Chapter Two

Substances: The Ontology[1]

§2.1 Real Kinds

Substances are those things about which you can learn from one encounter something of what to expect on other encounters, where this is no accident but the result of a real connection. There is a reason why the same or similar properties characterize what is encountered. We can begin with examples of substances that are kinds. I will call these substances "real kinds," contrasting this, as is traditional, with "nominal kinds."

Most of the various definitions currently offered of "natural kinds" capture real kinds of one sort or another. Sometimes, however, the term "natural kind" is used to refer merely to a class determined by a "projectable" property, that is, one that might figure in natural laws. Then "is green" and "is at 32 Fahrenheit" denote "natural kinds," predicates projectable over certain classes of subjects. What I am calling real kinds, on the other hand, must figure as subjects over which a variety of predicates are projectable. They are things that have properties, rather than merely being properties.[2] That is why Aristotle called them "secondary substances," putting them in the same broad ontological class as individuals, which he called "primary substances." True, unlike the Aristotelian tradition, in modern times concepts of stuffs and real kinds have traditionally been treated as predicate concepts. That is, to call a thing "gold" or "mouse" has been taken to involve saying or thinking that it bears a certain description. One understands something as being gold or a mouse or a chair or a planet by representing it as having a certain set, or a certain appropriate sampling, of properties. Or one represents it as having certain relations to other things, or having a certain kind of inner nature or structure, or a certain origin or cause. But I am going to argue, on the contrary, that the earliest and most basic concepts that we have of gold and mouse and so forth are subject concepts. Their abstract structure is exactly the same as for concepts of individuals like Mama and Bill Clinton. This is possible because Aristotle's various "substances" have an identical ontological structure when considered at a suitably abstract level. That is, surprisingly to us moderns, the Aristotelian term "substance," though very abstract, is univocal.

Real kinds are not classes defined by one property, nor are they defined by a set of properties. Compare them with natural kinds. "Natural kinds" are sometimes taken as defined by sets of properties set apart because they are "correlated" in nature (e.g., Markman 1989). Similarly, while agreeing with

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[1] Portions of §2.2 were drawn from "On swampkinds" in Mind and Language" (Millikan 1986) with the kind permission of Blackwell's Publishers and from "Historical Kinds and the Special Sciences" (Millikan 1999) with the kind permission of Kluwer Academic Publishers..

[2] A discussion of the ontological distinction between substances and properties is in (Millikan 1984, Chapters 15-17).

Russell on the term "natural kind," Hacking explains that Russell "made a rather charming comparison between natural kinds and topological neighborhoods, saying that the former may be thought of as intensional neighborhoods, in which every member is close to a great many other members according to some notion of closeness to be explained" (Hacking 1991a, p. 112, referring to Russell 1948). These descriptions don't capture the sort of real kinds I intend. Just as, for a realist, a natural law is not merely a perfect correlation between properties but must correspond to a real ground in nature that is responsible for the correlation, a real kind is not determined merely by a correlation of properties but requires a real ground to determine it.

Thus J.S. Mill said about his "Kinds" (the capitalization is in Mill) that "a hundred generations have not exhausted the common properties of animals or plants... nor do we suppose them to be exhaustible, but proceed to new observations and experiments, in the full confidence of discovering new properties which were by no means implied in those we previously knew" (from Hacking 1991a, p. 118). Surely we are not to understand this confidence as grounded in accidental historical convergence. Mill clearly had in mind that it is grounded in nature by a supporting natural ground of induction. Mill's Kinds are supposed to be genuinely projectable kinds, not the result of accidental correlations, accidental heaps of piled up properties. Mill's Kinds are real kinds.

In recent years a number of psychologists have been interested in the structure of concepts of "natural kinds" and in the development of children's understanding of these kinds (e.g., Carey 1985; Keil 1989, Markman 1989, Gelman and Coley 1991). Natural kinds are said by these psychologists to be distinguished in part by the fact that many true generalizations can be made about them, and that, as such, they provide an indispensable key to the acquisition of inductive knowledge. For example, according to Gelman and Coley (1991), people develop natural kind concepts

> ...with the implicit...goal of learning as much as possible about the objects being classified.... For example, if we learn that X is a "cat," we infer that it has many important properties in common with other cats, including diet, body temperature, genetic structure, and internal organs. We can even induce previously unknown properties. For example, if we discover that one cat has a substance called "cytosine" inside, we may then decide that other cats also contain this substance...(p. 151)

Gelman and Coley (1991) call this feature "rich inductive potential." Clearly a concept having this sort of potential does not emerge by ontological accident. If a term is to have genuine "rich inductive potential" it had better attach not just to an accidental pattern of correlated properties, but to properties correlated for a good reason.

Kinds are not real if they yield inductive knowledge by accident. Consider, for example, the kind that is jade. As Putnam (1975) informs us, jade is either of two minerals, nephrite or jadeite, which have many properties in common but not

for any univocal reason. Rather, each has these properties for its own reasons. Similarly, Putnam's earth water (H_2O) and twinearth water (XYZ) were conceived as having numerous observable properties in common, but not in common for any univocal reason. Inductive inferences from samples of nephrite to samples of jadeite, when the conclusions happen to come out true, are not true for a reason grounded in a common nature. There is no ontological ground of induction underlying such inferences. For this reason, jade is not a real kind. Nor, if Putnam's twinearth story were true, would generic water, conceived to be multiply realized either as H_2O or XYZ, be a real kind.

Real kinds are kinds that allow successful inductions to be made from one or a few members to other members of the kind not by accident, but because supported by a ground in nature. What we need to clarify is what various sorts of natural grounds there might be that would hold the members of a kind together so that one member would be like another by natural necessity. There are, I believe, a number of different types of reasons for the occurrence in nature of real kinds, these accounting in different ways for success in generalizing over encounters.

§2.2 Kinds of Real Kinds

Perhaps the best known real kinds are the sort Putnam called "natural kinds" in "The Meaning of 'Meaning'" (Putnam 1975). These are real kinds by virtue of possessing a common inner nature of some sort, such as an inner molecular structure, from which the more superficial or easily observable properties of the kind's instances flow. The inner structure results by natural necessity in a certain selection of surface properties, or results in given selections under given conditions. Popular examples of this sort of kind are the various chemical elements and compounds. Putnam gave water and aluminum as his examples. Strictly speaking, these are not kinds but stuffs, but we could treat samples of these as members of kinds. Certainly water molecules, electrons, protons, and so forth, form real kinds of this sort. Portions of water have an inner structure in common that produces different surface properties given different temperature conditions. Stars, planets, comets, asteroids, and geodes form real kinds, not because their properties flow always from exactly the same inner nature, but because they were formed by the same natural forces in the same sort of circumstances out of materials similar in relevant ways. Real kinds of these various sorts can be said to have "essences" in a very traditional sense, essences that are not nominal but real, discovered through empirical investigation. The ontological ground of induction for such kinds, the reason that the members have many properties in common, is that they have a few fundamental properties and/or causes in common that account with natural necessity for the others.

I will call real kinds of this sort "ahistorical" or "eternal" kinds. They are ahistorical because the location of the members of the kind relative to one another in historical time and space plays no role in explaining the likenesses among them. Less well known are historical kinds, kinds for which historical location does play a role in explaining likeness.

Aristotle thought that the various animal and plant species were ahistorical kinds. He thought that the members of each species were alike because of a common inner nature or form from which various more superficial properties flowed or would flow if this form was supplied with the right matter. Modern biologists disagree. The kind Homo sapiens, for example, displays no identity of inner structure, or none that has relevance, specifically, to being human. Your genes and my genes are not the same gene types, but are merely taken from the same gene pool. Indeed, there are almost no genes in the human pool that have no alleles left at all. Nor should it be thought that the genes that most of us happen to have in common are what really make us be human, the rest causing inessential differences. On the contrary, alternate alleles frequently perform essential developmental functions. According to contemporary biology, what species an individual organism belongs to depends not on its timeless properties, either superficial or deep, but on its historical relations to other individuals—relations essentially embedded in real space and time. Dogs must be born of other dogs, not merely like other dogs; sibling species count as two or more for the same reason that identical twins count as two, not one, and so forth. In the case of sexually reproducing species, species membership is usually determined in part by reference to interbreeding, and there is some reference to lineage in all but the most radical cladists' attempts at defining both species and higher taxa. What these references to interbreeding and lineage do is effectively to confine each species and higher taxon to an historical location in this world. Indeed, M.T. Ghiselin (1974, 1981) and David Hull (e.g. 1978) claim that by biologists' usage, species are not similarity classes but big, scattered, historical individuals enduring through time.

From this Hull concludes, 'there is no such thing as human nature' (p. 211), and it does follow, at least, that there is no such thing as a single set of founding properties, an inner human essence, from which all other properties characteristic of humans flow. On the other hand, given any species, there are innumerable traits that most of its members have in common with one another not by accident but for a very good reason. Hull himself emphasized that species as well as individuals (here he quotes Eldredge and Gould 1972) "are homeostatic systems....amazingly well-buffered to resist change and maintain stability in the face of disturbing influences" (Hull, p.199, Eldredge and Gould p.114). Stability results from continuity of selection pressures in a niche, which continually weed out the deleterious mutations that arise, thus preserving the well adapted status quo. And it results from the necessity for the various genes in a gene pool to be compatible with one another, so that throwing chromosomes together randomly from among the available alleles almost always results in a viable reproductive individual. This is what Eldredge, Gould and Hull refer to as "homeostasis" in the gene pool.

Underlying these stabilizing forces, however, is an even more fundamental force. New gene tokens are copied from old ones. A massive replicating process is at work in the continuation of a species. The role of the forces producing homeostasis is secondary, keeping the reproducing or copying relatively faithful over periods of time. The role of homeostatic forces is to see

that the kind does not do as Achilles' horse did and "run off in all directions," but remains relatively stable in its properties over time.

In sum, the members of biological taxa are like one another, not because they have inner or outer causes of the same ahistorical type, but because they bear certain historical relations to one another. It is not just that each exhibits the properties of the kind for the same ahistorical or eternal reason. Rather, each exhibits the properties of the kind because other members of the kind exhibit them. Inductions made from one member of the kind to another are grounded because there is a causal/historical link between the members of the kind that causes the members to be like one another. Biological taxa are historical kinds.

I have mentioned that the ontological ground of induction for many stuffs is ahistorical, for example, the ground of induction for the various chemical elements and compounds is ahistorical. But there also are stuffs whose ground of induction is historical, for example, peanut butter retains its basic properties over encounters because it is what is made by grinding up peanuts which constitute an historical kind, and cowhide does because it is the hide of the historical kind cow.

The two most obvious sorts of historical reasons why members of a kind might be caused to be like one another are, first, that something akin to reproduction or copying has been going on, all the various members having been produced from one another or from the same models and/or, second, that the various members have been produced by, in, or in response to, the very same ongoing historical environment, for example, in response to the presence of members of other ongoing historical kinds. A third and ubiquitous causal factor often supporting the first is that some "function" is served by members of the kind, where "function" is understood roughly in the biological sense as an effect raising the probability that it's cause will be reproduced, that it will be "selected for reproduction." It is typical for these various reasons to be combined. For example, many artifact kinds combine these features. Thus Frank Keil remarks,

> Chairs have a number of properties, features, and functions that are normally used to identify them, and although there may not be internal causal homeostatic mechanisms of chairs that lead them to have these properties, there may well be external mechanisms having to do with the form and functions of the human body and with typical social and cultural activities of humans. For example, certain dimensions of chairs are determined by the normal length of human limbs and torsos... (Keil 1989, p. 46-7)

Chairs have been designed to fit the physical dimensions and practical and aesthetic preferences of humans, who are much alike in relevant respects for historical reasons. Moreover, the majority of chairs have not been designed from scratch, but copied from previous chairs that have satisfied these requirements. They thus form a rough historical kind owing to all three of the above reasons. Clearly there are reasons that go well beyond (mysteriously agreed on) points of

definition why one knows roughly what to expect when someone offers to bring a chair. Similarly, one knows what to expect when someone offers to lend a phillips screwdriver (designed to fit screws that were designed to fit prior phillips screwdrivers), or to take one to see a Romanesque church —or, of course, to replace your back doorknob.[3]

The members of some historical artifact kinds are similar in nearly the same detail as members of animal species. In (Millikan 1984) I spelled out why the 1969 Plymouth Valiant 100 was a "secondary substance":

> ...in 1969 every '69 Valiant shared with every other each of the properties described in the '69 Valiant's handbook and many other properties as well. And there was a good though complicated explanation for the fact that they shared these properties. They all originated with the selfsame plan not just with identical plans but with the same plan token. They were made of the same materials gathered from the same places, and they were turned out by the same machines and the same workers...or machines similar and workers similarly trained [on purpose] ...[Hence all the Valiants] had such and such strengths, dispositions and weaknesses...placement of distributor... size of piston rings...shape of door handles....Valiants, like most other physical objects, are things that tend to persist, maintaining the same properties over time in accordance with natural conservation laws. ...Also, there are roughly stable prevailing economic and social conditions...in accordance with which working parts of automobiles tend to be restored and replaced with similar parts...
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> [The Valiant also] has an identity relative to certain kinds of conditional properties...For example, the fenders of the '69 Valiant that has not been garaged tend to rust out whereas the body stands up much better; the ball joints are liable to need replacing after relatively few thousands of miles whereas the engine...is not likely to burn oil until 100,000 miles... (Millikan 1984, p. 279-280)

Historical kinds of a somewhat less concrete nature are, for example, retail chains (McDonalds, WalMart) and buses on a certain bus line (bus #13, the Elm Street bus).[4] Many kinds of interest to social scientists, such as ethnic, social, economic and vocational groups, are historical kinds. For example, school teachers, doctors, and fathers form historical kinds when these groups are studied as limited to particular historical cultural contexts. Members of these groups are likely to act similarly in certain ways and to have attitudes in common as a result of similar training handed down from person to person (reproduction or copying), as a result of custom (more copying), as a result either of natural

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[3] The reference is to Fodor (1998).

[4] The latter example is Richard Grandy's (from conversation).

human dispositions or social pressures to conform to role models (copying again) and/or as a result of legal practices. More generally, they are molded by what is relevantly numerically the same historical niche, a certain homeostatic ongoing historical social context that bears upon them in ways peculiar to their social status. Boyd (1991) claims that members of some social groups may exhibit properties characteristic of the group as a result of being classified into these groups rather than conversely, but he argues that this does not compromise these social kinds as possible scientific objects. Members may come to form a cohesive social kind "only because" other members of the society class them together (stereotyping, prejudice, taboos) but the "because" here is causal, not logical, resulting in certain derived uniformities among members of the group. The kind that results is then real, not merely nominal. If social groups were not real, there could be no gain in empirical studies concerning them, for example, studies of the attitudes of American doctors toward herbal medicines, and so forth. Doctors are an actual-world group, not a set of possible properties in a set of possible worlds. That is why their attitudes and practices can be studied empirically. On the other hand, in so far as social scientists sometimes generalize across radically different cultures, not just, say, across Western cultures, the common historical thread across social groups is mainly just human psychology, the common psychological dispositions of the historical species Homo sapiens.

Historical kinds do not have "essences" in the traditional sense. On the other hand, a kind is real only if there is some univocal principle, the very same principle throughout, that explains for each pair of members, why they are alike in a number of respects.That is, the principle explains the likeness between members, not, in the first instance, the properties themselves. (To explain why a photocopy is like the original is not to explain why either has the properties it has. I can know why the photocopy is like the original without knowing what specific properties either of them has.) Only in some cases does the best explanation of this likeness concern likeness in inner constitution. In the case of historical kinds, although a statistically significant likeness among inner constitutions may result from the principles that group the members into the kind (most of your and my genes are the same[5]) this probablistic result is not what defines the species' unity. Most real kinds do not have traditional essences, but to be real they must have ontological grounds, and these could, I suppose, be called "essences" in an extended sense. One or another kind of glue must hold them together, making it be the case that properties exhibited by one member of the kind are always or often exhibited also by other members, so that induction is supported. We could extend the term "essence" so that it applies to whatever natural principle accounts for the instances of a kind being alike. But it is probably safer to stay with the term "ontological ground of induction" to avoid any possibility of misunderstanding.

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[5] About 90% are likely to be the same. It does not follow that there are many (even any) genes common to everybody. To conclude so would commit the fallacy of composition.

§2.3 Individuals as Substances

Not only real kinds but all substances must be held together by some kind of ground of induction. That is what makes them substances. A substance is something that one can learn things about from one encounter that will apply on other occasions and where this possibility is not coincidental but grounded. There is an explanation or cause of the samenesses.

Ghiselin and David Hull said that species are "individuals" because they are held together not by a traditional essence but through historical causal connections. The other side of this coin is that individuals are rather like species: Their ontological ground of induction is similar. If Xavier is blue-eyed, tall, good at mathematics and intolerant of gays today it is likely he will be so tomorrow and even next year. This is because he too is a "homeostatic system....amazingly well-buffered to resist change and maintain stability in the face of disturbing influences," and because Xavier tomorrow will be a sort of copy of Xavier today. Xavier today is much like Xavier yesterday because Xavier today directly resulted from Xavier yesterday, in accordance with certain kinds of conservation laws, and certain patterns of homeostasis, and because of replications of his somatic cells. Ghiselin and Hull say that species are individuals; conversely, some philosophers have thought of Xavier as a class consisting of Xavier timeslices each of which causes the next. Either way, there is a deep similarity between individuals and many historical kinds.

Because of the rich ontological ground of induction on which biological species rest, one can run numerous inductions over the members of any species, learning about most members from observing one or a few. The elementary student learns about sulphur from experiments with one sample. Similarly, she learns about frogkind by dissecting one frog, and about the human's susceptibility to operant conditioning by conditioning one friend to blink for smiles. One can learn from sample members of a species about the whole species for much the same reason one can learn about one temporal stage of a person from other temporal stages of the same person, and vice versa.

§2.4 Kinds of Betterness and Worseness in Substances

Unlike eternal kinds, historical kinds are not likely to ground many, if any, exceptionless generalizations. The copying processes that generate them are not perfect, nor are the historical environments that sustain them steady in all relevant respects. This is true of individuals as well. Depending on the category of individual and what it is made of, some properties will be less likely to change than others, but usually there are very few that could not change under any conditions. The idea that either an historical individual or an historical kind is somehow defined for all possible worlds, not just this one, such that there are definite properties that must endure for the individual to remain in existence, or that must be present for the kind member really to exemplify the kind, is mistaken. Who is really and truly a member of the working class? Here the principle or principles that cause or tend to hold the kind together catch up some members more squarely than others. Was Theseus' ship still the same ship after its last plank was replaced? There is nothing in nature to draw such distinctions. Historical kinds typically have naturally and irreducibly vague

boundaries. So do historical individuals. If their boundaries happen to be sharp, as they sometimes are in practice, this is a matter of historical fact, not some deeper necessity.

Real kinds are domains over which predicates are nonaccidentally projectable. There are good reasons in nature why one member of a real kind is like another. So, although real kinds can have vague boundaries, still, the question whether an item belongs to a certain real kind or not, or whether it is on its border, is written in nature, not just in English or !Kung. Whether an item item is or is not a member of a certain real kind often is a straightforward substantive question about how the world is, not a question of how we humans or we English speakers like to classify. If it is not like other members of the kind for the very same reason they are like one another, then no matter how many properties it has in common with them, it is not a member of the same real kind. Similarly, we take it quite rightly that whether a correct identification of an individual has been made is a matter of how the world is, not of how we humans or we English speakers like to identify. This has not, of course, stopped philosophers interested in such questions from thinking up numerous bizarre possible-world examples where it would not be clear whether this individual thing would be numerically the same as that one. Similarly, they might raise the question whether a dog with, say, 1/4 or 1/5 or 1/10 Coyote genes spliced in would be a dog. But the home of historical substances is in this world. Questions concerning their identities in other worlds are, in fact, subtly incoherent.

Historical substances are not likely to ground exceptionless generalizations. But many substances interest us not because they afford such reliable inductions, but because they afford so many inductions. They bring a great wealth of probable knowledge with them.[6] This gives rise, presumably, to the typicality effects explored by contemporary psychologists studying categories. It seems natural that people should work with a stereotype taken from knowledge of the most stable properties of substances when asked to describe the substance, in making guesses about category membership, when asked to make inferences about unobserved members, and so forth.

Because the occurrence of causative factors accounting for similarities can be more or less regular or irregular, and because the number of grounded similarities characterizing a substance can be larger or smaller, there are two

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[6] Andrew Milne suggests that historical kinds may be likely to have more projectible properties than ahistorical ones because "with ahistorical kinds, often things that are nomically quite separate are still projectible.... Properties that are only contingently correlated, in the sense that it is perfectly lawful for one to occur without the other, may nonetheless be projectible, because if one is copied the other may be too. So, for instance, while there is no law (so far as I know) connecting having a chitinous exoskeleton and having more than four legs, it is reasonable to assume that something with a chitinous exoskeleton has more than four legs because something with the exoskeleton is a copy of something else with an exoskeleton that had more than four legs" [private correspondence].

different continua from richer to poorer along which historical substances can range. These reflect (1) the reliability of the inferences supported, and (2) their multiplicity. Substances vary widely in both of these dimensions. If the substance is sufficiently impoverished in both of these dimensions, whether there exists a real kind at all can be a vague matter. There is no sharp line between what is and is not a substance. Rather, some things are, as it were, better substances than others, some are worth understanding as substances, others are too marginal or uninteresting. One might argue that even Californians form a very rough or vague historical kind. They are of the same species, many have copied behavioral patterns from one another, they have been subject to certain social and physical environmental influences from the same sources, hence certain very rough and uncertain generalizations can be made over them for good reason. There is a long, graded continuum between historical kinds suitable, say, to project sciences over and a great variety of poorer and less exact historical kinds that are nonetheless not nominal but real.

§2.5 Ontological Relativity (Of a NonQuinean Sort)

The category of substances, as I have defined it, is at root an epistemological category. As such, it cuts straight across many more familiar distinctions in ontology. What makes a substance a substance is that it can be appropriated by cognition for the grounded, not accidental, running of inductions, or projecting of invariants. This will be possible in different cases for very different reasons, due to very different sorts of causes, which is, of course, exactly what interests me about substances. It is their variety, considered from other ontological perspectives, that makes it easy to overlook their similarity relative to the projects of cognition. I have illustrated the category of substance by reference to individuals, stuffs and certain kinds whose members are ordinary physical individuals. But other ontological types can be substances too. Beethoven's Fifth has many properties that are unlikely to vary from performance to performance. You can recognize it and know what is coming next. This is also true of tellings of The Three Bears. Places have properties many of which remain the same over time. Dinner time and siesta time have pretty definite properties in many cultures. War among humans has certain properties that seem to remain pretty much the same over the ages. Western industrial economies can be studied as a real kind.

There is not one set of ontological "elements," one unique way of carving the ontology of the world, but a variety of crisscrossing overlapping equally basic patterns to be discovered there. Cubes are things one can learn to recognize and learn a number of stable things about such as how they fit together, how they balance, that their sides, angles and diagonals are equal, and so forth. In their commentary on (Millikan 1998a), Cangelosi and Parisi (1998) remark (correcting me) that white thing is something one can learn about. White things, they said, get dirty easily and, I now add, show up easily in dim light, stay cool in sunlight but also tend to blind us, and so forth. Understood as substances, however, I think that these entities are most naturally and also most correctly, named with simple nouns: "Cubes don't stand on edge easily," "White stays cool in sunlight," "squares have equal diagonals" and so forth. This reflects the fact

that qua naming substances, the terms "cube," "white," and "square" express subject-term thoughts. As substances, white and square are not predicates, not properties; they have properties. The same thing can be a property relative to certain substances and also a substance relative to certain properties.[7] Which way a thinker is understanding such an entity is generally expressed in the grammar. .

Just as properties do not have to have natural demarkation lines between them in order to be real, there are substances that have no natural boundaries along certain dimensions. Water shades into mud on one side and into lemonade and then lemon juice on another. Substances of this sort are organized around paradigms, or around peak points, or gradient shifts, at which causally intertwined properties are either historically or ahistorically determined to be collected together. Other cases often diverge from the paradigms along several dimensions. Closer approximation to the paradigm essences or paradigm historical causes linking these cases together yields closer approximation to other of the typical properties of the substance as well.

§2.6 Substance Templates and Hierarchy among Substances

I can observe today that Xavier has blue eyes and knows Greek, and unless Xavier is very unlucky, this will hold true when I meet him tomorrow. But if Xavier is sitting or angry or playing tennis when I meet him, this probably will not be true tomorrow. Similarly, if I observe the approximate adult size, preferred diet, variety and placement of internal and external organs (two eyes, two kidneys, one heart on the left) and general physiology of one member of the species Felis domesticus, all of these observations will probably yield correct predictions about the next member of Felis domesticus. But if my observations concern color, certain kinds of behavior patterns, and the pattern of torn ears, they will be unlikely to carry over to the next cat I meet. If they do, it will be a matter of accident. Again, if I have determined the color, boiling point, specific gravity, volatility, and chemical combining properties of diethyl ether on one pure sample, then I have determined the color, boiling point, specific gravity, volatility, and chemical combining properties of diethyl ether, period. If the experiments need replication, this is not because other samples of diethyl ether might have a different color, boiling point, and so forth, but because I may have made a mistake in measurement or analysis. But I cannot in this way determine the shape, volume, or purity of diethyl ether. These are not properties that generalize from one meeting to the next.

Now about diethyl ether you probably take me to be right, not because you know that the above is true of diethyl ether specifically. Rather, you know it is true of chemical compounds generally. You know that chemical compounds do not vary with respect to color, boiling point, combining properties, and so forth, but that they do vary, when encountered, with respect to size, weight,

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[7] For more on this theme, see (Millikan 1984) chapters 15-17. There I claim, for example, that unlike substances, properties are, as such, members of contrary spaces. These are groups whose members oppose one another, by natural necessity, on the ground of certain kinds of substances.

shape, ownership, monetary value, place they were mined (for mined minerals) and so forth. You know that there are properties that the chemical kinds have qua being those very chemicals again, and that there are other properties that only samples of them have. This is because you understand the category chemical compound to correspond not merely (if at all) to a substance (what, if any, are the determinate properties that every chemical compound has?) but to a substance template (§1.8).

Similarly, you probably take me to be right about Xavier, not because you know him personally, but because you understand him to fall under the substance template human being, and you have a good idea what determinables are likely to be constant for substances falling in this category.

But if you also agreed with me about Felis domesticus, why was that? Was it because you know that every species of animal is uniform, for example, with respect to adult size? But snakes and alligators keep right on growing. Or because you know that every species of animal is liable to vary in color from individual to individual? But this is not true of most species. Nor is it true of most species—perhaps only of mammals and some birds—that their behavior patterns may vary significantly from individual to individual. Animal is not as well-focused a template as either chemical compound or human being. Knowing just that something is an animal, you will have lots of ideas about the kinds of questions that can be asked about it, but for a significant proportion of these, you may not know in advance whether they can be answered univocally for the species as a whole. If you are given that the animal is a mammal, of course, this may help quite a lot. Categories like animal and mammal correspond, of course, to substances—each has some univocal properties of its own—but more important for the project of gathering knowledge, they bring with them substance templates. The categories animal species, mammal species, person crab, pebble, bridge, road, musical composition, chemical element, and book, for example, are all substance templates as well as corresponding to substances in their own right. As templates, they take predicates like "have shapes,"have colors," "have metabolism rates," "have specific gravities," "have spatial lengths," "have temporal lengths," "have designers," "are written in languages (French, German)," and so forth.

I have mentioned that substances vary both in the number of inductions they support and in the reliability of the inductions they support. Here we have a third kind of variability in substance quality. Substances vary in the availability and sharpness of focus of recognizable substance templates covering them. Where good substance templates are available and known, concepts of the substances falling under them are extremely easy to develop, for it is known in advance what kinds of determinables will be determinate for these substances, hence what kinds of inductions they can support. The discovery of substance templates requires something like meta-inductions, although there is some evidence that certain meta-inductions may be bypassed by human infants. Some grasp of certain templates, some grasp of the structure of certain substance domains, may be wired in (compare Keil 1979, 1989; Carey 1985; Atran 1989; Markman 1989; Spelke 1989, 1993; Gelman and Coley 1991;

Gallistel et al 1993; Marler 1993, Boyer 1998). For those disciplines systematic enough to be clearly labeled as well developed empirical sciences, the substances studied typically fall under well-focused substance templates, or under a hierarchy of such templates. Especially, well founded second order inductions of this sort would seem to underlie all of what Kuhn labeled "normal science." The basic principles of good scientific induction are never found in logic alone; all inductive reasoning rests on a posteriori projectability judgments (compare, for example, Boyd 1991).

Many substances do not fall under well-focused substance templates, however. Consider, for example, the substance chair. I have argued that this is an historical substance, but what substance template do chairs fit under? It is clear that one would not want to project a science of furniture, for example, for although there may be one or two questions pretty certain to have answers for each kind of furniture (what was it designed to be used for?), there are not nearly enough to delimit in advance all or most of the determinables that are relatively reliably determined for most chairs.

Aristotle thought there was a hierarchial ordering among all substances. According to the doctrine of "real definition" or of natural ordering by genus and differentia, substances were supposed to form a logical tree. I think this doctrine was seriously wrong. The structure of the domain of substances is frankly a logical mess, a mare's nest of overlappings and crisscrossings. There are multitudes of entwined substances, very very many more, surely, than we have ideas of. The ones that are picked up by thought and by language are only those that have properties of interest to us, but that they are interesting does nothing, of course, to make their status as substances less than fully objective. Tree structure is good for a general classification system to have (§3.2), but it is not the structure of the logical space of substances nor of most of its sub-spaces.

Consider butter on the one hand and human beings on the other. Clearly there is no natural way to hang these on the same logical tree. They are neither beside one another (horizontal) under some higher substance, nor is one included in the other (vertical), nor is there some more inclusive substance covering them both. (Aristotle might have said they are both subsumed under substance and under Being, but substance is not a substance and neither is Being.) When we look within domains rather than across them, matters are no tidier. Susan is a 1990s American mother and a professor and a diabetic. Each of these is a rough substance category, but there is no logical tree on which they all hang. Heated modern debates among biologists about principles of classification (phenetics, cladistics, evolutionary classification) reflect exactly this: there is no way to organize the substances that are of interest to the zoologist or botanist into a single hierarchy. The demand that biological taxonomy should settle on a single hierarchy is of course quite rational. A good classification system is needed for information storage and retrieval among the various biologists. The actual systems of classification used by biologists are compromises between good classification and respect for natural substance boundaries (compare Mayr 1981). In the natural domain of substances there is

a confusing crisscrossing, every which way. On the other hand, wherever there exist substances that are also substance templates a degree of hierarchy and order is naturally imposed on the domain of substances.

For every substance, one can ask how many inductions, if I knew to venture them, would yield reliable results. We also can ask, how many of these inductions I could know to venture in advance through grasp of a good template for the substance. The latter question is the more interesting to the epistemologist. The interesting question of inductive potential concerns how many determinables you know you can find stable values for, not how many stable properties the substance actually has. The best substances are the ones for which there are rich, known, substance templates, for example, the chemical elements and compounds, the various living species, and also individual members of these species, and most more ordinary individual physical objects. These are things we know how to learn many things about without wasting time on dozens of observations verifying the stability of each trait.

A question that has sometimes been asked by psychologists interested in categorization concerns which level of substance categories are inductively the most "fertile" to have a grasp of (see Komatsu 1998). The question assumes, of course, some degree of hierarchial structure within the domain to be considered. Now if one were to recognize only the lowest level substances, say, only the individual animals or only the species, although it is true that these have the greatest number of properties, learning about these properties would be a hopelessly inefficient process. One would have to start all over with each individual object or species, exploring its individual features, with no contribution from prior knowledge of higher substances carrying substance templates, either about its properties or its relevant determinables. It seems that there is no particular level at which greatest "fertility" lies. It results, rather, from an interaction between levels.