[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. Some 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).]*

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A short course in forgetting chemistry

Painting is alchemy. Its materials are worked without knowledge of their properties, by blind experiment, by the feel of the paint. A painter knows what to do by the tug of the brush as it pulls through a mixture of oils, and by the look of colored slurries on the palette. Drawing is a matter of touch: the pressure of the charcoal on the slightly yielding paper, the sticky slip of the oil crayon between the fingers. Artists become expert in distinguishing between degrees of gloss and wetness—and they do so without knowing how they do it, or how chemicals create their effects.

Monet's paintings are a case in point. They seem especially simple to many people, as if Monet were the master of certain moods—of moist bluish twilight or candent yellow beaches—but nothing more: as if he had no sense that painting could be anything but a method for fixing light onto canvas. In his singleminded pursuit of the grain and feel of light, he seems to forget who he is, and who he is painting. He has only a weak attachment to people, and he treats the figures who stray into his pictures as if they were colored dolls instead of friends and relatives.[i] Instead his attention is riveted to the blurry shapes that come forward through the imperfect atmosphere, and on the shifting tints of light that somehow congeal into meadows and oceans and haystacks. In that respect Monet's paintings are masterpieces of repression, keeping every thought quiet in order to concentrate on light: in order to pretend that there is nothing in the world—to borrow a phrase of Philip Larkin's—but the wordless play of "any–angled light," congregating endlessly on shadowed cliffs and ocean waves.[ii]

Recently art historians have learned to see that more is happening, and that Monet tried to give his paintings the sense of freedom and civility that he thought was appropriate to bourgeois society. He painted contemporary scenes, recent technology such as steamboats, and the life of leisure that he valued most. But still the idea persists that Monet is "just an eye," as Cézanne said, and for good reason: his paintings are ravishing, even for people who don't particularly like glaring multicolored sunlight or soggy green gardens. These days art historians are apt to be a little indifferent to Monet's eye, and the Impressionists can easily seem less interesting than the generations before them, who were tortured by history and the pressure of great painting, or the generations that followed, with their pseudoscientific and mystical preoccupations. A large part of that lack of engagement on the part of historians comes from Monet's technique itself: the paintings seem so obviously daubed, as if his only thought for the canvas was to cover it with paint as efficiently as possible. It can look as if he allowed one stroke for a leaf, another for a flower, and so on, building up meadows and forests through a tedious repetition. Often there is not much variety in the marks—no difference between thin and thick passages, no places where the canvas is suddenly bare, no contrasts between flat areas and corrugated impasto. Everything has a monotonous texture, like a commercial shag rug. In the later paintings, his technique only seems to get rougher and less controlled, until finally he ends up making lily pads and flowers out of swarms of haphazard brushstrokes, flailed over the canvas as if he didn't care. The paintings look easy, and even more childlike than the Abstract Expressionist paintings that used to be maligned for their supposedly childish technique.

But as I learned by trying to copy Monet's paintings, that idea is completely mistaken (Colorplate 2). It is not possible to reproduce the effect of a Monet painting by jousting mechanically with the canvas, jabbing a dot of paint here and planting another one there, until the surface is uniformly puckered in Monet's signature texture. A painter who does that will end up with a picture that looks soft and uninteresting, with a dull pattern of swirling circles like the ones left by some electric rug cleaners. A brush that's loaded with paint and then pushed onto the canvas makes a circle, more or less, but Monet's pictures do not have any circles in them. There is only one slightly rounded mark in this detail from one of his garden paintings—the blue patch at the lower right—and it's *rectangular,* not circular at all.

Nor does it help to make the usual sideways swipes at the canvas, because then the picture turns into a rainstorm of oval droplets, all falling in one direction. Some second–rate painters of Monet's generation tried to paint that way, and the result is pictures that have a windswept effect, as if they were greasy surfaces smeared by a cleaning cloth. (Sassetta's Madonna has the windswept effect in miniature, since he painted by slight flexes of his thumb and index finger, each time bringing the brush a few millimeters down and to the left.) But Monet's pictures have no direction: they are perfectly balanced, and marks go in all directions equally. Would it be possible to tell which way is up in this detail? It is omnidirectional, with no sign of the diagonal fall of brushmarks that is the sure sign of an ordinary painter. To a nonpainter, it may sound like an easy matter to make marks in all directions: after all, an artist could try painting with both hands, or experiment with rotating the canvas. But getting real directionlessness is immensely difficult: repeated gestures naturally fall into line with one another, and artists have to work hard against their own anatomy to make sure that one kind of mark does not overwhelm the others.

Not all painters want the effect Monet achieved: many prefer the energy that directed brushstrokes give, and they work *with* the marks as Sassetta did, leading them up and down figures, and around contours. Painters who prefer to hide the signs of their brushwork normally do so by smearing their brushstrokes into uniform areas, or else miniaturizing their brushstrokes so they fall below the threshold of normal vision. (Sassetta almost does that: in the original, the Madonna's head is quite small.) But for Monet and other Impressionists those strategies wouldn't have seemed right. They wanted something painterly, where the brushmarks show, and they wanted a more exacting lack of directional motion, something like the inhuman stasis that nature itself seems to have. A distant landscape might shimmer and sparkle in the sunlight, but it will not show any sign of running diagonally up or down. It merely exists: it's not going anywhere, it doesn't move from place to place. To achieve stasis in a painting, it turns out that it is not enough to make marks equally in all orientations as if they were scattered matchsticks. Such a painting will be a flurry of criss–crossing lines. To do what Monet did in this painting, it is necessary to make marks that have no set orientation *and* no uniform shape, so they can never congregate into herds and begin to march up and down like Seurat's dots sometimes do. Each mark has to be different from each other mark: if one slants downward, the next has to go up. If one is straight, the next must be arcuate. Lancet strokes must follow rounded ones, zig–zags must be cut across by ellipses, thickened strokes must be gouged by thin scrapes. Any pattern has to be defeated before it grows large enough to be seen by a casual eye.

[Ed.: insert colorplate 2 so it faces the following ¶.]

And even this is too simple. An ordinary square inch in a Monet painting is a chaos, a scruffy mess of shapeless glints and tangles. His marks are so irregular, and so varied, and there are so many of them, that it is commonly impossible to tell how the surface was laid down. There is a zoo of marks in this detail that defy any simple description. At the top right is a bizarre boat–shaped trough, made by gouging wet paint with the brush handle, and then pulling back in perfect symmetry. A pool of Yellow Ochre has been dropped just to its left, and it ran slightly over the lip of the trough before it congealed. To the left of that, a streak of Vermilion or Indian Red comes down, leaving an irregular trail over a layer of Cerulean Blue and Lead White. The Japanese call this technique "flying white," because a partly dry inkbrush will leave flashes of white as it drags across the silk. In the West there is no such poetic name, and drybrush technique is normally just called scumbling (a word that can mean many other things as well). At the far upper left, some Ochre has just barely skimmed the surface of the canvas, depositing little yellow buds at each intersection of the weave. None of those marks have names: they are all irregular and none is like any other. And there are even more unclassifiable examples even in this little detail: a double, snaking mark of deep Ultramarine Blue enters the scene at the left center, scratches and skims its way to the right, skips a few centimeters, and then hooks left and doubles back. It's a scumbled stroke, not a continuous brushstroke but a trail of shimmering vertical marks, like specters walking in a parade.

Almost twenty years ago, the art historian Robert Herbert noticed that it is often possible to see a pattern of brushstrokes that is actually underneath the painted scene, as if Monet painted on top of a rolling landscape of brushstrokes.[iii] If the paintings are lit from one side, those strokes can seem to make a painting by themselves: they are often thick, and they form a bas–relief of textures, like the fake oil paint texture that is pressed onto cheap reproductions of paintings. The "texture strokes," as Herbert called them, do not follow the shapes and colors of the objects in the finished paintings. The burs and ridges of a single texture stroke might run across part of a meadow and into the sky, or across part of a house and into a tree. Often it is impossible to tell what color the texture strokes were, since they are completely covered by the thinner colors of the final scene. To Herbert, that was evidence that Monet was not as spontaneous as people thought, and that he had a "method": a layered technique that required planning and patience in the manner of the Old Masters of the Renaissance. Apparently Monet had painted those brushstrokes, let them dry, and then made his paintings on top of them. But things are more chaotic than that. Monet did not lay down entire textured surfaces, and then leave the painting for two weeks while they dried, and then paint his pictures on top of them. (If he had, then the plastic reproductions would mimic his methods perfectly, since they are made by casting textured surfaces, coating them with photographic emulsion, and printing the paintings onto the surfaces.)

Instead the texture strokes are themselves built up in layers, and the layering went on continuously and without premeditated method until the paintings reached the magical point where it became impossible to tell how they had been painted: then they were finished. That moment is well known to painters. If an artist begins to paint a field, say by coating the canvas with a layer of green and then going over it with lighter and darker green, it will be obvious that the lights and darks are resting on top of the original middle green. After a while the different shades might nearly cover the first green, but even if that green shows through in tiny crevices, it may still look as if the meadow was made by floating local colors on top of a uniform background. In Monet as in other very different painters, part of the object is to work until it is no longer possible to tell what paint is on top and what is underneath. When that happens, it is a magical moment because the painting suddenly stops looking like a flat color–by–number with a few added touches, and takes on a rich and confusing aspect. The meadow is no longer a green card scattered with cutout plants, but a rich loam matted with plant life and moving with living shadows. Monet's texture strokes help that happen by raising glints of light that sparkle randomly among the painted stalks and leaves, confusing the eye and mimicking the hopeless chaos of an actual field. In this detail, the raw canvas shows through in a couple of places: one of them is just at the end of the snaking blue mark, short of the Emerald Green. But what color went down first? In the top half of the detail, it looks as if the light Cerulean Blue might be underneath, and the other colors on top of it—but on closer inspection, there is no uniform layer of Cerulean Blue. It's a mixture, already layered with overlapping pigments. And in the lower half, it is hard to say if blue is on top of white, of vice versa: they seem to be tumbling together at the bottom.

The trick, then, which is much more than a simple trick, is to lay down strokes that are different from one another, and to keep overlapping and juxtaposing them until the entire surface begins to resonate with a bewildering complexity.[iv] The marks must not be simple dabs, or shaped dashes, or any other namable form, but they must mutate continuously, changing texture, outline, smoothness, color, viscosity, brilliance, and intensity in each moment. I have taught classes in the Art Institute of Chicago, in which students try to copy paintings; first student of mine who set out to copy a Monet nearly gave up in frustration. Every time she put her brush to her canvas she ended up with some predictable pattern of marks. The first day she tried to sketch in a scene of the ocean, which Monet had painted in a light greenish blue. She produced a white canvas, sprinkled with blue polka dots. We examined the original from a few inches away, and we saw the ocean was made of four colors: a deep purplish hue signifying the depths of the ocean, a light Cobalt Blue reflecting the sky, hints of Malachite Green, and Lead White foam for the breaking waves. So she tried again, and made an awful Op Art pattern of colored circles. We looked more closely at the original, and saw that some of the marks were laid down almost dry, and brushed hard against the canvas, and others were wetter, and set down more lightly. She tried again, not wiping anything away, but building up the paint, and it began to look a little better. But then she had to stop working on the ocean, because the wet paint was beginning to slur together into a single hue.

She went on like that for two months, letting portions dry while she worked on other passages, exactly as I imagine Monet doing. Eventually she had built up the "texture strokes" that Herbert described, and she had succeeded in obscuring the layers of the painting, so it was no longer possible to be absolutely sure of which colors had gone down first. But still something was missing. Her picture looked mechanical, and it was too soft, like a blurry computer–screen version of a painting. (Or like the pricey framed reproductions that sell in museum shops, which are also nauseatingly blurry.) Monet's seascape is rough–edged, harsh, and scintillating, and hers was bleary and damp. The difference, and the key to the method, turned out to be the exact gestures that made the individual brushmarks. When we compared them, one of hers to one of his, we always found his were more pointed and creviced, more wildly asymmetric, than hers. His were as you see them in the detail: brilliant, fragmented, and disheveled. Hers were pats of butter, with rounded edges. We began trying to emulate his touch, and to turn her obvious inventory of marks into Monet's unpredictable starry shapes. How is it possible, we wondered, to load a brush with paint, touch it to a canvas, and come away with something as intricate as a corrugated swirl or a burst of sharp pieces? How can a single brush produce an interrupted pattern as fronded and curled as a lichen? Eventually we began to have some success, much to the delight of the crowds that regularly gathered around, watching us flounder; and the secret was a combination of two nearly indescribable elements.

First, it is necessary to have paint at the exact right texture. As it comes from the tube, oil paint is too thick, but if it is thinned with even a little turpentine, it is too dilute. My student used a combination of oils and varnishes, and she worked up the paint into stiff greasy lumps on the palette. Monet's paint must have been very much like what we made: it was shiny and resilient, thicker than cream, more liquid than vaseline, more rubbery than melted candle wax. If it was smeared with the finger, it would leave a ribbed gloss where the lines of the fingerprint cut tiny furrows; if it was gouged with the tip of a knife, it would lift and stretch like egg whites beaten with sugar. Only paint like that could smear across the canvas for a moment, and then suddenly break into separate marks. We succeeded in making many of the outlandish shapes that populate Monet's paintings, and the student's copy began to take on some of the mesmerizing intricacy of the original.

The second secret is in the gestures that Monet made when he was laying down the paint. The student let small gobs of paint rest on the top of the brush, so she could push the dry brush–end over the canvas, making a light scumble, and then suddenly turn the brush, plunging the wet paint into the weave and planting a thick blob as part of the same mark. Lifting the brush again, she could let the body of the mark trail off into a thin wisp or a series of trailing streamers as the paint broke away from the hairs of the brush. Everything depended on the way she moved in those few instants of contact. The best motions, the ones Monet must have made habitually, were violent attacks followed by impulsive twists and turns as the brush moved off. First the brush would scrape wildly, epileptically, against the canvas, jittering across its own trail, breaking it up, laying down thick paint alongside dry paint, and then it would abruptly lift and swivel, turning the jagged edges into little eddies. The gestures are a mixture of timidity and violence, of perfect control in the preparation and perfect abdication of control in the execution. Some of Monet's marks had real force, and the brush jabbed into the canvas and scraped off to one side. His canvases must have been stretched tightly, because he did not paint softly. The detail I am reproducing here is a graveyard of scattered brush hairs and other detritus. At the center left, glazed over by Malachite Green, are two crossed brush hairs, one of them bent almost at a right angle. Just below them are two of Monet's own hairs, fallen into the wet paint. A faction of an inch to the right of the green is a short piece of a brush hair, broken off by the impact with the canvas. The study of gestures reveals a Monet that I would not have suspected: to make paintings the way he made them, it is necessary to work roughly, with unexpected violence and then with sudden gentleness, and to keep turning the body against itself, so it never does quite what it wants to do—so it never falls into the routine of oval marks, all pelting down in one direction. The gestures tell the story of a certain dissatisfaction, and itchy chafing of the body against itself, of a hand that is impatient and deliberately a little out of control.

As far as I am concerned, those two elements are Monet's secret. The paintings are certainly not the instantaneous records of nature that they once seemed, but neither are they deliberate products of some academic method.[v] They depend from first to last on two nearly indescribable requirements: the precariously balanced viscosity of the pigment, and a nearly masochistic pleasure in uncomfortable, unpredictable twists and turns. The paintings are narcissistic, to use a word that is usually reserved for inward–turning twentieth–century art: they are about that beautiful moment when the dull oil paste, squeezed from the lead tube, becomes a new substance that is neither liquid, solid, cream, wax, varnish, or vaseline; and they are about the body's turning against itself, and within itself, to make shapes that the eye cannot recognize as human marks.[vi]

The science, or the pedagogy, that can describe these two secrets does not exist. Chemistry cannot help to define Monet's mixture, since the ingredients have to be adjusted depending on the picture, the passage, the weather, and the oils and colors that happen to be available. Every act of mixing has to start from scratch, resulting in a batch that is infinitesimally different from every other. A painter knows it by intuition—that is, by the memory of successful mixtures, by the look of the painting, by the scratchiness of the canvas's warp and woof, by the make and age of the paints, by the degree of fraying in the brush. It can just barely be taught, and it can never be written down. Likewise anatomy or physiology cannot help to define Monet's gestures, because they depend on the inner feelings of the body as it works against itself, and on the fleeting momentary awareness of what the hand might do next. The state of mind that can produce those unexpected marks is one divided against itself: part wants to make harmonious repetitive easy marks, and the other wants to be unpredictable. Books on painting are no help either, since they can only give gross formulas. Only being in the Art Institute with the student, standing next to the original, and taking up the brush myself, made it possible to communicate these thoughts.

Books cannot put Monet's "tricks" and "secrets" into words, but there is a discipline that has been working on the same kinds of problems since the time of the Greeks, and has a large vocabulary and wide experience in describing unnamable and unquantifiable substances. At first it seems that alchemy could not possibly teach us how to paint like Monet, and in fact it can't. Although many painters have been alchemists, those coincidences are usually not very interesting.[vii] Alchemy cannot provide a painting manual: luckily, nothing can do that but painting itself. But it can provide something more fundamental, which defines the experience I have ben trying to describe. Alchemy is the art that knows how to make a substance no formula can describe. And it knows the particular turmoil of thoughts that finds expression in colors. Alchemy is the old science of struggling with materials, and not quite understanding what is happening: exactly as Monet did, and as every painter does each day in the studio.

"It is difficult to get the news from poems," William Carlos Williams said, "yet men die miserably every day for lack of what is found there."[viii] To "get the news" from alchemy, it is necessary to pause in our headlong pursuit of useful knowledge, and spend some time thinking about the world as the alchemists saw it. At least the leap from painting to alchemy is not as big as it seems, because the ingredients of painting have never been too different from those of alchemy. Back in the seventeenth century, when alchemy was being practiced in every little town, painters and alchemists shared many substances—linseed oil, spirits, brilliant minerals for colors—and painter's manuals sometimes used the language of alchemy, calling for alchemical ingredients such as vitriol, sal ammoniac, and blood. Realgar and Orpiment are pigments that can be found in Renaissance paintings (they are bright orange and warm yellow) and they were also favorite alchemical ingredients because they yield arsenic and sulfur. The most famous artist's material, lapis lazuli, was also prized by alchemists, though it was too expensive for anything but the most lavishly funded work until the discovery in 1828 of artificial ultramarine. (Lead–tin white was also well known to the alchemists, and so were greens made with copper resinate.) Artists have made paints from a pretty red mineral called cinnabar, which is usually found in an impure state, “admixed with rocky gangue” as one author says. Because it is hard to purify, it is more common to make red paint out of Vermilion, which is the same chemical synthesized from mercury and sulfur. Mercury and sulfur are the two principal substances in alchemy, and even the method for making Vermilion has its alchemical connections. In the Dutch technique, mercury and melted sulfur were mashed together to make a black clotted substance called Ethiops mineral or Moor. When the Moor was put in an oven and heated, it gave off vapor that condensed onto the surface of clay tablets. The Moor is black, but its condensed vapor is bright red—a typical piece of alchemical magic—and it could be scraped off and ground into Vermilion for paint. So Vermilion is an artist’s pigment, composed of the two most important alchemical materials, and synthesized according to a method that was used by Greek alchemists. (Vermilion, incidentally, was the crucial evidence in the debunking of the Turin shroud: samples of the “blood” were sent to Chicago and analyzed in the McCrone Research Laboratories, by specialists in artists’ pigments; they found that the red was composed of mercury and sulfur instead of hemoglobin: it was cinnabar, not blood.)

Alchemists and artists also share a predilection for bizarre ingredients. Early in this century a gelatinous extract from the swim bladders of sturgeons was used as an ingredient in oil paint; and before the introduction of collapsible paint tubes in the mid-nineteenth century, artists bought their colors in packets made from pig’s bladders. In the Renaissance fish glues were sold in rancid wafers; the artists would pop them in their mouths to rehydrate them. Painter’s glue (called size) has been made from horses’ hoofs, stags’ antlers, and rabbit’s skin, it is still made from animal hides. Paint has been mixed with beeswax, the milky juice of figs, and resins from any number of exotic plants. Painter’s media have included dozens of European and Asian plants, oils made of spices like rosemary and cloves, and even ground–up fossilized amber.

Painters have always used outlandish methods, very much like the alchemical methods of their day. Rubens and his contemporaries boiled oil and lead into a stinking mixture called black oil, which was stored in airtight containers. To extract the particles of blue lapis lazuli from the colorless rock surrounding it, painters used the “pastille process”: they pulverized ore samples in a bag, mixed them with melted wax, plant resins, and various oils, and then kneaded the bag under a solution of lye (made with wood ashes) to coax out the blue particles.[ix] (The method works, but according to the sober voice of modern chemistry it does not require any of the exotic oils and waxes.) Lead White, the best white paint before the nineteenth century, was made by putting cast “buckles” of lead in clay pots partly filled with vinegar; the pots were stacked a shed with fermenting horse manure or waste tanning bark. Every few weeks the painter’s assistant would scrape the leprous flakes of lead carbonate off the buckles and put them back for more steeping.[x] Even traditional tempera painting, the mainstay of the early Renaissance, calls for an alchemical–sounding list of ingredients: it’s a good bet that Sassetta’s docile madonna is made of gold powder, red clay, calves’ hoofs, egg yolks from eggs produced by “city hens” (as opposed to “country hens”), oils, minerals, water, old linen, and marble dust. Recently archaeologists have analyzed the components of cave paintings in the American Southwest, and I have taught a class in those techniques, using vegetable juices, milk, and pig’s blood, with frayed sticks for brushes. One student even tried to replicate the silhouetted hands that are found on cave walls by filling his mouth with wet powdered charcoal and spitting over his outstretched hand.

These days, artists tend to use whatever is available in stores, and so they are even more like alchemists in another respect: they do not know (or care) what modern chemistry might have to say about their favorite substances. Nearly any artist would fail an exam on the composition of paints. What painter understands how varnishes work? Could any artist name the pigments in the different oil colors? What muralist knows why fresco requires lime plaster, ordinary plaster, cement, and sand? For those few who become interested in artists' materials, there are some odd surprises. For example Carmine, one of the deep red pigments, is not an inorganic chemical at all but an organic one, harvested by boiling small reddish insects and drying the residue in the sun.[xi] Most artists don't know such things because they don't matter: they have no connection to the meanings of the artworks they help produce. What counts, and what every artist must know, is how the different substances behave. Painters who buy their materials from art supply stores generally think that stand oil is the thickest medium for oil paints.[xii] It is amber colored and shiny, and it oozes from the bottle like triple molasses, or dark Chinese soy sauce. If a painting calls for truly viscous paint, then stand oil can be mixed into the paint to make a gluey mass. But without some knowledge of how stand oil works, the results can be disappointing. Paint mixed with stand oil is like cornstarch mixed with water: if you stir a little water into cornstarch, it forms a thick wet clay that can be rolled between the hands; but as soon as you let it alone, it relaxes into a fluid. In the same way, paint made with stand oil will run off the canvas before it dries. A brushstroke, thickly smeared, will loosen and fall, taking on a gloss as it runs down the slope of the canvas. The answer is to use stand oil in combination with other media, or put some on the stove and slowly boil it down until it becomes an evil–smelling viscid paste. Those are the kinds of things that artists who use stand oil have to know, and they have no relation to the chemical composition of the oil.

The world of visual art is filled with unknown materials. After a lifetime of experience, an artist comes to know a very small number of them intimately. One painter might be an expert in stand oil, and another in crayons. Sometimes artists have a hard time mixing with friends who seem to have tremendous amounts of knowledge—lawyers, who have learned thousands of precedents and procedures, or doctors, who have memorized drugs and symptoms—but knowledge gained in the studio is every bit as engrossing and nuanced: it's just that instead of learning words, painters learn substances. Long years spent in the studio can make a person into a treasury of nearly incommunicable knowledge about the powderiness of pastels, or the woody feel of different marbles, or the infinitesimally different iridescences of ceramic glazes. That kind of knowledge is very hard to pass on, and it is certainly not expressed well in books on artist's techniques. (One reason those books are so sterile is that they look at things from the point of view of science, as if everything has a fixed set of properties.) But it is a form of knowledge, and it is the same knowledge that alchemists had.

To learn the speech of alchemy it helps to think back to a time when there was no science: no atomic number or weight, no periodic chart, no list of elements. To the alchemists the universe was not made of molecules, which are made of atoms, which are made of leptons, bosons, gluons and quarks. Instead it was made of substances, and one substance—say, walnut oil—could be just as pure as another—say, silver—even though modern chemistry would say one is heterogeneous and the other homogeneous. Without knowledge of atomic structures—or access to an *Encyclopædia Britannica* with a periodic table—how would it be possible to tell elements from compounds? As far as artists are concerned, linseed oil might as well be an element. To the alchemists, oils were not hydrocarbons: they were a kind of fluid among many others, with affinities to steams and vapors as well as spirits, waxes, and sludges. Oils were what rose to the surface of a pot of stewing plants, or sat dark and fetid at the bottom of a pit of rotting horseflesh. That is the uncertain world that needs to be evoked in order to think back to the world of alchemy.

A typical laboratory might have had ore samples of the common metals—some tin, a chunk of iron, copper in nodules, a hunk of lead—and shelves full of other rocks in no particular order—a miscellany of crystals, sulfur, quartz, lime, saltpeter, sand. There would have been bottles of oils extracted from plants and trees—limewood, olive, parsley, rose—and spirits of all sorts—beer, liquors from berries, grains, and fruits. Since this is a thought experiment, you can add in imagination any objects you might find around the place you live: oddly colored earths, suspiciously triangular pebbles, shorn barks, piths of weeds, gnarled roots, withered tubers, rare flowers, different hairs, the hollow shanks of feathers, curious silks, stagnant infusions, stale waters of different colors and tastes. If you traded, as the alchemists did, you might have encountered even stranger things: horns reputedly from unicorns, red corals, powders allegedly from mummies, rocks in the shape of fishes and loaves of bread. Dragon's blood was an especially rare substance: not only was it necessary to find a dragon, but the alchemist had to wait until the dragon attacked an elephant. When it wrapped itself around the elephant and began sucking the elephant's blood, the elephant would weaken, and eventually fall, taking the dragon with it. Once in a while (this must have been one of the rarer events in nature) the elephant would actually kill the dragon, and the two of them would die together. At that moment the alchemist could rush up and collect the proper alchemical dragon's blood.[xiii]

All these things, from the most common pebble to the precious dragon's blood, would be the raw materials of the alchemical laboratory. What might you deduce about such a world if you fund yourself thrown into it, as the alchemists did, without any quantitative knowledge? How would you rearrange your miscellaneous collection so it reflected some rational or divine order? An actual alchemist would proceed by learning whatever metallurgy was known, and then move on to more esoteric experiments: but for this purpose, I want to imagine the basic condition of ignorance that any of us would face if we were put in an alchemist's shop—or an artist's studio—and told to work with what we found. For those readers who are already tainted by some knowledge of chemistry, an effective way to imagine the world before science is to recall experiences from childhood, when materials seemed to behave oddly or unpredictably. I do not remember the moment when I first learned that oil and water will not stay mixed, no matter how hard the cruet is shaken, but I have noticed it with annoyance many times since then. I do remember discoerving that a frozen wine bottle will explode, and that warmed liquor can be set on fire. For many people the most astonishing encounter with materials happens in the dentist's office, where they see the miracle of mercury: a cold, liquid, heavy, dry, opaque metal that wobbles and shimmers and weighs much more than any object should. The same substance baffled and entranced the alchemists.

Before the seventeenth century, and in my own childhood before I knew better, there was no triad of solid, liquid, and gas. (Not to mention the impossibly exotic new states that physicists and chemists study: plasmas, Bose–Einstein condensates, superfluids and supersolids.) Things had many colors, many tastes and odors and heavinesses. Some made you blink, some made you itch, or laugh, or gag. In prescientific European thought, substances were ordered in a continuous chain from solids through more refined, tenuous things like "mists, smokes, exhalations, air,… ether, animal spirits, the soul, and spiritual beings."[xiv] And if you think about it, the solid–liquid–gas trichotomy does not even do a good job describing something as simple as water. Isn't hard–frozen ice, the kind that can grip the tongue onto a metal bar, different from the soft warm ice of an ice cube? And aren't the many senses of snow as different from one another as fog is from vapor or steam? If it weren't for high school science, few of us would normally associate ice, water, and steam as the same chemical. For me, there is not one ice, but several. Like the proverbial Eskimos, I would count hard cold ice as different from warm ice, and I would separate rocklike ice (as in glaciers) from black ice (as in deeply frozen lakes), singing ice (as in fracturing ice floes), and watery ice (as in spring slush). Snows would be different creatures, and water and vapor different again. The formula, H_20, does not exist for me outside the laboratory. In its place is a welter of substances dispersed and hidden throughout the world, a whole unruly race of different creatures that only science claims are the single docile formula H_20.

Another example is oils and waxes. According to modern chemistry, oils, waxes, gasoline, natural gas, and some plastics all share the same structure—they are chains of carbon atoms flanked by hydrogen atoms. But it would be impossible, I think, to intuitively link wax and gasoline, or oil and polyethylene. In chemical terms, all that is required is to add a few carbon atoms to the chain. If the structure, called an alkyl radical, has between one and four carbon atoms, the result is a gas; if it has seven to nine, it is a volatile fluid such as gasoline (hence the phrase, "high octane," meaning a high percentage of eight–carbon chains); ten to twelve carbon atoms result in a less mobile liquid such as kerosene; thirteen to eighteen make sluggish liquids like diesel oil; more create slimy liquids, and finally soft solids like wax and hard ones like polyethylene.[xv] But what chemistry sees as the rudimentary addition of atoms to a linear chain, the eye and hand know as mysterious and utter transformations. Kerosene is much more like water than it is like wax, and wax is more like soft–packed snow than it is like polyethylene. Those are the kinds of unscientific classifications that need to be taken seriously in order to understand alchemical and artistic choices.

If our imaginary laboratory has polyethylene, snow, wax, kerosene, and water, then we might want to put the wax with the snow, the water with the kerosene, and the polyethylene with the miscellaneous rocks. Of course it would be possible to put snows, ices, and waters on a burner and verify that they are all related, and alchemists did as much. Many metallurgists knew that metals existed as solids, liquids, and invisible vapors. But without atomic theory, there are limits to how systematic that knowledge could be.

Even something as fundamental as a stone is hard to define. What makes stones stony? If we think how the lumpish human body—which is nothing but slabs of steak and flaccid viscera—is animated by a spirit, then we can also conceive of an essence of stoniness, something that might creep into the damp earth and make it more stony. Agricola, the seventeenth-century metallurgist, was thinking along those lines when he spoke of a "juice" (*succus*) that was a "stone-forming spirit" (*lapidificus spiritus*). Robert Boyle, one of the founders of modern chemistry, called it a "petrescent liquor," from the Latin word *petra,* rock; and he also thought there might be special juices for metals and other minerals (those he called Metallescent and Mineralescent juices). There were moments in the seventeenth century when no one could admit that fossils might be the records of animals that lived before the Biblical creation. People were dismayed by fossil shells on mountain tops and in mines deep underground, because they seemed to hint that the earth was much older than the 4,000 years that the Bible said it is. The idea of a stony spirit was used to help explain away the fossils: it was supposed that "stone marrow" (*merga*) "dissolved and percolated" through the earth, sometimes forming bone shapes and other fossils. Alternately, people thought that fossil shells had been real shells that were invaded by the stony liquor, a stone-forming spawn that seeped quietly up from the depths of the earth and overtook the slow and the dead. Anything might be turned into stone, and European collectors had specimens of men's tongues and hearts invaded by "stone-forming waters." Some parts of the world had springs whose water turned to stone, which was allegedly proof that their liquid was stone seed and water commingled.

So even an object as simple as a stone might be composed of earth and a stony spirit. It's a reasonable idea, if you think about it without the prejudice of science. Some stones are brittle and flinty, and they must have more stone sprit than friable chalks and clays. It might even be possible to give some order to the imaginary museum by ranking stones according to their stoniness. And what are the differences between stones and metals? Would we want to distinguish minerals or salts from earths? Certainly gems and crystals are different from dirt, but which differs more: a crystal and a clod of earth, or gold and sulfur? Many authors thought gold, silver, iron, copper, lead, and some other substances were just as different from one another as gems, fossils, and other "earths." It was routine until the mid–eighteenth century to keep fossils together with minerals as examples of "stones"—as if a fossil shell were a kind of rock, like a garnet. Michele Mercati, a sixteenth century doctor and botanist, thought there were ten kinds of stones:

1. earths,
2. salts and nitres,
3. clays,
4. acid juices (*succi acres*), including copperas and "metallic ink" (*melanteria*),
5. oily juices (*succi pingues*), including sulfur, bitumen, and pit coal,
6. marine stones, including sponges, corals, and the Halcyon Stone (*alcynium*), which was thought to be a "stony concretion" of sea foam,
7. earths resembling stones, including manganese, calamine, and the legendary Stone of Assos (*sacrophagus*),
8. stones engendered in animals, including bezoar, stag's tears, toad-stone, and pearls,
9. stones in the shapes of animals and plants (*lapides idiomorphoi*), and
10. marbles.

I wonder if anyone these days could do as well, juggling what could be actually seen with the legendary stories told by travelers and ancient authors.

Gases were especially hard to figure out, since they are mostly invisible. Jean–Baptiste Van–Helmont, who coined the word "gas," tried his hand at classifying them and ended up with six species of the new substance:

1. gas produced by burning wood, which he called "woody spirit' (*spiritus sylvestris*),
2. gas produced by fermenting grapes, apples, and honey,
3. produced by the action of acid on calcareous bodies,
4. produced by caverns, mines, and cellars,
5. produced by mineral waters, and
6. produced by the intestines.[xvi]

Even this list is probably more elaborate than anything we might draw up without calling on some memory of elements like nitrogen, helium, and oxygen. Even modern chemistry lab, where the gases can be sampled in their pure states, would not be much help. If we were to smell bromine—a choking red gas with a suffocating odor—would we know how to tell it from iodine vapor, or any number of disagreeable violet gases? And even if we managed to construct Van–Helmont's list, where would we go from there? Would it help to classify gases by their smells? Are "visible gases" such as steam different from invisible ones? Does each liquid have its own gas? These are all unanswerable questions without knowledge of modern chemistry, and so they correspond roughly to what the alchemists had to work with.

There were other problems as well. Since the alchemists had no graduated thermometers, they also had no way to quantify heat and cold. Instead of measuring temperatures, they classified "grades" or "species" of fire. Each species had its own essential properties. The medieval alchemist Artephius specifies three fires: the fire of the lamp, "which is continuous, humid, vaporous, and spiritous"; the fire of ashes (*ignis cinerum*), which makes a "sweet and gentle heat"; and the natural fire of water, "which is also called the fire against nature, because it is water." Like many unscientific insights, this one has what we now can only call a poetic truth. Water *does* have its heat, and so it is like the heat of flame, but less strong. The seventeenth–century alchemist Johann Daniel Mylius said there are four heats: that of the human body, of sunshine in June, of calcining fire, and of fusion (he means chemical fusion, not nuclear fusion). Other authors specify the heat of a manure heap, or of a brooding hen, or of a virgin's breasts. (That is the mildest heat, the one closest to coldness.) Usually the hottest species of fire was "wheel fire," a heat so intense that the flames would encircle the crucible. The lack of thermometers was the despair of experimentally–minded alchemists who wanted to tell their friends how to make some special substance, because there was no dependable way to give the recipe. It is no wonder the Rosicrucians called fire "the great indescribable spirit, inexplorable in eternity."

If it was to be possible to even come close to repeating an experiment, the alchemists needed to describe differences in heat, color, and time without thermometers, spectrographs, or accurate clocks. In this vein Marius, a medieval metallurgist, tries to define the major metals as exactly as he can:

> Iron is made from dense quicksilver mixed with sulfur of a color halfway between red and white, and it is cooked for a long time, even longer than copper, by a moderate heat… Copper contains a small amount of redness, so if iron lies undisturbed a long time, it becomes rusty and takes on a reddish color.
>
> Tin is made from pure quicksilver mixed with pure white sulfur. But it is only cooked for a short time. If the heat is too small and the time is too great, it will turn into silver.
>
> Lead is made from coarse quicksilver mixed with coarse sulfur that is white with just a little red.[xvii]

Needless to say by modern standards most of this is mistaken: lead is not made from sulfur, but is an element in its own right, and so are tin and iron. Marius also struggles with the precision of language. What, a modern chemist might ask, is a "long time"? What is a "moderate heat," or a "small amount of redness?" Without quantifiers, Marius's distinctions are just rules of thumb, incomplete descriptions that have to be corrected by experience. That is the problem that confronts artists, because they are interested in nuances of mixture. It is not possible to make a recipe for the textures Monet used, or the colors he mixed; instead, the student has to see them made, and then repeat the process as accurately as possible.

Without the instruments of quantitative science the world will remain a blur. Here, as a last example, is a concerted attempt to order the world: a list summarizing an anonymous medieval treatise traditionally ascribed to the Arabic alchemist bir Ibn ajjn. The book, called the *Summa perfectionis,* was widely consulted until well after the Renaissance, and it does an excellent job at bringing order to the study of "earthly things." [xviii] When I read through it, I marvel that so much clarity could be brought to the world of confused and nameless objects:

I. *Terrena* ("Earthly things")
- A. Four Spirits [i.e., volatile substances]
  - 1. Quicksilver
  - 2. Sal ammoniac [ammonium chloride, NH_4Cl]
    - a. Mineral form
    - b. Dirty, yellow form
    - c. Artificial form produced from hair
  - 3. Auripigment [arsenic sulfide]
    - a. Impure, mixed with stones and earth
    - b. Yellow, opaque, earthy [impure As_2S_3]
    - c. Yellow, golden, "alive" [purer As_2S_3]
    - d. Yellow mixed with red [mixture of As_2S_3 and As_4S_4]
    - e. Red, with dirty "eyes" [impure As_4S_4]
    - f. Pure red, capable of splitting [purerAs_4S_4]
  - 4. Sulfur
    - a. Red, difficult to find [apparently fabulous substance]
    - b. Yellow, color of "pure varnish" [crystalline sulfur]
    - c. Yellow, grainy [perhaps mineral sulfur with its matrix]
    - d. White mixed with earth [an obviously impure form]
    - e. Black [either sulfur mixed with asphalt, or iron sulfide]
- B. Seven bodies [i.e., the seven known metals]
  - 1. Gold
  - 2. Silver
  - 3. Copper
  - 4. Tin
  - 5. Iron
  - 6. Lead
  - 7. "Karesin" or "Catesin" [possibly bronze composed of copper, zinc, and nickel]
- C. Thirteen stones
  - 1. Marchasita [pyrites, including "fool's gold," FeS_2]
    - a. Similar to silver in color
    - b. Red, like copper
    - c. Black, like iron
    - d. Golden
  - 2. Magnesia [a miscellaneous category]
    - a. Like black earth, presenting "shining eyes" when broken [probably manganese oxide with small reflective crystals]

b. Ferrous, bitter, and masculine
c. Similar to copper, with “shining eyes,” feminine [probably “manganese–spar,” i.e. rhodochrosite or rhodonite]

3. Edaus [either iron ore composed of iron oxide, or iron filings or iron slag]
4. Thutia [zinc compounds, especially zinc carbonate, $ZnCO_3$, and zinc oxide, the latter a sublimation product in brass–making]
5. Azur [lapis lazuli, $Na_{4-5}Al_3Si_2O_{12}S$]
6. Dehenegi [malachite, $CuCO_3 \bullet Cu(OH)_2$]
7. Ferruzegi [turquoise, principally $CuAl_6(PO_4)_4(OH)_8 \bullet 4H_20$]
8. Emathita [hematite or “bloodstone,” Fe_2O_3]
9. Cuchul [antimony sulfide and lead sulfide (galena, PbS)]
10. Spehen [misreading; perhaps a form of cuchul]
11. Funcu [Latin succen, arsenic oxide]
12. Talca [Arabic talq; not talc, but mica or layered gypsum]
13. Gipsa [Arabic jibsn, gypsum, $CaSO_4$]
14. Glass

D. Six atraments [metallic sulfates and their impurities]

1. Black atrament [impure $FeSO_4$]
2. Alum [$KAl(SO_4)_2$ in varying degrees of purity, as well as other metallic sulfates]
3. Calcandis or white atrament [Arabic qalqant, a weathering product of iron or copper ores or alum]
4. Calcande or green atrament [Arabic qalqdis, iron and/or copper sulfate]
5. Calcatar or yellow atrament [Arabic qalqar, either the decomposition product of sulfide– and sulfate rich copper or iron ores, or else burnt iron vitriol (iron sulfate), i.e., iron oxide]
6. Surianum or red atrament [Arabic sr, same as above]

E. Six boraces [$Na_2B_4O_7$]

1. Red borax
2. Goldsmith’s borax
3. Borax Zarunde [a geographical location]
4. Borax arabie or alkarbi [“willow,” apparently a reference to a gum and borax extracted from it]
5. Nitrum [soda, $Na_2Co_3 \bullet H_20$, often confused with borax]
6. Tinchar [another designation for borax]
7. Borax of bread [possibly potash or soda sprinkled on bread to produce a shiny surface]

F. Eleven salts

1. Common salt [presumably NaCl]
2. Bitter salt [perhaps a kind of rock salt]
3. Salt of calx [slaked lime, $Ca(OH)_2$]
4. Pure salt
5. Sal gemma [rock salt]
6. Salt of naphtha [NaCl contaminated with asphalt]
7. Indian salt [not identifiable]
8. Sal effini [not identifiable]
9. Sal alkali [soda]
10. Salt of urine [$NaNH_4HPO_4$ produced by decomposition and drying of urine]
11. Salt of cinder [potash, K_2CO_3]

II. *Nascentia* (plants)
III. *Viventia* (animals)

To accomplish this feat of classification, bir takes commonsense categories—stones, salts, metals, spirits—and uses them to put everything from dirt to urine in its place. It is a tremendous accomplishment, but imagine how difficult bir's task would be if he were transplanted to a modern city. To the already bewildering list of objects in our imaginary alchemical laboratory, we could add the full roster of twentieth–century industry: the hundreds of kinds of commercial plastic, the varieties of glass, fiberglass, foams, rolled metal, laminates, composites, and look–alikes that make up our everyday world. At that point, it would become impossible to even make a simple list of all the substances, and there would be no hope of mastering their properties in a lifetime. Who knows the names of the substances in their toaster, their phone, or their car? Who could tell what metals or plastics comprise their "silverware"? That is one of the reasons why contemporary art still keeps to the simplest, most traditional materials. Despite the rise of multimedia, film, video, and installation, the majority of artists master their materials, and the majority of painters do not stray any farther toward modern technology than acrylic paints or brushed aluminum: not because they are suspicious of technology, but because there is so much to learn about even the simplest substances.

So this is what substances look like to painters: chemistry and science are there, but so far in the background that they might as well not exist. All that remains (all that counts) is what it looks like, what it feels like, what it does when it is mixed with something else. If I gently swirl a viscous, violet liquid into clear water, it finds its way slowly downward, turning and branching like an inverted blue tree. It drifts into spirals and curlicues. In a few moments the blue tendrils are faint and almost too small to see, and if I return in a half hour, the water is a uniform milky blue with no sign of motion.

Science can follow this as far as the production of swirls and eddies—the "chaotic dynamics" so beloved of contemporary science and art. When the liquid settles, it becomes trackless and homogeneous, and its intricacies pass beyond human imagination. The glass seems quiet, and with its light blue tint, it looks like a new substance, a perfect mixture of the violet and the clear. At that point there is not much more to do or say. It is interesting that both a scientist (in this case, a specialist in fluid dynamics) and an artist (or anyone interested in reproducing the effects of swirling liquids) will be likely to find the middle stage the most intriguing. Before the liquids are mixed, they are less compelling, and after the mixture is complete, they are again a little boring.

Adam McLean, a contemporary Scottish scholar and spiritual alchemist, recommends this kind of simple experiment to understand how substances interact. He describes an afternoon's work in the laboratory using traditional alchemical substances—although kitchen chemicals would do just as well, and it would also be possible to use painting media, or the chemicals in a child's chemistry set. Even swirling blue food color into a glass of water is a simple alchemical experiment, and if the color is oil paint and the water is oil, it is also a routine artistic procedure. McLean tabulates his ingredients, giving their names in several different languages:

SODA	≤	Sodium Carbonate	Na_2CO_3•$10H_2O$
LYE, ALKALI	∫	Sodium Hydroxide	NaOH
BLUE VITRIOL	Ω	Copper (Cupric) Sulfate	$CuSO_4$•$5H_2O$
GREEN VITRIOL	√	Iron (Ferrous) Sulfate	$FeSO_4$•$7H_2O$
WHITE VITRIOL	ç	Zinc Sulfate	$ZnSO_4$•$6H_2O$
VOLATILE ALKALI	μ	Ammonia	NH_3OH

The four columns nicely summarize four ways of knowing chemical substances. On the left is the alchemical name, then its alchemical symbol, followed by the modern chemical name and symbol. It is typical that there are many variations in the alchemical names and symbols, and virtually none in the chemical nomenclature. Alchemists tended to love a measure of mystery, and many tried to keep things obscure even when they knew what they were dealing with. Some alchemical texts used symbols like these instead of words, both as a shorthand and also to keep the whole activity secret. The symbols express their frame of mind better than anything else, and I will be using some of them in this book when they fit my themes.

McLean is interested in the pure phenomenon of liquids mingling and separating, and how it conjures the idea that the mind might also be full of mingling and separating thoughts. He recommends working in a darkened room, and using three colored light bulbs to help see the changes in the liquids. The experimenter is to fill a flask with water and add a few crystals of one of the substances. McLean continues:

> Observe minutely the way in which the substance dissolves. One might for example, see streams of coloured liquid rising from the crystals, or a denser layer of liquid forming at the surface of the crystals may descend in the flask forming a layer at the bottom.
>
> Use illumination from the bottom and observe the changes using different colours of light. In some experiments, gently heat the base of the flask… One will see

> convection currents forming in the flask, and dissolved material will be carried upwards and mix through the whole solute.
> Meditate upon this phenomenon… bearing the experience into one's inner world, inwardly picturing it, and allowing this inner picture to take on its own life. Return outwardly to the experiment in progress, and absorbing with one's senses the continuing events in the flask, then inwardly digest these again.[xix]

Anyone who performs McLean's simple instructions, and is willing to forget their chemistry, will be swept into his frame of mind. Tentative or explosive motions of one liquid through another are irresistibly metaphors for mental states. In alchemy, the Latin word *labor* is used to describe the procedures, methods and techniques—the daily struggle with materials. Also in Latin, *ora* means prayer, and the alchemists never tired of pointing out that *labor* and *ora* spell laboratory. As in the artist's studio, so in the alchemist's laboratory: both of them mingle *labor* and *ora*. Here in McLean's laboratory, "meditating" and "inwardly picturing," *labor* effortlessly becomes *ora*.

The same kind of dynamic, swirling, unstable mixture of fluids can also be seen in paintings, wherever an artist has tried to mingle substances that do not go together easily. Leonardo's *Last Supper* is a crumbling ruin, the effect of media that could not harmonize with one another. One of his paintings of the Madonna developed terribly wrinkled skin, like paint on a car hood that is about to crack open and fill with rust. In the twentieth century that kind of experimentation is just as common as it was in the Renaissance. Like Gustave Courbet a century before, the French artist Jean Dubuffet mixed gravel and earth into his pigments, and he experimented with the kinds of oil and water mixtures that are bound to cause trouble in a painting. Some of his canvasses are like still photographs of the battling fluids McLean describes.

[Ed: insert colorplate 3 so it is opposite the following passage.
There is no ¶ break here.]

Colorplate 3 is a detail from the abdomen and left flank of a figure Dubuffet calls *The Ceremonious One*. (Note that it's been rotated ninety degrees; several plates in this book have been turned so they can be reproduced as large as possible.) From a distance, Dubuffet's figure is a quizzical, mottled–looking fellow, but from up close he is a roiling wreck. His skin is puckered and split, as full of cracks and oozes as a drying patch of mud. On the left there are great spreading blossoms of white and purple: they are oily pigments that were put down over watery ones. The same effect happens whenever you put a drop of oil on the surface of water. Next time you boil spaghetti, sprinkle the water with dried marjoram or thyme, and then add a drop of olive oil: the oil will spread the spices out, pushing them away and thinning itself into a film. If you look closely at the white splotches, you can also see faint tendrils where the paint spilled outward in little rivulets, like mudslides down a mountain. In the middle of this detail there is a passage that looks like bark. It is the result of putting down an oily elastic layer over a smooth dry layer of blue: the white shrank as it dried, split, and pulled itself apart. To the right of the bark there are wet–in–wet experiments, where brown was dribbled into white. The weights and oilinesses of the two colors must have been about equal, because the brown stayed put—except that it couldn't mix with the white, so as the brown droplets spread out, they couldn't touch one another. Each rounded droplet of brown is separated from the next by a thin mortar of white. And at the far right margin is a huge spill, a greasy torrent that began to thicken and set halfway down. Dubuffet didn't control these effects, because they are too intricate and hard to predict. But he must have relished what he saw because he chose to leave the painting in this state. The blotches and splatters look like natural forms—bark, caked mud, flowers, bricks—but this is part of a human figure, so they also mimic skin that ages, dries, and finally splits. It is a fascinating and repulsive inventory of effects: wrinkles, cracks, sores, liver spots, and wounds, all remade in paint. If you stand in front of the painting, and step a foot or two farther back, they all recede into place and the painting becomes a portrait of a happy, disorganized–looking person with filthy clothes. But up close, the randomness and beauty of incompatible, degenerating substances is played out inch by inch in the paint itself. The paint depicts skin, but it also *is* skin. It is rich with the feelings of rotting, suppurating, mouldering, and desiccating. Just looking at it is feeling age and decay. This is the mystery and attraction of pure, nameless substances.

When nothing is known, anything is possible. An alchemist who added "aqua regia" to "luna" might not have had any idea what could happen. An artist who mixes salt into a lithograph, or beats water into oil paint, is taking the same kind of chance. If there is no way to predict the outcome, or to confidently name the substance, or to describe the process accurately enough so it can be repeated by someone else, then the experimenter has to watch as carefully as possible and take note of every change. That close observation is sometimes lost today, when we think we know what substances are. In a chemistry experiment, the chemist might watch for just one thing: a certain temperature, or a pressure, or the signs of boiling. But artists and alchemists have to keep their eye on everything, because they do not know what to expect. Monet paid strict attention to the motions of his wrist and arm, and the varying pressure of his brush against the canvas. He must have spent hours at a time getting his media just right, testing it again and again by dipping a brush into it, or tilting the palette to see how fast it ran. All of it was done without words, but with intense concentration.

Though it's not my subject in this book, there are also parts of chemistry that are stranger, and less well known, even than the contents of the alchemists' fuming furnaces. *The Structures of the Elements* is an authoritative survey of the different crystal forms (the allotropes) of the chemical elements. The longest section is on sulfur, one of alchemy's principal players, and it ends with an astonishing list of "provisional, doubtful, and insuffiently characterized forms of sulfur." These elusive allotropes are named after their even more eccentric-sounding discoverers: the Four Sulfurs of Korinth; the Twelve Crystalline Fields of Vezzoli, Dachille, and Roy; the Sixteen Sulfurs of Erämetsä; the Violet Sulfur of Meyer; the Purple sulfur of Rice; the Black Sulfur of Skjerven; the Cubic sulfur of Bååk. Even science has its backwaters, its unverified results, its encyclopedias of things that are seldom seen. People like Erämetsä spent years waiting, watching their test tubes and evaporation dishes, hoping for the same red, green, violet, purple, or black.[xx]

There might be a world of difference between a greasy oil and an oily grease, or a reddish white and a whitish red. Nothing can be ruled out and anything might be meaningful. From a welter of poorly understood substances, artists and alchemists make their choices more or less at random. In part they know what they want, and in part they are just watching to see what will emerge.

Notes to chapter 1

i On this question see Anne Wagner, “Why did Monet Give up Figure Painting?” *The Art Bulletin* 76 no. 4 (1994): 613-29.

ii Larkin, “Water,” *The Whitsun Weddings* (London: Faber and Faber, 1964), 20.

iii Robert Herbert, “Method and Meaning in Monet,” *Art in America* 67 no. 5 (1979): 90–108.

iv Painters’ “tricks” are explored in my *Pictures, And the Words that Fail Them* (Cambridge: Cambridge University Press, forthcoming), chapter 2.

v On instantaneity in Monet, see Steven Levine, “The ‘Instant’ of Criticism and Monet’s Critical Instant,” *Arts Magazine* 55 no. 7 (1981): 114–121.

vi A different argument on narcissism is proposed in Rosalind Krauss, “Impressionism: The Narcissism of Light,” *Partisan Review* 43 no. 1 (1976): 102–112; and see Steven Levine, *Monet, Narcissus, and Self-Reflection: The Modernist Myth of the Self* (Chicago: University of Chicago Press, 1994).

vii Alchemical themes exist here and there throughout Western painting, but they are virtually never of central importance in the paintings. This is argued in my “On the Unimportance of Alchemy in Western Painting,” *Konsthistorisk tidskrift* 61 (1992): 21–26, and in the ensuing exchange of letters with Didier Kahn; my reply is “What is Alchemical History?” *Ibid.* 64 no. 1 (1995): 51–53.

viii Williams, “Asphodel, That Greeny Flower,” I, in *The Collected Poems of William Carlos Williams, Vol. 2, 1939-62* (New York: New Directions, 1988), 318.

Earle R. Caley, “Ancient Greek Pigments,” *Journal of Chemical Education* 23 (1946): 314–16; quotation on p. 315.

Artists’ Pigments, A Handbook of their History and Characteristics (Washington, DC: National Gallery of Art, 1986-1993), vol. 2, distributed by Oxford University Press (1993), edited by Ashok Roy, p. 162. For early nineteenth century examples of alchemical artists’ materials see *The Artist’s Companion, and Manufacturer’s Guide* (Boston: J. Norman, 1814).

ix A. Kurella and I. Strauss, “Lapislazuli und natürliches Ultramarin,” *Maltechnik restauro* 89 no. 1 (1993): 34–54, especially 38–39; and Edward Norgate, *Miniatura or the Art of Limning, Edited from the MS in the British Library* [Bodleian MS Tanner 362] *by Martin Hardie* (Oxford: Clarendon, 1919), reprinted (New Haven, CT: Yale University Press, 1997).

x Roy, *Artists’ Pigments, op. cit.,* 38-39, 68.

xi Edward Bancroft, *Experimental Researches concerning the Philosophy of Permanent Colors,* 2 vols. (Philadelphia: Thomas Dobson, 1814 [1794]), vol. 1, pp. 305, 317.

xii See Alexander Eibner, *Über fette Öle, Leinölersatzmittel und Ölfarben* (Munich: B. Heller, 1922).

xiii Heinrich Conrad Khunrath, *Ampitheatrum Sapientiæ Æternæ, Solius Veræ* (Hamburg: s.n., 1595, 1604, 1609, *et seqq*.); Michael Maier, *Symbola aureæ mensæ duodecim nationum* (Frankfurt: Typis Antonij Hummij, 1617), reprinted (Graz: Akademische Druck, 1972).

xiv John Read, *Prelude to Chemistry, An Outline of Alchemy, its Literature and Relationships* (Cambridge, MA: MIT Press, 1966 [1937]), 17-18, paraphrasing Aristotle's theory of vapors and smoke. See Aristotle, *De coelo; De generatione et corruptione*. See *Aristotle's Generatione et corruptione,* translated by C. J. F. Williams (Oxford: Oxford University Press, 1942), book ii; and *Aristotle, Meteorologica,* translated by H. D. P. Lee (Cambridge, MA: Harvard University Press, 1962). Lee is a typical rationalist: "That the *Meteorologica* is a little-read book," he says, "is no doubt due to the intrinsic lack of interest of its contents. Aristotle is so far wrong in nearly all his conclusions that they can, it may with justice be said, have little more than antiquarian interest." *Ibid.,* xxv-xxvi.

xv *An Introduction to Materials,* edited by Helen Wilks, in the series Science For Conservators, vol. 1 (London: Crafts Council, 1984), 98. Several of the phrases, including "mobile liquid" and "slimy liquid," are quotations.

Georg Agricola, *De ortu et causis subterraneorum* (Basel: Froben, 1546), lib. iv, and Agricola, *De re metallica* (Basel: E. König, 1657), 512 ff. See also Anselmus Boetius de Boodt, *Gemmarum et lapidum historia* (Leiden: Joannis Maire, 1636), 13, 24, 29. For further references see David Murray, *Museums: Their History and their Use, With a Bibliography and List of Museums in the United Kingdom* (Glasgow: J. MacLehose and Sones, 1904), 3 vols, vol. 1, n. 2.

Nicolaus Steno, *Prodromus… English'd by H. O.* [Henry Oldenburg] (London: F. Winter, 1671), preface.

Agricola, *De natura fossilium,* translated by Mark Chance Bandy and Jean A. Bandy (New York: Geological Society of America, 1955), lib. ii, and Agricola, *De re metallica, op. cit.,* 578b. See also Leibniz, *Summi polyhistoris Godefrodi Guileilmi Leibniti Protogaea* (Göttingen: I. G. Schmid, 1749), §36; and Johann Schröder, *Pharmacopoeia Medico-Chymica* (Leiden: F. Lopez d'Haro, 1672), book iii, p. 42. There are further citations in Murray, *Museums, op. cit.,* vol. 1, p. 73 n. 1.

Pierre Gassendi, *Viri illustris Nicolai Claudii Fabricii de Peiresc, senatoris Aquisextiensis vita,* third edition (The Hague: Adiani Vlacq, 1655), 90, 151-2, 156. See Murray, *Museums, op. cit.,* vol. 1, p. 92, n. 1, 2.

Johann Christian Kundmann, *Rariora naturæ et artis, item in de re medica* (Breslau: Michael Hubert, 1737), 62, 72, 110.

Matthew MacKaile, *The Oyly-Well; or, a topographico-spagyricall Description of the Oyly-Well at St. Cathrinis-chappel, in the paroch of Libberton* (Edinburgh: Robert Brown, 1664), 136, also described in Murray, *Museums, op. cit.,* vol. 1, 197. *The Oyly-Well* is a translation of MacKaile, *Fons Moffetensis* (Edinburgh: Robert Brown, 1659).

For several schemata see Murray, *Museums, op. cit.,* vol. 1, p. 212 ff.

See John Kentmann's catalogue of his collection, published in Conrad Gesner, *De omni rerum fossilium genere* (Tiguri: I. Gesnerus, 1566), reprinted in Murray, *Museums, op. cit.,* vol. 1, 212.

Pliny *Historia naturalis* xxxvi. 27.

The list is reported in Murray, *Museums, op. cit.,* vol. 1, pp. 213-14.

xvi Jean Chretien Ferdinand Hoefer, *Histoire de la chimie,* 2 vols. (Paris: Bureau de la revue scientifique, 1842-43), vol. 2, pp. 135-46, as quoted in Allen G. Debus, "Renaissance Chemistry and the Work of Robert Fludd," in *Alchemy and Chemistry in the Seventeenth Century* (Los Angeles: William Andres Clark Memorial Library, 1966), 1–29, especially 23.

Artephius, *The Secret Book,* in Lapidus, *In Pursuit of Gold: Alchemy in Theory and Practice, Additions and Extractions by Stephen Skinner* (London: Neville Spearman, 1976), 41–64, especially 56. For the original see *Artephius Arabis Philosophi Liber Secretus nec non Saturni Trismegisti, sive F. Helix de Assisio Libellus,* second edition (Frankfurt [?]: s.n., 1685 [?]). There is also a seventeenth-century translation: *Artephii liber secretus,* translated by William Salmon (London: Thomas Hawkins and John Harris, 1692).

“*Der grosse unbeschreibliche Feuergeist, in Ewigkeit unerforschlich*.” *Geheime Figuren der Rosenkreuzer* (Altona: J. D. A. Eckhardt, 1785 [–1788]). The original edition is extremely rare (a copy is in the Duveen collection); see also the facsimile and translation, *Secret Symbols of the Rosicrucians of the 16th and 17th Centuries,* translated by George Engelke (Chicago: Aries Press, 1935).

xvii *Marius: On the Elements,* edited by R. C. Dales (Berkeley: University of California Press, 1976), 154, translation modified.

xviii In typical alchemical fashion, the book was not originally called *Summa perfectionis,* and it was not written by bir but by Paul of Taranto, a thirteenth-century scholar who lived in Assisi. See the exemplary scholarship on this subject by William Newman, *The* Summa perfectionis *of Psuedo-Geber: A Critical Edition, Translation, and Study* (Leiden: E. J. Brill, 1991). The list that follows is from *Ibid.,* 111-15.

The lack of connection between science and art on this score is the subject of my “The Drunken Conversation of Chaos and Painting,” *Meaning* 12 (1992): 55–60.

xix From Adam McLean, “Working with Practical Alchemy, No. 1” *Hermetic Journal* 14 (1981), 37–39.

xx Jerry Donohue, *The Structures of the Elements* (Malabar, FL: Robert E. Krieger, 1982), 354-69. I thank Roald Hoffmann for bringing this to my attention; he points out that one of Erämetsä’s sixteen sufurs was red—a goal of several alchemical recipes.