, difference, and singleness, as if they were two unique individuals who could never be exactly equal. Unless they are mechanically balanced, two marks will suggest inequality, and all the dynamics of relations that go into being human.

It may seem that I am reading too much into a pair of marks, but that is only so if we decline to look closely and think openly about what we see. The beginnings of pathos, domination, loneliness, instability, and love are all present in the most careless and accidental pair of marks—say the two minuscule bars of blue and rose in Magnasco's sea. The blue tilts slightly upward, and has a little curve to it, and the rose is lenticular, and has a tiny echo to its left. They are a perfect pair and a whole, and yet they can never be balanced: that is the dyadic relation in miniature. It contains the seeds of any human relation. The dyad is a new unit but it is also formless incipience and incompletion—as if it must divide, because anything that is two must become one or three.

3

From here the doctrines multiply. The monad and dyad are wonderful starting places for meditating on the relation of substances, and on relation in general, but it was never easy for the alchemists to explain how all substances are comprised of just sulfur and mercury. The sixteenth–century visionary Paracelsus is conventionally, but unjustly, credited with introducing a third principle to help bring sulfur and mercury together: salt, the "double saline mediator,"

which is sometimes written as ⅄, as if to imply that two things fuse into a third. In the Renaissance sulfur, mercury, and salt became the *tria prima,* the three first principles. In books they are represented as the alchemical triangle, sometimes constructed from three serpents. With three principles instead of two, the associations at once become much more dense. Alchemists who were interested in spiritual and religious meanings quickly baptized them the "three hypostatical principles" (*principia;* in Arabic, *arkn*) of body, soul, and spirit, bringing them perilously close to the Christian Trinity. Other alchemists found ways of squeezing the four Greek elements of water, air, fire, and earth, so they would fit the new Trinity. As in all number symbolism, schemata were trimmed as best they could be to match the new regime:

Mercury	*sulfur*	*Salt*
metallicity, liquidity	inflammability	uninflammability
volatile, unchanged in fire	volatile, changed	found in the ashes
Holy Spirit	God the Father	Jesus Christ
spirit	soul	body
water	air and fire	earth
phlegm	fat	ash

The rearrangements and substitutions among the triads produce an almost uncontrollable plethora of meanings, and alchemists never stopped rearranging them.[xxvii] The triad has a burgeoning usefulness, as opposed to the empty monad and the irresolute dyad. Once there are three, there is structure: there can be pictorial compositions made of triangles, families made of more than just husband and wife, Christian theologies, and whole natural histories, each more interesting than the simple dichotomy of opposites.

In post–Renaissance alchemy substances were often thought to be made of sulfur, mercury, and salt, or of the three principles together with the metals copper, iron, tin, lead, and gold. The Renaissance alchemist called Basil Valentine classifies gemstones this way: diamond, he says, is made of "fixed coagulated mercury," while rock crystal is only made of ordinary mercury (*Mercurio vulgi*). Ruby is composed of the "tincture of mars" (*Tinctura Martis*) or "sulfur of iron," emerald is the sulfur of Venus, granite the "soul of Saturn" (*Anima Saturni*), and sapphire is composed of sulfur and the "tincture of the moon" (*Tinctur Lunæ*). These are all beautiful ways of thinking about gemstones, and they have their share of truth. Leonhardt Thurneysser von Thurn, a disciple of Paracelsus, wrote a monstrously long treatise classifying varieties of parsley and other garden plants by noting the exact proportion of sulfur, mercury, and salt that produce each one. He goes in exhaustive detail through every possible medicinal use and property that they might possess, and explains them all in terms of the three principles. The plant in Figure 1 is called *oppopanacis,* and it has six parts of sulfur, two of salt, and four of mercury (as Leonhardt notes at the top right). Using sulfur, salt, and mercury, the whole wide world could be built out of three common parts.

4

The quaternary relation, or tetrad, can spring from any of the sets of three. John Dee imagines fourfoldness as something that "flows" from the monad, in the way that the point at the center of the cross can be extended into its four arms. He calls this kind of addition and subtraction "mechanics": just as "geometricians teach that a line is produced by the flowing of a point [*LINEAM, EX PVNCTI FLVXV*]," so "our lines signifying the elements are produced by the continuous fall of drops that become a flow [*quasi FLVXV*]."[xxviii] We are to imagine the corporeal numbers, pouring themselves into new shapes, and it could also be an image of the liquidity of paint, smearing a point into a line, pushing a line into a cross. A tetrad can also be made of two dyads, or a triad and a monad, and any such combination will reverberate—an alchemical term—with the qualities of its constituents. One tetrad, therefore, may be utterly unlike another.

To alchemists, the four elements are everywhere. The medieval writer Marius analyzes milk in order to show that even fluids can contain all four of the classical Greek elements earth, air, fire, and water. If milk is whipped, cream appears at the top, and if the remainder is put in a jar, it will separate into whey and water. Then if the whey is burned, ashes will remain. The experiment yields the four constituent products of milk: butter from the cream, water, fire, and ashes from the whey, and they translate into air, water, fire, and earth. The butter is air, Marius insists, because it can nourish fire. Milk contains a little fire, both because it warms the body and because the whey burns. Eggs have also been subjected to this quadrature. The shell is the earth, the white water, and the yolk fire, for three different reasons: the shell is chalky, so it must be earth; the white is fluid, so it is water; and the yolk is fire, since it's yellow. That leaves air unaccounted for, and according to one alchemical text it can be found in the two membranes that separate the other three parts of the egg. The inner membrane between the yolk and white is more tenuous, in keeping with its closeness to fire, and the outer membrane between the white and the shell is farther from fire and closer to earth. Hence an egg contains earth, water, fire, "upper air" and "lower air." Although many creatures lack one or another of the elements—according to where and how they live—humans are usually said to be made of all four.

Another example, more neatly worked out than eggs or milk, explains why a log has all four elements. When a log burns in the fireplace, the flame seems to grow from the wood itself, like fiery leaves. (Some writers noticed that if fire is the child of wood, then it is an ungrateful progeny, since it also eats away at the wood until nothing remains save piles of white ash.) Green wood also hisses, and weeps tears of water and sap. Smoke rises and dissolves into air, and sometimes steam can be seen escaping or condensing on nearby windowpanes. There is a great quantity of this unseen spirit: Van-Helmont noted that "sixty-two pounds of oak charcoal yield one pound of cinders," so the rest must be "woody spirit."

In modern chemistry, we could say that the hydrocarbons in the wood decompose, with the hydrogen combining with oxygen to yield water and the carbon remaining behind. But that description would have been too simple for the alchemists, because it goes against the richness of experience. In alchemical thinking there are four substances working together to destroy the log: fire, earth (as the wood itself), water, and air. It is also possible to evade the Greek quaternity and think of the burning log as three things instead of four: a combustible element in wood, an element that can be vaporized, and an element that can neither be burned nor vaporized. Paracelsus thought that those were sulfur, mercury, and salt respectively, so that wood is composed of a certain mixture of three elements instead of four.

This kind of reasoning is rooted in the human imagination, and it continued right up to the brink of modern chemistry. According to proponents of the disproved "phlogiston theory," fire exists in an invisible combined state (*phlogiston*) and a visible uncombined state (common fire). Burning a log is liberating phlogiston, and revealing both the fire and the remaining substance. Hence the phlogiston theory, which stands at the threshold of chemistry, can be understood as a further reduction of the number of elements in the log. At first it was four, in the system used by the Greek and Arabic writers, then it was three, in some treatises of Renaissance alchemy, and finally two, in the eighteenth-century phlogiston theory.

It seems as if the quaternion, as it was called, is an especially sturdy number. Jung proposed four colors as the standard alchemical sequence: black, white, yellow, and red. In Greek natural philosophy, the four elements—earth, air, fire, and water—have four associated qualities—moist, dry, hot, and cold. (The alchemists call them *qualitates*.[xxix]) The four elements

do not correspond exactly to the four qualities, so the arrangement is sometimes imagined as a square of elements with sides that are qualities:

Many things make sense with the help of this diagram. Fire is hot and dry, water is cold and moist. When earth (meaning anything in and on the earth) is heated, it becomes dry and catches fire. When air becomes too moist, it rains as water. The inscribed square shows that grease is cold, since it is a little more like earth, and oil is moist, since it is nearer to air. To the English mystic Robert Fludd, air is “dense and crass” fire, water is dense air, and earth is dense water, giving the square a circulating motion.[xxx] The Greek way of thinking is comforting and circular. The quaternion corresponds to the four elements, the four qualities, and to many other sets of four:

the four seasons

the four Evangelists (Mark, John, Matthew, Luke)

the four sacred animals (lion, eagle, man, and cow)

the four kinds of substance (animals, plants, metals, and stones)

the four kinds of animals (those that walk, swim, crawl, and fly)

the four sorts of stones (precious, light, hard, opaque)

the four ages of man (*infantia, adolescentia, maturitas, senectus*)

the four winds (Eurus, Zephirus, Aquilo, Auster)

the four humors (sanguine, melancholic, phlegmatic, choleric)

the four temperaments or "complexions" (vivacity, gaiety, nonchalance, and slowness)

the four movements of nature (ascendant, descendent, horizontal, and circular)

the four terms of mathematics (point, line, plane, space)

the four terms of metaphysics (being, essence, potential, and action)

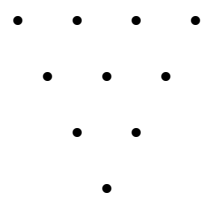
the four moral virtues (prudence, justice, temperance, and power)

the four rivers of Eden (Physon, Gihon, Hiddekel, Euphrates)[xxxi]

The problem, of course, is that the same kind of list can be made for two, three, four, five, six, seven, and twelve. The Christian Trinity is resilient, but the Greek system of four elements is almost designed to be disassembled, especially when it has to somehow accommodate the three principles.[xxxii] Simpler accounts solve the discrepancy by fiat: thus an anonymous eighteenth–century treatise on the "powder of projection" declares that salt is dry, sulfur hot, and mercury both cold and humid, so that the four Greek qualities hot, dry, cold, and humid are squeezed into the primary trinity.[xxxiii] But even though sleight of hand can solve the problem by erasing one system or another, the choice between four Greek elements and three principles was a serious one.

The diagram of elements and qualities is also vulnerable when it comes to unusual substances. Anyone who has had mercury in their hands, and felt its curious weight, has been drawn to reflect on the nature of liquids. Mercury is like water, and yet it is like metal. Mercury poses severe problems for the stability of the square, since it is both moist and dry, both water and earth. On the square, that translates into a torsion that breaks the diagram entirely. Mercury's many names reflect the alchemists' bewilderment: it was called quicksilver (meaning "living silver"), dry water, living water.[xxxiv] "Living water" (*aqua vitae*) also meant alcohol, a most wonderful water since it burns. A glass of alcohol is indistinguishable from a glass of water, but it burns with a cold flame, as befits something cold and moist. Aqua vitæ therefore collapses the square of elements into a triangle, by pulling together the opposite vertices of fire and water.

All of these strange substances tear at the neat diagram, dismantling it in favor of a simpler form—say a triangle, or a straight line. In that way, the alchemists worked backwards from tetrads to triads and dyads, to the unary Stone itself:



Because sulfur, salt, and mercury are a mystic reflection of the Trinity, they are also one. "In the profound depths of the nature of mercury is sulfur" is a saying attributed to bir.[xxxv] Basil Valentine's *Triumphal Chariot of Antimony* sings the praises of antimony in such a way that it

begins to appear as if it is the Stone itself. Antimony "combines the virtues" of all precious stones, he writes, and it can be prepared so it becomes "a true Stone."[xxxvi] Just as the theology of arithmetic can become monotheistic, alchemy can become monolithic—in the literal sense of that word, "one stone." Paracelsus helped along these confusions by claiming that earth, air, fire, and water are each composed of the three principles of sulfur, mercury, and salt, but that each principle is different in each element (air's sulfur is not the same as water's sulfur). A little math suggests that implies there are twelve principles, or perhaps an infinite number, if they change in every substance.[xxxvii]

Jung supported his sequence of four color stages by reducing more complicated texts to their "fundamental" four stages black, white, yellow, and red (*nigredo, albedo, citrinitas, rubedo*). Many alchemical texts do not keep to the four-step sequence, and it is also common to find black, white, red, or black, white, green (*viriditas*), red, or an indefinite number of cycles, or no color identifications at all.[xxxviii] Even the 4-3-2-1 sequence is often only wishful thinking on the part of readers and alchemists. A modern work, John Read's *Prelude to Chemistry,* proposes such a sequence:[xxxix]

Four elements	Three principles	Two opposites	One stone
Earth			
	Spirit		
Air		Moon	
	Body		Tincture
Fire		Sun	
	Soul		
Water			

This tempting simplification, first proposed by MichaSdziwój in 1604, has been repeated in several texts.[xl] But such a simple reduction is rare. The alchemists are usually much more deeply confused or uncertain. Four is close to the limit of what the imagination can hold, and quadripartite schemata tend to become unstable and collapse.

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The alchemists also had stories about the numbers seven (the metals) and twelve (the months of the year), but the trail becomes fainter after the quaternity. The periodic table that clogs our imagination of substances is the end of these exfoliating fantasies. Its very length makes it immune to allegory, since it is impossible to concoct personal stories for *all* the elements.[xli] Primo Levi's poetic novel *The Periodic Table* achieves a partial imaginative rethinking of the elements, including several alchemical episodes. He has stories to tell about most of the common elements, but he cannot bring the entire periodic table into the life of the imagination, and he says nothing about the awkward polysyllabic elements that crowd the end of the table.[xlii] Perhaps a precondition for modern science is a robust autoimmunity to all forms of allegorical meaning.[xliii]

To a modern reader, the forest of alchemical substances and symbols seems more difficult to learn than the periodic table, but in practice it is somewhat easier. Though alchemists also worked with a large number of substances, they did not have words or symbols for all of them.[xliv] The obscure synonyms and symbols that make it so difficult to understand books of alchemy are not endless, and a few common ones are used most of the time.[xlv] Some of the basic alchemical symbols have been in use since earliest antiquity. The elegant Greek elemental symbols (which may have an Egyptian origin) are the most universal: fire f and air F tend upward, and water d and earth g downward. They can be superimposed into a kind of star of David, with a horizontal line across the middle D meaning all the elements in balance. The symbols for the planets are also ancient, and like the astrological signs they may have begun in Egypt. Some may be pictographs: according to tradition Saturn's scythe, which he used to castrate his father Cronos, is visible in his sign T.[xlvi] Mars's sign may be a picture of his shield and spear O, and Venus's looking-glass is supposedly depicted in her sign I. It seems that four of the seven planets had metallic associations from earliest antiquity (Sun = gold, Moon = silver, Saturn = lead, Mars = iron), but Jupiter's identification with tin, Venus's with copper, and Mercury's with quicksilver were undecided until relatively late.[xlvii] Those are the indispensable symbols, and there are about two dozen others that are common in the texts.

Some are simple pictures. Sand, for example, is written as a pyramid of dots \ and ¶ means hart's horns. Others are made of the initials of names, such as a fused C for *balneum Mariæ* (the double boiler), M for "quintessence," three long V for substances that have layers

(*stratum super stratum*), and ª for extract of coral. The commonest signs give rise to many related ones. Thus Venus I provides the model for the sign of mercury A (with two arcs atop the circle), and also for cinnabar i (the mirror inverted), sulfur S (with a triangle instead of a circle), tartar } (with a square instead of a circle), potash R (with the top of the square deleted), and a dozen others. The dotted circle of gold L becomes salt G when a line is put through it. Some alchemists saw that as a symbol of the earth that is in salt. Further alterations give saltpeter : (salt on its side), verdigris ≈ white vitriol ç blue vitriol Ω green vitriol √ lye ∫ ammonia µ soda ≤ and a host of others. In this way both the number of symbols is kept within bounds that can be easily memorized, and each one can have a personality and not just a set of sterile statistics like our modern chemicals. A glance at one of the huge catalogues put out by modern chemical suppliers—one that I receive lists 33,000 chemicals—shows how impossible it is to have even fleeting acquaintance with the number of substances that are commercially available. Alchemists preserved themselves from conceptual infinity by limiting names and symbols.

Oil paints are also a limited domain whose names be slowly be learned.[xlviii] Given enough time, each color gets its own personality, and the sum total of all pigments acquires a kind of familial feel. Payne's Grey is the cold, undependable grey that tints everything with the color of blue steel. Malachite and Emerald Green are also cold, but even they are friendly in comparison with the sour stain of Viridian, which leaches its bitter tone into every color it touches. Among the blues, Cobalt and Cerulean Blue are light and airy, and Ultramarine is watery and lush. Azurite is the rich blue–green that makes a limpid summer sky when it's mixed with white. Few people beside artists know about oil colors. Even art historians and critics do not recognize them when they encounter them in pictures. They call them "red," "blue," or "yellow" and they invent adjectives to describe them—"rust colored," "tangerine," "cream–colored." That is a little like going to a party and not remembering anyone's name. For painters, the colors are old friends. If you're a German painter, Vermilion is *Zinnober:* it can never be anything else, just as your friends and relatives cannot have arbitrary names. It's not difficult to learn the basic pigments; I have given a number of them in this book, and a few visits to a painter's studio can help. They are the family whose conversations echo back and forth in paintings of all centuries. (Normally their names are not capitalized. I have capitalized them in this book to emphasize their individuality: to a painter they are not generic terms, but very particular characters.)

It is similar in chemistry, where chemists will recognize the typical colors of burning copper or zinc (its flame is greenish–white), and the rainbow colors of the sulfides and ferrocyanides. But it is not possible to go too far with colors in chemistry or alchemy, because they are infinite and infinitely deceptive. Alchemists sometimes used the four colors Jung names, especially to talk about ideas like purity, perfection, and death; but much more often they worked with a continuous rainbow of hues, and they delighted in whatever colors the substances could yield. The peacock's tail (*cauda pavonis*) was a good sign, and seeing all the colors of the rainbow at once is not unusual in alchemical experiments.

The twilight of lesser–known pigments (Manganese Violet, Scarlet Vermilion, Egyptian Blue, Ultramarine Ash, Woad) is a perennial siren to painters who feel they need to explore the dim outlying parts of the spectrum. Generally, though, painters settle for favorite groups of colors, and work with them to the exclusion of many others. They become faithful to certain combinations, and to certain manufacturers, and most painters can talk at length about their accustomed pigments. Usually only salesmen know the entire range of any company, and only conservators and restorers know the even wider domain of historical pigments. The infinity of paints, like the infinity of substances, is limited by what the imagination can populate with personality. Each paint needs to have its particular feel, its quirks and idiosyncrasies, or it cannot take its place in the mixtures and blendings that lead from the dyad through the triad and the qaterniad, and then back to the one.

Notes to chapter 2

i See my "Art History and the Criticism of Computer–Generated Images," *Leonardo* 27 no. 4 (1994): 335–42 and color plate, and "There are No Philosophic Problems Raised by Virtual Reality," *Computer Graphics* 28 no. 4 (1994): 250–54.

ii A different approach to this subject, involving the history of counting in the ancient Near East, is explored in my *Pictures, And the Words that Fail Them* (Cambridge: Cambridge University Press).

iii Stuart Schneiderman, *Lacques Lacan, Death of an Intellectual Hero* (Cambridge, Mass.: Harvard University Press, 1983), 7 ff.; Lacan, *Le Séminaire,* edited by Jacques-Alain Miller, vol. 20, *Encore* (Paris: Editions du Seuil, 1975), 122 and *passim,* cited in Ellie Ragland-Sullivan, "Counting from 0 to 6: Lacan, 'Suture,' and the Imaginary Order," in *Criticism and Lacan,* edited by P. C. Hogan and L. Pandit (Athens and London: University of Georgia Press, 1990), pp. 31–63, especially p. 30.

iv For lists of terms used by Iamblichus, see "The Pythagorean Titles of the First Ten Numbers, From the Theology of Numbers by Iamblichus," translated by David Fideler, in *The Pythagorean Sourcebook and Library,* edited by Kenneth Sylvan Guthrie *et al*. (Grand Rapids, MI: Phanes Press, 1987), 321-24. (The *The Pythagorean Sourcebook* was first printed in 1920; "The Pythagorean Titles" was added for the 1987 edition.)

v *Monas hieroglyphica Ioannes Dee* (Frankfurt: Apud Iohannem Wechelum et Petrum Fischerum consortes, 1591), originally (Antwerp: G. Silvius, 1564); Conrad Hermann Josten, "A Translation of John Dee's 'Monas Hieroglyphica' (Antwerp, 1564), With an Introduction and Annotations," *Ambix* 12 nos. 2–3 (1964): 84–221, especially 128–29, translation modified.

vi The concept comes from Plotinus; see Ubaldo Ramún Pérez Paoli, *Der plotinische Begriff von Hypostasis und die augustinische Bestimmung Gottes als Subiectum* (Würzburg: Augustinus-Verlag, 1990).

vii Damisch, *La Fenêtre jaune cadmium, ou, Les dessous de la peinture* (Paris: Seuil, 1984).

viii Matthew Moncrieff Pattison Muir, *A History of Chemical Theories and Laws* (New York: J. Wiley and Sons, 1907), reprinted (New York: Arno, 1975), 4 ff.

ix “Unarius non est numerus, & ex ipso numerus omnis consurgit.” This sentence is the subject of a commentary by Dee’s contemporary Gerhard Dorn [Gerardus Dorneus], in the *Theatrum chemicum,* 6 vols. (Strassburg: E. Zetzner, 1659–61 [1602]), 390–91. See Josten, “A Translation,” *op. cit.,* 108.

x Iamblichus, *Theology of Arithmetic,* translated by R. Waterfield (Grand Rapids, Michigan: Phanes Press, 1988), 38. For the original see Τα Θεολογουμενα τησ Αριθμητικησ, edited by V. de Falco (Leipzig: Teubner, 1922).

xi See Marcelin Berthelot and Charles Ruelle, *Collection des anciens alchimistes grecs* (Paris: Steinheil, 1887–1888), 3 vols; and H. G. Sheppard, “The Ouroboros and the Unity of Matter in Alchemy: A Study in Origins,” *Ambix* 10 no. 1 (1962): 83–96. An ouroboros is illustrated in Thoeodoros Pelecanos, *Synosius* [1478], Bibliothèque Nationale, MS. grec 2327, fol. 297, reproduced in Count Stanislas Klossowski de Rola, *Alchemy, The Secret Art* (London: Thames and Hudson, 1973), pl. 1.

xii Michael Maier, *Atalanta fugiens* (Oppenheim: H. Galler, 1617), emblem XIV. Translation modified from *Atalanta Fugiens, An Edition of the Fugues, Emblems and Epigrams,* edited by Jocelyn Godwin (Grand Rapids, MI: Phanes, 1989), 129. There is no full, reliable English translation. See the MS translations in the British Library, MS Sloane 3645, and at Yale, Mellon MS 48.

xiii *Clangor buccinae,* in *Artis auriferæ, quam chemiam vocant,* 2 vols. (Basel: Conrad Waldkirch, 1572), vol. 1, 530, cited in Helena Maria Elisabeth de Jong, *Atalanta Fugiens: Sources of an Alchemical Book of Emblems* (Leiden: E. J. Brill, 1969), 131–32.

xiv Senioris Zadith, Filii Hamuelis, *Tabula chimica,* in *Theatrum chemicum, op. cit.,* vol. 5, 233, also cited in de Jong, *Atalanta Fugiens, op. cit.,* 132.

xv Gottlieb’s pictographs are studied in my *Domain of Images: The Art Historical Study of Visual Artifacts* (Ithaca, NY: Cornell University Press, forthcoming).

xvi It depicts the boat from which Jesus’s disciples caught fish, as described in John 21:4–9. The boat tips because the fish were caught by casting a net to the right, and the disciplines lean that way to haul in the net.

xvii In addition a large portion of the paint surface has been lost and restored—perhaps up to one–quarter of it. The area of this detail is unaffected. I thank Sarah Fisher of the National Gallery, Washington, for this information.

xviii Raffaele Soprani, *Le vite de'Pittori, Scultori, ed Architetti Genovesi,* second edition, edited by Carlo Giuseppe Ratti (Genoa: Nella Stamperia Casamara, 1769), quoted in Valentina Magnoni, *Alessandro Magnasco* (Rome: Edizioni Mediterranee, 1965), 11. For similar examples see Philip Sohn, *Pittoresco: Marco Boschini, His Critics, and Their Critique of Painterly Brushwork in Seventeenth- and Eighteenth-Century Italy* (Cambridge: Cambridge University Press, 1991).

xix A lovely example of the application of this idea is Karli Frigge, *Alchemy and Marbling* (Joppe, The Netherlands: Karli Frigge, 1996), large 4to, which explores marbleized endpapers as an alchemical metaphor.

xx Iamblichus, *Theology of Arithmetic, op. cit.,* 44-45.

xxi See *Marius: On the Elements,* edited by R. C. Dales (Berkeley: University of California Press, 1976), 15 n. 16, which lists the first two Latin sources as the *Liber Apollonii* (c. 1143) and Avicenna's *De mineralibus*—for which see *Avicenne De congelatione et conglutione lapidum* [late 12th c.], translated by Alfred Sarashel, edited by Eric John Holmyard and Desmond Christopher Mandeville (Paris: P. Guethner, 1927).

xxii Arthur J. Hopkins, *Alchemy: Child of Greek Philosophy* (New York: Columbia University Press, 1934); R. Hookyaas, "Chemical Trichotomy before Paracelsus," *Archive Internationale d'Histoire des Sciences* 28 (1949): 1063–74; and Hookyaas, "Die Elementenlehre des Paracelsus," *Janus* 39 (1935): 75–88.

xxiii John Read, *Prelude to Chemistry, An Outline of Alchemy, its Literature and Relationships* (New York: MacMillan, 1937), reprinted (Cambridge: MIT Press, 1957), 19.

xxiv Andreas Libavius, *D. O. M. A. Alchemia… opera e dispersis passim optimorum autorum* (Frankfurt: Iohannes Saurius, 1597), translated into German as *Die Alchimie des Andreas Libavius* (Weinheim: Verlag Chimie, 1964), Erster Trakt, Kap. L [XLIX], p. 316.

xxv A. K. Ramanujan, *Speaking of Siva* (Harmondsworth: Penguin, 1973), 48-49. I thank Steven Feite for this information.

xxvi There is a longstanding connection between alchemy and gnosticism, which turns on this dualism. See for example Jean-Jacques Gilbert, *Propos sur la chrysopée* (Paris: Dervy Livres, 1995), 209-69; H. J. Sheppard, "Origin of the Gnostic-Alchemical Relationship," *Scientia* 97 (1962): 146-69; and Sheppard, "Gnosticism and Alchemy," *Ambix* 6 (1957-58): 86-101. I thank Mike Dickman for bringing these to my attention.

Read, *Prelude to Chemistry, op. cit.,* 26.

xxvii See especially a MS attributed to Raymond Lull, *Commentum super lapidem philosophorum,* mentioned in Michela Pereira, *The Alchemical Corpus Attributed to Raymond Lull,* Warburg Institute Surveys and Texts, no. 18 (London: Warburg Institute, 1989), 68, no. I.11.

Basil Valentine, *Von den Natürlichen und ubernatürlichen Dingen. Auch von der ersten* Tinctur, *Wurtzel und Geiste der Metallen und Mineralien,* edited by Johann Tholden (Leipzig: Bartholomæus Voigt, 1624), 87–88. In the large literature on Basil Valentine see first Karl Sudhoff, "Die Schriften des sogennanten Basilius Valentinus: Ein Beitrag zur Bibliographie der Alchemie," *Philobiblion* 6 (1933): 163-70; and J. R. Partington, *A History of Chemistry,* 4 vols. (London: MacMillan and Co., 1961), vol. 2, 190–95, especially 190 n. 7.

Leonhardt Thurneysser von Thurn, *Historia Unnd Beschreibung Influentischer, Elementischer und Natürlicher Wirckungen* (Berlin: Michael Hentsken, 1578); and see J. C. W. Moehlen, *Beiträge zur Geschichte der Wissenschaften in der Mark Brandenburg… I. Leben Leonhard Thurneissers zum Thurn… II. Fragmente zur Geschichte der Chirurgie von 1417 bis 1598… III. Verzeichnis der Dohm– und Kollegiatstifter* (Berlin and Leipzig: George Jakob Decker, 1783), Part One reprinted as *Leben Leonard Thurneissers zum Thurn* (Munich: Werner Fritsch, 1976). Thurneysser also wrote an explicitly alchemical work; see Peter Morys, "Leonhard Thurneissers *De transmutatione veneris in solem* [1585]," in *Die Alchemie in der europäischen Kultur- und Wissenschaftsgeschichte,* edited by Christoph Meinet (Wiesbaden: Harrassowitz, 1986), 85-95.

xxviii Josten, "A Translation," *op. cit.,* 107, 158–59, translation modified.

Marius: On the Elements, op. cit., 128-31.

Turba philosophorum, originally in *Artis auriferæ, op. cit.* An English translation is *Alchemy, the Turba Philosophorum or Assembly of the Sages, Called also the Book of Truth in the Art and the Third Pythagorical Synod,* translated by Arthur Edward Waite (London: George Redway, 1896), reprinted (London: Vincent Stuart and John M. Watkins, 1970), 11-12.

In a Greek source they are given as "virgin earth, igneus earth, carnal earth, and sanguineous earth," and in the *Turba* more simply as water, fire, earth, and air. *Alchemy, the Turba Philosophorum or Assembly of the Sages, op. cit.,* 21-22.

John Maxson Stillman, *The Story of Alchemy and Early Chemistry* (New York: Bover, 1924), reprinted (New York: Dover, 1960), 321.

xxix In Aristotle they are "contraries," εναντια or "differentiæ," διαφοραι. See Mary Louise Gill, *Aristotle on Substance, The Paradox of Unity* (Princeton: Princeton University Press, 1989), 68.

xxx Robert Fludd, *Anatomiæ ampitheatrum effigie triplici, more et conditione varia* (Frankfurt: Theodor de Bry, 1623), 25; Fludd, *Philosophia Moysaica* (Gouda: Petrus Rammazenius, 1638), translated as *Mosaicall Philosophy* (London: H. Moseley, 1659), 69 ff.; and Allen G. Debus, "Renaissance Chemistry and the Work of Robert Fludd," in *Alchemy and Chemistry in the Seventeenth Century* (Los Angeles, 1966), 1–29, 28 n. 32, which lists these sources.

xxxi Some of these are from Antoine-Joseph Pernety, *Dictionnaire mytho-hermétique, dans lequel on trouve les allégories fabuleuses des poètes, les métaphores, les énigmes et les termes barbares des philosophes* (Paris: s.n., 1758), *v.* "nature," 324–25. The rivers of Eden are from D. L. B., *Traité de la poudre de projection, divisé en deux lettres* (Brussels: s.n., 1707), 5. For the latter see Denis Duveen, *Bibliotheca alchemica et chemica. An Annotated Catalogue of Printed Books on Alchemy, Chemistry and Cognate Subjects in the Library of Denis I. Duveen* (London: E. Weil, 1949), reprinted (London: Dawsons of Pall Mall, 1965), 586.

xxxii In the alchemy of a'far aldiq, the three principles are treated in order, and then united, avoiding the internal contradictions of methods that alternate between three principles and four elements. See Julius Ruska, *Arabische Alchemisten, II. a'far aldiq, der Sechste Imm,* Heidelberger Akten der Von–Portheim Stiftung, vol. 10. (Heidelberg: Carl Winter's Universitätsbuchhandlung, 1924b), 56–57.

xxxiii D. L. B., *Traité de la poudre, op. cit.,* 13.

xxxiv Albertus Magnus, *De ortu et metallorum materia,* in *Theatrum chemicum, op. cit.,* vol. 2, p. 123.

xxxv “In profundo naturæ mercurii est sulfur.” From *Chrysopoiea: Being a Dissertation on the Hermetical Science* (London, 1745), 11. The author is quoting Bernard Trevisan, who was quoting bir.

xxxvi Basil Valentine, *Der Triumph-Wagen antimonii,* edited by Johann Tholden (Hamburg [not Leipzig, as it is usually given]: J. Apels, 1604), in Latin as *Currus Triumphalis Antimonii* (Toulouse: Petrum Bosc, 1646), 1–114. There are at least three English translations, all as far as I have seen from the Latin version: see *The Triumphant Chariot of Antimony,* translated by J. H. (London, 1661); or *The Triumphal Chariot of Antimony,* translated by Arthur Waite (London: James Elliott & Co., 1893).

xxxvii Massimo Luigi Bianchi, “The Visible and the Invisible: From Alchemy to Paracelsus,” in *Alchemy and Chemistry in the XVIth and XVIIth Centuries,* edited by Piyo Rattansi and Antonio Clericuzio (Dordrecht: Kluwer, 1994), 17–50, especially 22, citing especially Paracelsus, *Elf Traktat (Von der Wassersucht. Andere Redaktion),* in *Theophrast von Hohenheim genannt Paracelsus Sämtliche Werke,* edited by Karl Sudhoff and W. Matthiessen (Munich and Berlin: R. Oldenbourg, 1922–33), 14 vols, vol. 1, p. 13.

xxxviii Jung, *Psychology and Alchemy,* translated by R. F. C. Hull (New York: Routledge, Kegan, Paul, 1953), revised edition (Princeton: Princeton University Press, 1968), 229–231, mentions the three–step sequence as well. The four colors come originally from Pliny, *Historia naturalis* xxxv.31. Another common 4–color sequence is black–green–white–red. See Joachim Tancke, *Promptuarium alchemiæ,* 2 vols. (Leipzig: Henning Grossn, 1610–14), facsimile edition (Graz: Akademische Druck, 1976), vol. 2, 70.

xxxix Read, *Prelude to Chemistry, op. cit.,* fig. 11, p. 132.

xl For example, Eric John Holmyard, *Alchemy* (London: Penguin Books, 1957). Sdziwój's chart is reproduced in Read, *Prelude to Chemistry, op. cit.,* fig. 14, p. 209, from Sdziwój [Sedeimir, Sdziwjz, Sendivogius, Cosmopolite, Angelus Doce Mihi Ius, etc.], *Novum Lumen Chemicum e naturæ fonte et manuali experientia depromptum,* reprinted in *Musæum Hermeticum Reformatum et Amplificatum… continens tractatus chimicos XXI præstantissimus* (Frankfurt: s.n., 1749 [1625]), 545-84. The treatise originally appeared as *De lapide philosophorum* in Prague in 1604, but I have not seen a copy of that edition. See *Novum Lumen Chymicum,* second edition (Paris: Apud Renatum Ruillium, 1608), and many later editions. The first English translation is *A New Light of Alchimie,* translated by J. F. M. D. (London: Richard Cotes, 1650). For further information see Zbigniew Szydo, *Water Which Does Not Wet Hands: The Alchemy of Michael Sendivogius* (Warsaw: Polish Academy of Sciences, 1994), 37; *Roman Bugaj, MichaSdziwój (1566-1636), ycie i Pisma* (Wrocaw: Ossolineum, 1968); and Josef Svatek, *Culturhistorische Bilder aus Böhmen* (Vienna: W. Braumüller, 1879).

xli On this subject see also Brian Rotman, *Ad infinitum: The Ghost in Turing's Machine, Taking God out of Mathematics and Putting the Body Back in, An Essay in Corporeal Semiotics* (Stanford: Stanford University Press, 1993).

xlii Levi, *The Periodic Table,* translated by Raymond Rosenthal (New York: Schocken, 1984).

xliii Robert Boyle was the beginning of this turn away from imaginative contact with elements: he critiqued the three- and four-fold classifications in favor of often undefined simple elements. For a summary of his views, see E. J. Dijksterthuis, *The Mechanization of the World Picture,* translated by C. Dikshoorn (Oxford: Clarendon Press, 1961), 433-35; and for the full anti-Paracelsan argument, Boyle, *The Sceptical Chymist* (London: J. Cadwell for J. Crooke, 1661).

xliv The best source for alchemical symbols is H. C. Bolton, "Symbolism in Alchemy and Chemistry, A History of Chemical Notation," Library of Congress, MS 1218. The most thorough single primary text is the *Medicinisch– chymisch– und alchymistische Oraculum* (Ulm: s.n. 1772), reprinted (Zurich: Bibliothèque Ethnographique et Métaphysique, 1981). See also G. W. Geßmann, *Die Geheimsymbole der Alchymie, Arzneikunde und Astrologie des Mittelalters* (Ulm: Arkana, 1959).

xlv See Oswald Croll [Crollius], *Basilica Chymica* (Frankfurt: Gottfried Tampachen, 1609); Nicaise le Febure, *A Compleat Body of Chymistry,* translated by P. D. C. (London: Thomas Ratcliffe, 1664); Robert Hooke, *The Diary of Robert Hooke, 1672–1680,* edited by Henry Robinson and Walter Adams (London: Taylor and Francis, 1935); Nicolas Lemery, *Cours de chymie* (Paris: Lemery, 1675); John Harris, *Lexicon Technicum* (London: Daniel Brown *et al*., 1704), *v*. "Characters"; and D. McKie, "Some Early Chemical Symbols," *Ambix* 1–2 (1937–1946): 75–77, for the latter part of this history.

xlvi In the seventeenth century Salmasius suggested that the symbols derive from the names of the deities, so that the first two letters of Saturn (Κρονοσ) provide his symbol. Claudius Salmasius, *Plinianæ exercitationes* (Utrecht: J. vande Water, 1689), 872 ff.; and see Ulrich Friedrich Kopp, *Palæographia critica* (Mannheim: the author, 1817–29), vol. 3, p. 341; and J. R. Partington, "Report of Discussion upon Chemical and Alchemical Symbolism," *Ambix* 1–2 (1937–1946): 61–64, especially 64.

xlvii See the list in Partington, "Report of Discussion," *op. cit.,* 62.

xlviii A good place to start is nineteenth-century books on pigments, since they are most thorough and give some historical depths. See Heinrich Ludwig, *Die Technik der Oelmalerei,* 2 vols. (Leipzig: W. Engelmann, 1893), vol. 2, pp. 138-177, for a list of the pigments available in Germany in 1893; a slightly earlier list is in Friedrich Jaennicke's *Handbuch der Ölmalerei* (Stuttgart: P. Neff, 1878), 40-74.