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VALUE IN THE LARGEST VIEW: MORE LIFE

being Chapter Two of
A GENERAL THEORY OF VALUE
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In this chapter I propose that positive value (to a given system) is properly attributed to whatever nudges its evolution in a positive direction, and negative value to whatever nudges it in a negative direction.

Transforming this statement into something less tautological and more useful will take a while. Not just because the subject is intrinsically so large, but because any theory that aligns *evolution* with *value* too directly, too simply, will find itself on a collision course with such deeply held ethical principles as fairness, compassion for the weak, the intrinsic worth of individuals, and even the desirability of living to a ripe old age, all of which can be seen as impediments to the evolutionary process. This potential for collision directs us to the deeper philosophical question of just what the "positiveness" mentioned in the opening sentence consists in. In Chapter One, I suggested that it is contained in the phrase "more life." This will need more explaining both because we know that evolution depends on there being much death, and because the "more" in "more life" can have both a qualitative and quantitative meaning. We will also have to be careful about specifying who or what is judging value on behalf of whom or what.

I. Value and Evolution

The desire to find a basis for social and ethical behavior in the larger patterns of nature by using the idea of evolution (rather than divine design) is not new. This is especially true today, when most college-educated people not only accept the truth of the theory of evolution more or less as Darwin proposed it,[i] but accept also that there is a parallel—if not a completely deterministic, causal relationship—between biological evolution and how institutions, cultures, markets, art forms, languages, and so on proliferate, develop, transform, and die away. The Darwinian principle of "survival of the fittest," for example, is often cited as explaining, and even justifying, many seemingly-harsh competitive practices in the business world. As anyone who has served uneasily on a selection committee would agree, the process that Darwin called "natural selection" provides something of a rationale, aligning what we do quite consciously with the blind but to-be-respected forces of Nature. Historians speak coolly of the rise and decline of civilizations and institutions, and we readily see in this some significant similarity to the rise and demise of species, accepting the inevitablity implied. Have we not learned that wildfires are the forest's way of renewing itself? When we speak approvingly of "development"—human or economic—we commonly invoke what we believe to be an abiding correspondence between development and natural growth, and, cancers aside, between natural growth and positive, i.e. successful, evolution. Through genetic variation, which is nature experimenting, evolution also produces the *new*—and the new, we moderns believe, is always good. At least potentially.

To be sure, those who make comparisons between nature's ways and ours often over-generalize, and sometimes for selfish reasons (say, to justify callousness or foment change). If that were all that were wrong, then nothing more need be demanded than greater carefulness in making the comparisons. But the move from theorizing about biological evolution to theorizing about cultural evolution, even with the best of intentions and scientific acumen, would remain a tricky one. Some say it is a transition that scientifically cannot, and morally *should* not, be made. Many argue that the Darwinian processes of random genetic mutation/variation, of reproduction with heredity, and of natural selection, do not actually describe—let alone circumscribe—the fate of species such as ourselves. *Homo sapiens*' ability to organize the world with design, foresight, and moral purpose puts mankind largely outside of the laws of evolution as they apply to the lower genera. Moreover: as it should. Just because nature is "red in tooth and claw" does not mean we should be. Indeed, the very opposite is implied. Humans have language; ideas—"memes"—carried by language and other communication media do not replicate like genes. These spread in importantly different ways (rather like diseases if we *must* make a biological analogy). Furthermore, they argue, the time periods involved are vastly different. For cultural evolution—should such be admitted to exist—the period of significant change is decades, centuries, perhaps a millennium or two. For biological evolution it is generally thousands or millions of years, while for physical and cosmological evolution it is billions of years.

Far less, they say, does the theory of evolution have anything to tell us about the complex texture of day-to-day human experience.

Others do not agree with this assessment, however, and I count myself among them. That cultural evolution does not proceed by precisely the same rules as biological evolution or with exactly the same sorts of outcomes is a point easily conceded. Absolute homology between the two is not required for light to be shed either way. Rather, we should want to know whether the processes of biological evolution inform, infiltrate, spur, constrain, shape, or in some interesting way reappear in the processes of cultural transmission with sufficient plainness to call the latter processes themselves "evolutionary."[ii] We should also want to know whether any reverse influences are to be found: does cultural evolution ever guide biological evolution? As in the case of humans preserving "bloodlines" the answer seems to be Yes, as I remarked upon in the last chapter.[iii] And then there is genetic engineering...

But why argue the point at all? What is at stake?

What is at stake is an understanding of our place in nature and in history deep enough to provide grounds for critiques and justifications of "progress." And these are high stakes indeed. It matters a great deal how scientists and other experts invoke the theory of evolution to locate Man in some proper—read: *legitimate*—position in relation to Nature, and it matters far beyond the boundaries of environmentalism as conventionally defined. What *are* our "natural" rights with respect to other species, to each other, to the land? Is violence an inescapable feature of life on earth? How should we treat our infirm? Is abortion the same as infanticide, and never justified? How does cooperation come about? Is the institution of private property inherently unjust, or is it an unavoidable and not-to-be-regretted extension of animal territoriality (which can be shown to be life-promoting for all)? And, our question: why does this action or object seem to us to have more *value* than that one? In general (check one), are all/most/some/no moral principles totally at odds with evolutionary ones? Or can all/most/some/none be reconciled? As old as they are, questions like these are being asked with renewed urgency as we try to move *forward,* in some ill-defined sense, knowing as much as we do about our origins as a species and our commonality with all living things.

It is clear that there were, and still are, people all too ready to apply basic Darwinian principles directly to human affairs. At the turn of 20th Century for example, both landed gentry and working-class revolutionaries could find support for their political views in evolutionary theory. The former believed that their long-held privilege was a sign of their "fitness" as a class. The latter argued that species extinction and replacement was working in *their* favor. And from some place in between, the upwardly-mobile bourgeoisie saw in the Darwinian principle of "survival of the fittest" a fine justification for *laissez faire* capitalism.

But as time goes by rigid parallels between biological and cultural evolution of the sort propounded, say, by Herbert Spencer in the late 1800s, are rapidly being supplanted by considerably more sophisticated ones.[iv] We now understand, for example, that natural selection occurs not in one way but in a number of ways, extinction—"survival of the fittest"—being the least of them. Differential reproduction rates between populations is by far the larger factor, and no creature need die before a ripe old age for evolution to proceed. Fitness, it turns out, is not just an individual matter; a *group* can be thought of as evolutionarily fit (or not), and its common genes thought of as the units that persist—and the units that seem to *want* to persist—from generation to generation. On this interpretation of fitness (called "group-" or "inclusive fitness"), a great deal of selfless and cooperative behavior that previously seemed anomalous falls neatly into the ambit of evolutionary theory.

Nor does variation and natural selection occur only among populations of creatures. It proceeds *within* them as well. In every animal's immune system, for example, certain antibodies multiply to fight off viruses, which themselves mutate as though to avoid being fought off. Neuronal connections in the brain may themselves be formed and re-formed under a regime of speeded-up evolutionary processes, and what we call "learning" might be nothing more (or less) than these processes at work.[v] Indeed, working on this principle, there are computer programs that "breed" new programs, which are then selected for functionality, which then "breed" with each other again, and so on, evolving, finally, into complex programs that carry out sophisticated computational tasks in ways that no human being can understand or decode. It seems that fundamental evolutionary principles, applied in this way, may well hasten new technological developments, new medicines, new teaching methods, and so forth.[vi]

We also are beginning to understand how biological novelty arises not only through random mutations in genetic codes externally precipitated (by stray cosmic rays, for example) or through mutation rates that respond to environmental factors,[vii] but from deep *within* complex systems, complexity kneading and reading itself: evolution following *con*volution, as it were, at the molecular level. We know that many scales of organization can—and most often do—*co*exist in a single system, like so many different radio stations on the same radio dial but each operating at a different wavelength.

We also know that the general increase of complexity through evolutionary time is neither linear nor assured. Rather, it proceeds in fits and starts and over so broad a front that today we see the simple and the complex coexisting everywhere: hammers, bicycles, cameras, computer chips...viruses, earthworms, dogs, ballet dancers...*together*. If anything, it is the distance between "the simple" and "the complex" that grows and fills itself with instances.[viii]

What has all this to do with value?

If the theory of evolution has any general message for us, I suggest that it lies in this almost-tautological statement: "Life's purpose is proliferation." Life's purpose is more life, in both quantity and quality. In this context, good-ness, positive value, can hardly help but appear (to the participants in this game, at least) as an attribute of anything that promotes the process.

And now the bad news. From life's point of view, what it is that *proliferates* may just as well be particular genes or species or traits or behaviors as family names, firms, technologies, religions, stars, black holes, TV shows, or whole civilizations. As far as nature is concerned, what proliferates may as happily be any or all of these things as be nice human beings like you and me, our children, or the ideas we give birth to and nurture. For on the largest and least anthropocentric view it is simply patterns of *information* that evolve and not you or me, nor your people or my people, except insofar as we exemplify and embody the processes of variation, selection, reproduction, variation, selection, reproduction...rolling like a wheel through time, a wheel begetting wheel-begetting wheels.

If this picture of the world is essentially accurate, then the course of moral philosophy and of "value studies" must pass through some rather wild territory. When the phenomenon of life is understood as dispassionately as science would have us understand it—as the result of a trick stumbled upon as the universe cooled, a trick without end or final purpose, the replication of replicators—then caution would seem to be advised in equating goodness too simply with *more life*.[ix] More radically yet: if perpetuation itself depends on self-perpetuation, so that the universe we have, from photon to mastodon, is the one we have because the components of it that *could* have been here but *are* not here, are absent because they could not adequately reproduce themselves—if the universe we live in is just one of perhaps a handful of universes that *made it through* several galactic collapses to black holes, that *learned* in some sense to persist with just the right physical constants to precipitate collapse and rebirth with just the right physical constants again—then Darwin's vision was not just of plants and birds and lizards and monkeys, but of everything: the stars, the Beginning, Time itself.[x] Who dares draw from this extravagantly amoral vision of the universe any lessons for everyday life?

On the other hand, as cautious as one might want to be about using evolutionary theory to gain insight into human affairs, it is hard to deny that something very much like variation and natural selection does go on, for example, between firms that compete for market share (some going bankrupt while others prosper), between nations that compete for resources (some losing wars and declining while others win and advance), between ideas and inventions (some laying unused while others gain acceptance and prevalence), between languages that "want" to be spoken by more people (some, like Latin, dying out while others, like English, becoming global), between individuals who compete for each other's favors (some failing while others go on to spread the successful method called *politics*). Without ignoring the differences, it is hard to deny the affinity between "variation" and "invention," between "reproduction" and "manufacture," between "selection" and "choice." Indeed, in our social relations, in our tools and technologies, and in our languages (formal and natural), it is hard *not* to see evolution at work, hard *not* to see it expressing itself, as it always has, in an irregular but general increase in the number and variety of things produced that are more complex, more organized, and in at least some respects more efficient, than their earlier "models."

And why need all this be *mere* analogy? It seems to me a curious if noble foolishness not to admit that human culture is a superstructure built upon, over, and out of, Nature's indifference, her blind fructitude, her serendipitous embrace of the accidental. How likely is it that modern human behavior—from mate selection to family life to gender differences to our basic needs and appetites—does *not* have written into it the story of biological evolution?

The reach of evolutionary theory is long and wide. And the more open we are to the empirical evidence, the more likely we are to find its explanatory power growing. But one might have *moral* objections to interpreting human affairs in terms of evolution, biological or cultural; and these objections might carry more weight than scientific ones. This is not because one wants to assert, as creationists do, that the theory of evolution is wrong, or "just a theory." One might object to evolutionary explanations, and especially those that tie strongly to biology, because one feels that one must propound views that are most morally effective *even if those views are less than perfectly scientific* by some contemporary measure.

Take, for example, the perennial "nature-nurture" debate as to whether heredity ("nature") or upbringing ("nurture") more fully accounts for the skill and characterological differences among people. Let us suppose that it has been scientifically shown that heredity, race, body-type, etc. account more strongly for individual personality traits and success in life than do family customs, education, training, personal experience, and so forth. There are two ways to advocate that we should concentrate our efforts on *nurture* nonetheless. The first is to concede that nature counts more than nurture but add that, since racial discrimination and/or interfering with the reproductive freedom of individuals is unconscionable (not to say illegal), *all we can do* is attempt to improve those cultural practices that constitute nurture (e.g., schooling, child care, diet, transmission of values). Second, we can try to discount, undermine, question, or simply ignore all the science that proves that nature is more influential than nurture.

Now, the first response asserts that nurture is still eminently worth our attention, and this is to the good. But it leaves intact a certain amount of fatalism. One has a fall-back position: "Well," we might say, "it was in his or her *nature* to be bad (or lazy or stupid or sickly). We did what we could." The second response may be unscientific, but it is not irrational since it has the salutary effect of increasing the responsibility its adherents feel towards raising children, towards maintaining cultural institutions, and so forth. For when nurture is believed to be *all*, and not just "important," there is no fall-back position, no excuse that will exonerate the nurturer. When every child is taught, for example, that they can become "anything they want to be," this tantamount-to-magical belief, this mistaken idea, might well have consequences that are more moral—and, paradoxically, more evolutionary—than ideas based on a truer understanding of the rigidities of inherited physical traits, social class, and the like.[xi]

Ideas themselves differ in the rate at which they are adopted and replicated, at which they "succeed" in a Darwinian sense. It is ironic that one such quite-successful idea is that there is no truth to evolutionary theory, at least not for human beings or at a cultural level.

We will return to our discussion of evolution in social and cultural terms later in this chapter and in the next. First, though, we need to enlarge our repertoire of concepts, making them as precise as possible. We need to define *value* in evolutionary terms.

II. Complexity-and-organization, Ω, defined.

We saw evidence in Chapter One how more-highly-evolved living systems tend to be both more complex and more organized than non-living and less-highly-evolved living systems. So, too, we found, were music, language, and DNA generally more complex *and* more organized in total as we looked at longer strings of symbols—a point that seems self-evident until we realize that it presumes that the sequence in question is neither so repetitive as to make the whole predictable from a part, nor so very complex that, defeated, we would call it random.

There would seem, in fact, to be a "sweet spot," a particular balance of complexity and organization that avoids the two extremes just mentioned and that characterizes all interesting-to-us and somehow vital systems. Where exactly does this sweet spot lie, and at what or how many scales? What is the magic combination? And might this combination—expressed, say, as the sum or difference or ratio of complexity, *C*, to organization, *R*, at some certain scales—be the same for all living (and life-promoting) systems? Plausible answers to these questions will soon become apparent; but we need more theoretical scaffolding to get them into view. Indeed, this "scaffolding" will constitute the very framework of our theory of value.

As in Chapter One, the mathematically-minded reader will find technical expressions of what follows in the footnotes. A system's "degree of complexity-and-organization," when it is not spelled out, will be denoted by the upper-case Greek letter Ω, "omega." Specifically, the (degree of) complexity-and-organization, Ω, of a given system at a given scale is computed as the square root of the product of its actual complexity, C_{act} (hereinafter denoted simply as *C* and referred to as "complexity"), and its degree of organization, *R*, both of which we studied in the last chapter. That is to say:

$$\textit{complexity-and-organization} = \sqrt{\textit{complexity} \times \textit{organization}}\ ,$$

or, using more compact mathematical notation:

$$\Omega = \sqrt{CR}\ .$$

We observe from this definition, first, that Ω is always greater than or equal to zero; second, that if either complexity, *C* , or organization, *R*, goes to zero, then so does Ω; and third, that Ω has units of *bits*, i.e., the same unit of measurement as complexity, organization, and, of course, information.[xii] One wrinkle, though: In Chapter One, following Brooks and Wiley, I defined organization as the simple arithmetic difference between potential complexity and actual complexity, that is, as C_{pot} minus C. Here, however, and henceforth, we shall define R just a little more elaborately: as the *square root* of the difference of the *squares* of potential and actual complexity. Thus, where before we had R equal to C_{pot} minus C, now we have R equal to $\sqrt{C_{pot}^{\ 2} - C^2}$. This way of formulating R will offer us several advantages later on without affecting in the slightest the arguments made in the last chapter using the older formulation. Indeed, through most of this book, continuing to think of organization as the simple arithmetic difference between potential and actual complexity will do little harm. [xiii]

The intrinsic relationships between C, R , and Ω can best be visualized by plotting them on a simple graph. In Figure 2.1, the degree of organization, R, is assigned to the vertical Y-axis, and (actual) complexity, C , is assigned to the horizontal X-axis. Since Ω is the square root of their product, Ω appears in the graph as a set of contours along which its magnitude does not change. (Remember: many combinations of C and R yield the same value for Ω.) Ω-contours further away from the origin, i.e. situated to the right and up, represent higher values of Ω. Like the contour-lines on a topographical map, Ω-contours represent a *surface* viewed from above—the "Ω-surface" we can call it—sloping downward to the "south" and to the "west" from a high zone in the "northeast." Notice that there is something of a ridge along the diagonal from the origin (at the southwest corner) to the high zone. We can call this ridge the "ridge of Ω."

Figure 2.1 Graph of complexity, *C*, organization, *R*, and complexity-and-organization, Ω

Now, the opposite of *complexity* is *simplicity*: the lack of one implying the plenitude of the other. The opposite of *organization* is *disorganization*, the lack of one implying the plenitude of the other. Any system, as analyzed at a certain scale or as averaged over several scales, can thus be described as being situated either at one of these four extreme states or as lying somewhere between them:

simple-and-organized (low C, high R),
complex-and-organized (high C, high R),
simple-and-disorganized (low C, low R), or
complex-and-disorganized (high C, low R).

Note that only "complex-and-organized" has high Ω. The other three have low Ω, with "simple-and-disorganized" having the least.

A variable *not* represented in Figure 2.1 is our old friend *potential* complexity, C_{pot}. Of course, C_{pot} is latent in *R* by definition, but it would be nice to see it on the graph in its own right. Luckily, this is an easy omission to remedy. As Figure 2.2 shows, C_{pot} appears as a series of quarter circles, centered on the origin of the graph. Each arc represents a constant value of C_{pot}, with the larger, more enclosing arcs representing higher values of C_{pot} than the smaller ones.[xiv] One might think of these arcs as views-from-above of quarter-cylinders that cut down and into the Ω-surface. Travelling along the *intersection* between any one C_{pot} arc and the Ω-surface represents how, for a given value of C_{pot}, the maximum value of Ω lies on the ridge of Ω, which is where *C* and *R*. are equal to each other, while minimum values of Ω lie along both of the two axes to either side, as though in trenches, where either *C* or *R* are zero or close to zero.[xv]

Figure 2.2 Plotting potential complexity, C_{pot}.

For convenience, we can classify the Ω-surface into three regions, as shown in Figure 2.3. The first region we might reasonably name "*rigidity*": here organization is much greater than complexity. The second region we might name "*chaos*": here organization is low while the system's actual complexity approaches the limit of the complexity possible for it.

In the third, "just right" region (*pace* Goldilocks), the region roughly midway between chaos and rigidity, the degree of complexity and the degree of organization of the system are about equal and Ω is close to maximum for any given value of C_{pot}. I have called this region, somewhat pre-emptively, "*life*." Theoretically, we can expect to find our Ω "sweet spot(s)" somewhere in this region—on or near the ridge of Ω.[xvi] We will use the term "Ω-*optimality*" to mean "having or exhibiting close-to-maximum Ω for a given magnitude of C_{pot}." Ω-optimality thus implies lying on or near the ridge of Ω.

We are ready to find out whether a theory of value, both plausible and supported by empirical evidence, can be educed from this flurry of abstaction.

Figure 2.3 Three regions on the Ω-surface

III. Value Defined and Its Meaning Explored.

Although I have not yet presented all the evidence for doing so, in both this chapter and the last I have associated the total degree of complexity-and-organization in a system, Ω, with its "lifefulness." From here it is a short step to propose the following: that positive value is attributed to anything that increases lifefulness, i.e., *that increases* Ω, over a given period of time.

One can see how evolution would "allow" such an idea to succeed. Not by chance is it familiar. It is the idea that underlies all moral traditions that have taken human "fruitfulness and multiplication" to be a paramount goal and that have developed rules—some seemingly far-fetched—that ensure that goal's long-run fulfillment. *The "thrust of life" is its own increase, and what we call "good" is that which rehearses or reflects back to us, maintains or accelerates, this ancient, self-perpetuating trend.* ("I have put before you life and death, blessing and curse," says Moses in Deuteronomy 30:19, "Choose life—if you and your offspring would live..." "The purpose of life is life," said Goethe. "Good is all that serves life; evil is all that serves death," writes Erich Fromm, "Good is reverence for life, all that enhances life, growth, unfolding. Evil is all that stifles life, narrows it down, cuts it into pieces.")[xvii]

Let us state our hypothesis more sensitively: *Anything that changes the complexity-and-organization of a system has value to that system in the amount of the change*. Thus, where *V* stands for *value* and is measured in bits, where *x* is a particular thing or event, and where P is the system, creature, or person experiencing *x*, we can write:

the *V* of *x* to P is equal to the change-in-magnitude-of-Ω of P that is atttributable to *x*,

or, in more compact mathematical notation:

$$V_{\mathrm{P}}(x) = \Delta\Omega\ (\mathrm{P} \mid x\ ).$$

Here the Greek symbol Δ, "delta," means "change in...," and the vertical slash, |, means "given...," (or in this case "because of..." or "attributable to..."). More compact and more memorable is the following formula, which expresses essence of the hypothesis:

$$V = \Delta\Omega,$$

or "value is change in complexity-and-organization." To apply this expression to a particular situation, one must just remember, of course, to recover the appropriate qualifications, attributions, and identities.

Now, the reader would not be blamed for finding these equations rather too facile. "Value," after all, is an enormous and subtle topic, built into the warp and woof of all the humanities and the social sciences—not mention economics, religion, and much of everyday conversation. How likely is it that a theory of value, itself of any value, could be boiled down to such a simple formula? Is this not taking scientific reductionism too far? And besides, if this is really *science*, then where is the experimental evidence, and where are the procedures for actually measuring Ω?

I ask the reader for patience. Much of the rest of this book is an unfolding of "$V = \Delta\Omega$," and by the end of it we ought to find that the subject of value is indeed as inexhaustible in nuance and detail as we first expected it to be. For now, let us admit V as a candidate for consideration, and let us judge the candidate by how it promises to behave. Does V, as defined, behave remotely the way we think a good measure of value *should*? Does it represent anything we already know about value, about *what* we value, *when* we do, and *why*? Can it then go on to clarify any ethical or economic conundra, or at least suggest where their difficulty might lie? Does it connect us to life at large, and its evolution?

After we have completed this stage of the inquiry—call it our "screen test of V"—we will indeed look at what empirical support can be found for Ω's relationship to lifefulness and for the claim that value is essentially a measure, or registration, of Ω's change. This happens in Chapter Three.

Notice first of all that while Ω is always greater than or equal to zero, V can be positive, negative, or zero in magnitude.[xviii] Things that change the complexity-and-organization of a system can be "good" for the system (V greater than zero), "bad" for it (V less than zero), or neither (V equal to zero). This accords well with intuition: things and events can be valued, disvalued, or regarded with indifference.

Notice, second, that with our definition of V it makes little sense to speak of the value of something without specifying to whom (or to what) that something has value. Moreover, if x is the "something" that has value to P because it changes the complexity-and-organization of P, it may also be the case that P changes the complexity-and-organization of x at the same time, in the same encounter. If so, then x and P *have value to each other*—and not necessarily *equal* value. This is surely a realistic representation of life as we find it.

Notice, third, that measuring V requires that two points in time, or two states of the system, to be brought into comparison. Value arises from a change or a difference in states; it is not a state in itself. It follows that the only way to speak about a thing's *intrinsic* value—the value it has for just existing—must be equal to its Ω-as-found, since the only Ω-magnitude one ought to compare it to, for existing at all, is zero. Thus a thing's intrinsic value is not the same as its conventional or average value, which should be defined in its relation to one or many other systems.[xix] Does this not make sense?

Notice, fourth, that just as we found with C and with R in the last chapter, a particular magnitude of Ω is properly associated with a particular *scale* of operation of the system. This feature of Ω, and therefore V, is worth dwelling upon for a couple of paragraphs:

A song or building or organism might contain higher Ω at small scales than at medium or larger scales. A large block of apartments, for example, consisting of hundreds of identically-shaped living units like cells in a hive, is quite uniform and repetitive in over-all structure. At the scale of these "cells" and larger, Ω is low (for being too organized). But at the smaller scale of furniture, of clothing, and of the gestures of individuals within these apartments, Ω is apt to be high. At these smaller scales, extremely complex-and-organized things are likely to be going on: cooking, eating, piano-playing, head-scratching, joking, dreaming, love-making, not to mention faucets dripping, paint peeling, bananas ripening, fans blowing, and a variety of small machines whirring and calculating and ticking as they go about serving their owners' needs. Because of all this, no two interiors are identical. Each is immensely complex; and this makes each interior—when viewed, measured, appreciated at this finer scale—utterly unique as a whole.

Or think of behavior of soldiers on parade, marching back and forth on a perfectly mown field, in perfect coordination, and on command. Here are a thousand individuals behaving as one: less an organism than a multipart machine—highly organized, not very complex. Now think about what these soldiers are thinking about, or of what their brains and bodies are actually accomplishing at the scale of neurons and blood cells, even as they outwardly exhibit the far simpler order. They are models of Ω-contained, Ω-enwrapped, of immense Ω largely sealed off from outside view.[xx] Ditto for choirs and orchestras, for drivers and shoppers. Does it not behoove us, when making value judgments, to take into account the effects of some action, x, on the complexity-and-organization of P at scales we can't easily see? *These* scales—and not the ones we find easiest to manage—may be the important ones, the ones bearing the greatest burden of keeping the system maximally alive.

Notice, fifth, that because *V* is so abstractly defined, it leaves open the answer to the question of how best to examine the *experience* of value. There are several alternatives. We can think of value experiences as something both viscerally felt *and* rationally calculated by planning, option-weighing, remembering, and empathizing creatures such as ourselves. Or we can think of value experiences as something less formed: real and felt, but subject to a minimum of rational calculation, as when my cat, locked in the house all day, "decides" whether he is more hungry claustrophobic and either waits around for food or shoots out the door when I come home. (In many situations, humans are no more calculating than this.) Or we can think of value as a change in the behavior of some "system," like a computer or machine or market or business, that is itself not complex-and-organized enough to feel or experience anything. In this third case, *we* do the value-estimating and value-experiencing *for* them, as when we decide where in a room a chair is "happiest," at which settings a machine runs most smoothly, or with what rules and incentives, prices and products, a business thrives in changing circumstances. In all of the above interpretations of the value experience, what is increasing or decreasing (says our theory) is some entity's complexity-and-organization at some life-important scale to it.

But, we still wonder, what of the subjectivity, the *feeling*, of value? Is "consciousness" in the way *we* understand consciousness—i.e., awareness that one is personally alive in a real world—necessary for value to exist?

The answer, I think, is No, although it is natural for us to want to locate all valuation in ourselves. After all, what is good for a tree's life or a worm's life might be *obvious* to us, but it is *of value* to them; and *that* value is not ours to experience except, perhaps, empathetically. It seems natural that higher organisms would evolve (or, in the case of complex machines, be designed) to have regard for their own condition. That "regard" would consist in the organism registering in some part of itself the state of its own overall lifefulness—or, more importantly, registering any *change* in that lifefulness. "How'm I doing?" is the question any organism with some autonomy must ask with an urgency that is proportional to that autonomy. And since a perfectly fine-grained diagnostic report of its every part's functionality would require a computational complexity that met or exceeded the complexity of those parts, a summated, statistical report must suffice: something like Ω, in which much information is lost. I would suggest that this monitoring, this diffuse watchfulness over the condition of the whole relative to its environment, might be what constitutes consciousness, and that the fullness and keenness with which consciousness is itself experienced is a function of the complexity of the organism. Any robot that is complex-and-organized enough to behave exactly like we behave in most situations would necessarily feel—to itself—like we do too.

All this is why Ω-optimality does not presume to identify or measure the amount of some sort of life-essence or life-substance. It is not some magic formula like the Secret Name of God that Rabbi Löw legendarily inserted into the forehead the Golem, a clay effigy that then rose up to become a man. Rather, Ω (and Ω-optimality) is something measured, something registered. It is a broad statistic that *accompanies* life rather than constitutes it, like body temperature, a "vital sign" of life—rather than life itself or its Secret.[xxi]

We can glean still more from representing *V* graphically. Because *V* is a difference, or motion, of a certain size in a certain direction, *V* is what mathematicians call a *vector*. A vector is not represented graphically by a *point*, but by an *arrow*, which is to say, by two points and a direction between them. In our case, the tail of the arrow can represent the starting magnitude of Ω, and the head of the arrow can represent the new or final magnitude of Ω.[xxii] All of the vectors (i.e., arrows) shown in Figure 2.4 represent the same amount of positive value. They all "go" three contours *up* the Ω-surface (which happens, in Figure 2.4, to represent a gain of 1.5 bits).

Figure 2.4 Some vectors of positive value, equal in magnitude.

The positive value vectors shown in Figure 2.4 also go (on average) most steeply up the slope of the Ω-surface from where they start. They are the shortest vectors, involving the least change in complexity-and-organization, separately, that will yield the most change in complexity-and-organization from their particular starting points.

Now let us pay attention to the obvious: *these vectors point in different directions*. When complexity is very low and organization is high, so that the system is close to *rigidity*, the vector of greatest positive value points to the right, i.e. almost due east. Why? Because from this position on the Ω-surface there is more value to be had in seeking more complexity, *C*, than there is in seeking more organization, *R*. By contrast, when complexity is high and organization is very low and the system is close to *chaos*, the vector of greatest positive value is pointed up, almost due north. From this position there is more value to be had in seeking more organization than there is in seeking more complexity. And from starting positions where complexity and organization are already roughly equal in magnitude, the most value is to be gained by increasing both complexity and organization in roughly equal amounts. These last vectors lie on the ridge of the Ω-surface and point northeast.[xxiii]

What does all this illustrate? Something rather commonsensical, actually. When the direction in which value lies depends upon where one presently "is," our model is demonstrating one way of describing value's well-known and problematic "relativity." More than this, it suggests some resolutions and strategies.

To get a feel for this, imagine a committee meeting at which two members are each advocating different courses of action.

One claims that greater organization is needed: he wants more or tighter rules; he wants to eliminate unproductive programs, services, options, even people. He wants to simplify; he wants to organize; he wants to prioritize and generally streamline the department's operations. He talks a lot about "focus" and how it's been lost. He admires firms that are "lean and mean." He wants more reporting and more responsibility.

The other argues that what is needed is greater flexibility, a decentralization of power, the inclusion of new tasks, programs, and personnel. She wants to relax the rules, not tighten them. She draws attention to currently overlooked or low-priority activities. By questioning some and honoring others, she tries to equalize people's preferences, to break up cliques and habits, to work around prejudices.

Now, the source of these two people's disagreement may have nothing to do with their vision of what a "great" company *would* look like. “Growing,” “dynamic,” “efficient,” “lively,” “fun to work for”...these describe a company that works in high-Ω territory. This is a vision they probably share. What they might unwittingly disagree about is where the company currently *is* on the Ω-surface, and so it's no wonder they disagree about which new heading promises more Ω. If their debate could focus, rather, on determining where the company actually *is* in these terms, then it is very likely that their “positions”—and so the courses of action they advocate—will come to resemble one another.

Something similar can be said of such general political orientations as "anarchist" and "reactionary." In general, anarchists find the world already too constraining, too stifling and rule-bound; they advocate less hierarchy, fewer rules, more ambiguity, greater options, higher risk, etc. The anarchist's constant fear is of social and personal sclerosis, of ossification.

Reactionaries, on the other hand, find the world already too chaotic, too unpredictable.

They tend to advocate limits, hierarchy, obedience, clarity, the tried-and-true. The reactionary's constant fear is of the "slide into chaos." But both anarchist and reactionary might in fact share a similar vision of a future, more perfect world: one that is vital, healthy, free, harmonious, etc. Much of their conflict arises—or might arise, anyway—from their differing readings of The Situation, and these readings might well be based on accurate perceptions of *their* environment but mistakenly (or self-interestedly) generalized to the whole. And so they press for starkly different programs.

The more familiar political orientations we call "liberal" and "libertarian," "progressive" and "conservative," "left" and "right," are more complex than this, of course. But a careful dissection of the views held by these groups would, I believe, reveal that they are admixtures of these purer anarchistic and reactionary prescriptions, each attached to a different aspect or scale of society's doings (e.g. business, finance, education, defense, art...; personal, local, regional, national). The ideal of *more freedom*, for example, means something different to conservative and liberal. For the conservative, it is apt to mean increasing potential complexity, C_{pot}, without increasing actual complexity, C. This prescription increases organization, R, which is why freedom, for the conservative, is likely to be thought of as a potential-for-action that is always to be enlarged but not much realized (because this would break with decorum, order, responsibility, etc.). *More freedom* for the liberal on the other hand, tends to be thought of as increasing C_{pot} without the increase of R, meaning that C must increase. That is, the liberal generally wants more potentials-for-action to be realized, to be fulfilled. She wants to equalize the likelihoods of permissible actions' happening while increasing also the number of permissible actions. Politically, much of this debate is framed in terms of "opportunity," i.e., in talk about about how many and how real the opportunities *are* for different segments of society. But here is the point of our brief (and alas still-too-shallow) analysis: *both the conservative and liberal conceptions of "more freedom" make sense*. Both would increase C_{pot}. But they maximize value on different sides of the ridge of Ω. The conservative's notion of freedom maximizes value when the system is on the "south slope" of the Ω-surface and complexity is too great (i.e. when C is much greater than R), and the liberal's maximizes value when the system is on the "west slope," and organization is too great (i.e. R is much greater than C). Both the conservative's and the liberal's prescriptions *can* increase Ω. Which one actually *does* or will, which one succeeds in moving the system to high Ω territory, depends on where the system presently is on the Ω-surface

We should note, however, that *at no* position on the Ω-surface does *decreasing* both C *and* R yield positive value.[xxiv] It's also worth nothing that if one does not know where a system lies on the Ω-surface, then increasing its C and R *equally* is the only sure-fire value-positive strategy. It is also the optimal strategy when the system actually *is* on the ridge. Could this be the reason why conservatives and liberals ought each, by turns, to have their way?[xxv]

In many conflicted situations, just deploying the "one-mountain-many-paths" metaphor can bring about some progress. Better than the "common-goal-different-roles" (or "-different-strategies") metaphor, the idea of the Ω-surface (Mount Omega) helps each party locate itself on a landscape at the outset, one whose higher elevations are characterized by a set of abstract systemic qualities that are as open to interpretation as they are easy to commit to, and yet that are not empty. Importantly, it also allows us to contemplate actions that involve going "down" or "across" the Ω-surface before going up. After all, the hallmark of being human is that we can test our ideas before we act. We can weigh the probable long-term effects of our actions. We can turn down tempting opportunities for immediate rewards, and we can put up with short-term failure if we think it leads to long-term success. Although certain species of animals seem to share capacity with us to some extent, biological evolution as a whole exhibits no such foresight or patience at all.[xxvi] If there is any divine design in evolution, it would seem to begin with us.

The Ω-surface has no pinnacle. Its ridge extends to the right and up indefinitely. Moreover, no matter where a system begins, any path that consistently maximized positive value will eventually move to, along, and up the ridge where complexity and organization are roughly equal in magnitude and Ω is maximum for its potential complexity, C_{pot}. Goose and gander, each maximizing value from wherever they began, come eventually to travel alongside each other to higher Ω territory. This comes about through no miracle of goodwill or coordination between them. It is a result of two facts: first, that from every possible starting point on the Ω-surface there is, mathematically, one and only one path that consistently maximizes slope, and second, that all such slope-maximizing paths from and through all points on the Ω-surface tend to converge with absolute altitude. Prediction: *we can expect that all highly evolved systems will have found their way to some position close to, or directly upon, the ridge of* Ω*, and* Ω*-optimality*.

This is *not* to say, however, that a particular system responding to its environment (or to its own inner rumblings) cannot move in *any* direction on the Ω-surface. Systems need not follow maximum-value paths religiously, and many do not. Being physically constrained to a certain magnitude of C_{pot} is common. Nor is it to say that living systems can't come to a halt for an indefinite period at a certain point on the Ω-surface and just idle, i.e., reproduce or persist without change in complexity or organization for millennia. Bacteria ruled the earth for millions of years without much change. They were once the world's only living organisms and they dominate, numerically, to this day.

It seems appropriate, then, to ask two, related questions:

(1) What *prevents* a system from leaping about from one combination of complexity-and-organization to another, more or less "at will," and
(2) what prevents a system from scooting effortlessly up the Ω-surface to infinite Ω?

The second question, especially, reveals that implicit all along in this chapter has been the metaphor of *gravity*: the idea that it takes *work* of some sort—the application of energy or time or intelligence—to climb "up" the Ω-surface. But since there are no forces in purely mathematical spaces such as the one in which the Ω-surface exists, we must wonder: Is the model of gravity misleading? Might simple *inertia* be the more appropriate metaphor, a native "unwillingness" for a system to move at all, regardless of direction or slope (which the system actually doesn't feel)? Or perhaps neither gravity nor inertia is an appropriate model for describing how a system moves "with difficulty" on the Ω-surface. Perhaps we should be looking for an analog to *friction*. Or are there *obstacles* on the slopes of Mount Omega?[xxvii]

These questions might seem abstruse, a tangle of gratuitous metaphors, a physics imposed where there really is none. But meditating on these metaphors will take us, I think, to the source of what we daily mean by "work," and how work "creates value." And it will permit us a glimpse of how the theory of value being outlined here can begin to address questions of economic and moral interest in a new way.

The screen test of *V* continues.

IV. Difficulty and motion on the Ω-surface.

There's nothing for nothing in this world, we are taught. No free lunch. And experience seems to confirm it: few creatures reproduce, learn, grow, develop, find happiness, and so forth without paying some price, without overcoming some resistance, without facing some risk. A deep and even cosmic limitation seems to be at work to make life rare in our universe and its flourishing here on earth no certain bet. "Life's an uphill battle" we say in maturity, when simple *persisting* seems to be something of a trick.

Science tells us that evolution could not proceed without natural selection, which is the loss of reproductive capacity associated with certain incremental steps away from a previously viable, self-reproducing position on the Ω-surface. This is true for all creatures and perhaps all matter. But we humans, having evolved foresight, find that we can be on the lookout for such reproductive dead-ends and pitfalls. Indeed, so precarious is the world we have made that not only *can* we be watchful, we *must* be.[xxviii] Over hundreds of thousands of years of cultural evolution, we have learned to make *rules* for ourselves that will prevent us getting too near to these dead-ends and pitfalls in the first place. Many of these rules are ones that we follow "religiously" and almost instinctively, such as the taboos against incest and cannibalism or rules having to do with the care of children until (at least) their reproductive age, rules about reciprocity, fidelity, sexual attractiveness, and so on. Certainly, if there were no inherent limitation to people's seeking more life and no potential for disaster, there would be no need for economics and no need for law; there would be no need for religion, medicine, or much else. We would all be getting richer, smarter, sexier, and healthier by the minute, without setback or disappointment, *ad infinitum*. We would be as gods.

Whence, then, comes the gravity, the inertia, the friction, the resistance to our infinite improvement? Whence the *difficulty* of it all? Can we talk about all this without arriving at too-simple a labor theory of value on the one hand, or too-literal an interpretation of the story of our exile from Eden on the other?

The Second Law revisited.

We need not look far for at least one kind of "gravity" in our model. It is the Second Law of Thermodynamics.[xxix]

When systems are cut off from material, energic, and informational trade with the outside, their internal organization tends to decrease and their actual complexity increase. This might happen as tiny bursts of complexity invade from the quantum-scale "basement" up into the atomic first floor and molecular second floor, so to speak, and then percolate to larger scales yet (this being one explanation of the Second Law favored by Roger Penrose).[xxx] Or it might happen as minor irregularities inherent in the original state of a system (at one or several scales) begin to propagate themselves. In either case the result is the same: left to their own devices, isolated systems begin to lose structure, become disarrayed, turning to dust or to a mixed-up gas. Actual complexity, C, approaches potential complexity, C_{pot}, and R dwindles...until, finally, a state of chaos reigns.

The Second Law is easily represented in our scheme. We can visualize it as a vector field following C_{pot} contours in a clockwise flow. This "Second Law vector field" is shown in Figure 2.5.[xxxi]

Figure 2.5 The "Second Law vector field." Any organized system, isolated, will tend to drift towards internal chaos along the C_{pot} contours shown, at one or several scales.

The effects of the Second Law are all around to see. From coffee-makers to automobiles, every component of every machine we assemble is seeded with its own failure: microscopic cracks and faults are sooner or later breached though wear and tear and temperature change, and an avalanche begins that finally breaks the part into dysfunctional pieces. Something similar occurs in animals as the process of cell division fails or runs amok, or as glands under- or overproduce certain hormones. Treachery from within, as it were.

But just as often unwanted bundles of complexity arrive from the outside: in Trojan horses. Not only does the human body, for example, constantly need to correct its own tendencies toward metabolic waywardness, it has also evolved an extremely sophisticated *immune* system to contain and control microscopic destabilizing agents breaching its boundary from the outside. We call them "germs" and "viruses" and "parasites." Poisons, bullets, and knife-points breaking our envelope set off cascades of disorganization too, but by different mechanisms. Indeed, our bodies are constantly filtering out the bulk of the disorganizing complexity that surrounds us and, at the same time, undoing the damage of what gets in. Faulty data, human error, and lies, are what we call the gratuitously complexifying agents that get into minds and organizations, and these either set off wild goose chases on the spot, or create complexity time-bombs that go off when the truth is finally learned.

It is on account of the Second Law, too, that we find we must maintain our external physical environment. Paint peels, stones crumble, roofs leak; windows become blotchy and jammed...and it's no one's fault. Gardens require constant pruning, clipping, and trash removal to impose order over nature's desire for more complexity and less order. Progressive personal dishevelment too is "natural." Is there no end but death, wonders the little boy, to washing and brushing, buttoning, smoothing, putting things away...? Businesses and institutions must constantly fight tendencies to fall apart. At least half of the job of *management* is to keep people together and "on track," which is to maintain *R* against the forces of anarchy, deceit, and neglectfulness in the social realm.

In sum, examples are legion of the hold that the Second Law of Thermodynamics has on everyday life. Despite the fact that no *real* systems are quite as closed as physics textbooks require them to be for the Second Law to hold perfectly and canonically, the simultaneous tendency toward increasing complexity and decreasing organization is no laboratory curiosity. For what is not a perfectly closed system—and thus losing organization from within—finds itself part of a larger system and having to pay some portion of *that* larger system's debt to the Second Law. Going up in scale there is always an outside, while going down in scale there is always another "outside" inside, locked up in smaller containers.[xxxii] The Second Law therefore manifests itself to some degree in all systems, mechanical, chemical, biological and social, the vast majority of which are at least as "open" as they are "closed" to their surroundings and to their own member-parts' harbored complexity, and the vast majority of which are therefore exposed to both internal and external forces that could erode their organization by increasing the frequency of their visits to once-unlikely states of being.

The effects of the Second Law are many, then, and examples have been duly noted in the literature.[xxxiii] Less often noted, however, has been the tremendous amount of regularity and *organization* that the terrestrial environment also provides its living guests for free, as it were: the rhythms of day and night, light and dark, hot and cold, the seasons, the tides, the singular and constant tug of gravity, the uncountable but regular frequencies of vibrations in air and water, of rock and bough. (I pointed some of these out in the last chapter [p. 19].) Some parts of the world rigidify for such long periods that they, too, provide a great deal of the structure of, and for, life. Think of our once-molten caves and mountains—indeed of the solidity of the earth as a whole—and how, along with architecture, they provide the order we call "shelter" with their present stability.

But still less often noted are the salutary effects of *letting the Second Law have its way*. The complexity of wine, for example, starts with the relative simplicity of grape juice. Left alone for years on end, the cellared bottle of wine is about as close as one can get to an ideally closed system. Over time, a wide range of chemical reactions—dominated by the break-down of sugars to alcohols via anaerobic fermentation—spontaneously "seek" lower organization and higher complexity, the very complexity we prize in the wine's taste and nose. Something similar goes on in the depths of a gardener's compost pile.

Without the Second Law, genetic mutation—the accidental rearrangement of nucleotides in DNA during transcription or reproduction—would not occur, and no species could hitch a ride along its C_{pot} contour from too great a proximity to rigidity toward the (likely) greater fitness of higher Ω.

In the cultural realm: if half of the job of management is to keep people together and on track, as I said earlier, then the other half of the job is surely defeating the forces of habit and tradition. The Ω-surface has two downward slopes from the ridge: one is westward, towards rigidity. Resisting the slide in this direction, the good manager encourages his people to act more freely. He invites them to bounce ideas off each other, to react more quickly and sensitively to random-seeming events in the firm's environment, to go back to school, and so on. He himself becomes more tolerant, explorative, even silly at times. There is an art to letting things go in this way, as R. G. H. Siu convincingly showed in *The Tao of Science* (1957) and its sequels.[xxxiv]

And if this does not add complexity and decrease organization fast enough, there is always the practice of messing things up deliberately; the bible for which, at least in management theory, was surely Tom Peters's *Thriving on Chaos* (1989) or *Liberation Management* (1992), the latter tellingly subtitled *Necessary Disorganization for the Nanosecond Nineties*. Business bookshelves are crammed to this day with variations on the theme of how to emplace flexible, decentralized management systems. In a volatile global economy with intense competition in every quarter, it seems that success goes to those companies that can increase their operating complexity by breaking themselves down into freer, more autonomous, parts—all while staying organized thanks to telecommunications and project-scheduling software.

Perhaps the idea of working *with* the Second Law to achieve value—rather than always against it—is originally an Asian and Buddhist one. There is an old Zen story of the master who orders a young disciple to sweep up the leaves in a fall garden. When the disciple is done, he calls the master out to inspect his work. The master is not happy. The disciple sweeps again, this time on his hands and knees with a small brush and under every bush. Once again the master is not pleased, and once again the disciple applies himself...until not a leaf is to be seen on the ground. Not one. The master emerges for the third time. He surveys the scene and then walks wordlessly out into the garden. Striding up to some trees, he starts shaking their branches vigorously. The disciple looks on, aghast. "Ahh," sighs the master as golden leaves again float to the ground, "now *that* is perfect."[xxxv]

In the arts too, not all is symmetry and harmony and control. As Morse Peckham argues in *Man's Rage for Chaos* (1965), a good deal of modern art came from allowing accident to complexify and breathe life into otherwise dead forms and routinized media. Jazz is a prime example; abstract expressionism another, the architecture of Frank Gehry or Coop Himmelblau today yet another. One opens oneself to chance and impulse; one uses not-completely-controllable media; one lets certain things go their chaotic, entropic way. That greater beauty is frequently to be found in the products of benign neglect rather than of mastery and control has long been known. One combs one's hair perfectly, and then ruffles it a bit. One lets the creepers grow wild...but not too wild. No *real* flower is mathematically perfect, and that failure is as inevitable, physically, as it is essential to that flower's beauty. Our Zen story is an allegory of value—about the mastery of benign neglect and the benign neglect of mastery.

Can our theory of value make sense of this conflicting advice about when to counteract and when to go along with entropy? I think so. The screen test of V continues.

Figure 2.6 overlays a single C_{pot} contour on the Ω-surface in the now-familiar graph of C vs. R. (Here C_{pot} = 7 bits, but the number 7 is arbitrary, used for illustration purposes only.) It also shows the same contour is mapped in the space of C vs. Ω . We imagine the system to be canonically closed, as the Second Law requires, and we imagine it starting out in the "north-west" corner, i.e. as very simple-and-organized, "rigid."

Figure 2.6 The trajectory of a closed system going from rigidity to chaos under "mandate" of the Second Law of Thermodynamics (i.e. constant potential complexity).

From point A to point B, greater Ω is to be had simply by letting the Second Law have its way. Over this stretch, V is positive, albeit ever less positive as the ridge of Ω is approached. At the ridge exactly, V is zero. From B to C, however, letting the Second Law have its way yields only lower levels of Ω. Over this downhill stretch, V is increasingly negative.[xxxvi] And so we have a context-dependent rule that always yields positive value: "Let the Second Law have its way if you are on the northwest slope of the Ω-surface, and fight the Second Law if you are on the southeast slope." A rule for *laissez-faire*.

We can learn more from Figure 2.6. Our system has been thought of as a perfectly closed one. It is therefore constrained to a fixed magnitude of C_{pot}—constrained, that is, to running back and forth on the "C_{pot} = 7 bits" contour as though on a curved rail because the addition (or loss) of energy and/or material and/or information from the outside is not possible. Under this limitation, an Ω of 4.95 bits is the best this system can do.[xxxvii]

It would seem, then, that in order to get out of the rut of running back and forth along a C_{pot} contour, *the system must be open*. It must be able to do one or all of the following:

- Access energy, information, and material from the outside world;
- Break open its own components, like grapes, to release the structure, complexity, and energy locked up in them at smaller scales;
- Develop vision of its *own* structure and functioning—learn to *see itself* in some sense—and to pack *this* information back into its every part.

These are all avenues to openness. At risk of loss of Ω to be sure, the system must be able to *add* to itself in literal and cumulative ways: *more* components to combine, *more* relationships to establish within and without, *more* and *different* scales of complexity-and-organization to be brought into play, and therefore *more* possible states to be in as a whole. All of these "abilities" increase the potential complexity of the system while having variable effect on the actual complexity of the system. All, therefore, permit Ω to grow larger on average, or at some certain scales, than it formerly could.[xxxviii]

This, I would suggest, is the essence of the distinction we intuitively make between *evolution* and *improvement*. Improvement works by rearrangement only—the rearrangement of an existing set of elements in time, space, or frequency of interaction to achieve the best balance between organization and complexity. *Evolution* goes further: it adds to the repertoire, it lengthens the song, it enriches life *by re-finding the optimum balance between complexity and organization at ever-higher absolute levels of complexity-and-organization*. With evolution, C_{pot} increases too: the frontier moves outward.[xxxix]

In Chapter One we talked about how chess games and pieces of music start simply, grow in complexity, and then close in simplicity again. We also noted the existence of the same pattern in written and filmed narratives: simple beginnings, mounting complications, resolution. This observation is a staple of narrative theory. We might now see that most satisfying games and works of art describe not an arc in complexity alone, but an arc in complexity-and-organization, *one that arrives at a higher level of complexity-and-organization than at the beginning*. That is what makes (some) fictions moral. Having travelled, having experienced, having seen, suffered, and learned, both the protagonists of the narrative and we—the reader/viewers—arrive at a situation and/or an understanding of the world that contains more elements, more interactions, and more rules than the one we started with.[xl] Although there are no greater number of rules at the end of a game than there were in the beginning, games can still elevate players' Ω in an irreversible way too, if, with each game, players learn its "finer points" and learn higher-level, unlegislated optimization rules having to do with larger or longer-lasting patterns. This is more C, more R, and more C_{pot}. This is what *satisfaction* consists in: not a return to the beginning, but a return to Ω-optimality at higher Ω altitude—evolution in miniature.

This, in outline, is the link between complexity-and-organization, Ω, and human satisfaction, which we will denote S and discuss at some length in Chapters Four and Six. Increase in satisfaction, which yields happiness, is the chief everyday measure and manifestation of (positive) value in our lives, and it is no simple matter to achieve it over the long term.

Right now, though, let us return to the evolutionary perspective.

What "drives" evolution?

This whole discussion delivers to us a picture of evolution something like Figure 2.7. At the largest biological scale, every branching point is a speciation event; every arrow that goes into the grayed areas represents a once-viable species now gone, and every arrow that stays in the white represents the birth of a successful new species, alive, probably, to this day. *Homo sapiens* is located at the top right (or northeast) corner of the white area, bacteria at the bottom left (or south-west) with viruses a little lower yet and just edging in.

Figure 2.7. The evolutionary Tree of Life, highly schematic, time not directly represented.

Question: What "drives" newer species *up* the ridge of Ω to higher territory rather than down it or off it?

Answer: Well, theoretically, new varieties and new species—and indeed, at a finer scale, new individual organisms—can just as easily find themselves possessed of *less* total Ω (say at the scale of DNA codons) as of *more*. Theoretically, as long as these new varieties, species, or individuals fall within the white, reproductively-viable area of Figure 2.7, survival for another generation is more or less assured. But realistically, on the ground as it were, the symmetry is broken by change in the complexity of the environment over time.

Consider: the environment of any member of a reproductively successful species quickly begins to consist of large numbers of other individuals like itself. This has two effects.[xli] First, it makes life intrinsically more crowded and more complicated. Just getting around becomes more difficult—what with bumping into fellow organisms all the time. Second, with any shortages of resources for the group—air, light, food, shelter, mates—*competition* begins, and with competition the selection of individual organisms whose inherited behavior-patterns are by chance marginally more aggressive or more flexible, more hardy and/or sexy and/or...well, more complex-and-organized and thus better able to negotiate the newly-more-complex environment. Add now the presence of other burgeoning species in the neighborhood—some predators, some prey, some competitors, some just getting in the way—and...more complication. When the going gets tough, the tough get more complex-and-organized.

Can stable states be reached? That is, can populations of a given species get along nicely at some particular spot in the space of complexity and organization (if not the same spot on the face of the earth) for long periods of time? Yes. Look around: every living animal, plant, and microorganism you see is witness to that species' long viability at some contour of Ω. And occasionally, new individuals (no less than new species) can come *down* the ridge of Ω or off to the side a bit, and, still in the "white," be no worse off for it, especially if they can migrate to a simpler part of the world. But the general rule is this: *reproductive success breeds complexity in the environment; and complexity in the environment selects for improved creaturely "smarts," i.e., for higher* Ω.

What is true in biological evolution has its analog in cultural evolution. Much of civilization emerged from the exigencies of agriculture—exigencies such as, for example, needing to stay in one place for year-long periods, working with others, dividing land, surveying and counting, storing things, making large and heavy tools like plows, domesticating animals, planning, nursing, and waiting. Agriculture itself was stumbled upon as a response to population growth: more food was now needed than could be procured by the old hunter-gatherer ways, and in lands now far from Eden. With the success of agriculture came *urbanization*; cities have been the "hotbeds" of culture ever since, places where increasing human (and animal) densities have for tens of thousands of years favored the proliferation of laws, of techniques for time-keeping and record-keeping, of opportunities for exchange, as well as of specialized technologies for sheltering, feeding, entertaining, locating, coordinating, and generally "servicing" the activities of ever greater numbers of people living in ever closer and more frequent contact with each other *as strangers*. All of this, in turn, both catalyzed and demanded concomitant growth in human mental complexity-and-organization, requiring, among other things, the elaboration of language and rituals and the acquisition of new production skills and forms of literacy, this over longer periods of formal education through ever-more-extended childhoods.[xlii] Ideas themselves are forced to evolve through competition with each other.

The Story of Civilization told along these lines has been schoolbook wisdom for some time. It remains essentially correct. Today one might only add a chapter about how, in the last two decades, computers and telecommunication systems have both provoked and managed still higher levels of connectivity (potential complexity) and coordination (organization)—about how computers and telecommunications will soon make of all the world not a global *village* (McLuhan's pre-industrial image here is seductive but wrong) but every real village part of one virtual global city.

At a *very* much smaller scale, a complementary explanation to the one above helps account for the dominant, ratcheting motion of life-forms up the ridge of Ω. To understand it, we must go back to molecular biology once again.

During the process of DNA replication, it seems that *adding* a segment to the total length of the DNA molecule is in some way easier, and thus more likely to occur, than removing or losing a segment of it. DNA is slightly "sticky" in this sense. This means that, on average, over many cycles of replication bathed in a soup of related chemical compounds and in addition to replication errors, a given species-typical sequence of DNA accidentally attaches new nucleotides to itself more often than it loses "old" ones. Add one nucleotide, add another, add another...and pretty soon one has a genetic mutation of a particular sort: a mutation that increases DNA's total size by a codon-length or more. (A "codon," remember, is nucleotide triplet and the smallest scale at which DNA carries information.)

Now, some of these added codons, just like ones transformed by repication error, will become *expressed*, meaning, will become manifested at the larger scale of the organism's body—in its tissues and organs and/or in its proclivity to behave in certain ways under certain environmental circumstances. Other newly-added codons however—ones that are, for whatever reason, illegible to DNA's self-reading protocols—will *not* be expressed. These will just go along for the ride, replication after replication, generation after generation, like so many unreadable and unread footnotes.[xliii] Of the newly-added codons that *are* "read" and *are* expressed, a few will prove to be adaptive to the organism (i.e. prove helpful in the struggle to live long enough to reproduce) and a few will prove maladaptive. But most, even though they result in some slightly changed appearance or function of the organism, will make no appreciable difference at all to its reproductive fitness, at least not immediately, and perhaps not ever. From a strictly reproductive-fitness point of view, these codon-additions at the DNA scale, these mutations, might just as well have remained unexpressed, "junk."[xliv] But—and here is the point again—all net additions of nucleotides to DNA are additions to its length and therefore to its total potential complexity. All serve not to *guarantee* the immediate increase of total Ω, but to raise potential complexity, C_{pot}, and therefore to raise also the ceiling of *possible* values for total Ω at some time in the future.[xlv] All expressed additions do the same thing for a smaller set.

Alas, no parallel to the "stickiness" of DNA seems to exist in many of the essential vehicles of cultural evolution. Here, new ideas and interpretations, elaborations of older practices and artifacts, decorations, amplifications, riders, and codicils, are just as likely to be shaken off as incorporated. In the 20th century, the "shaking-off" processes of streamlining, paring, and efficiency-seeking outpaced the traditional, more cumulative ones. Among the cultural institutions in the U.S. that have suffered from this reduction are education, art, religion, serious (i.e. difficult) music, conversation, theater, and particularly fine architecture, landscape, and urban design. To go back a moment: in biological evolution, *expressed mutations that do little or no harm*—just like un- or not-yet-expressed mutations—*are as happily borne along from generation to generation as those that do some immediate good.* Mother Nature is extravagant in this way. Driven quite literally by cosmic energies, and having discovered the secret of life (namely, "birth" and "death" with imperfect and multiple self-replication events in between), she now sets herself to composing variations upon a theme, tirelessly, almost maniacally, spinning new patterns and producing new finery and seeing if the sporting of them does not get in the way of doing it again, going another round. Nature embroiders her every "product line" to the very edge of viability, loading every next generation with some presently-useless, and possibly-harmful new gew-gaw.

My point: How very different this is from human productivity under the regime of free markets and "value engineering," no matter how often their proponents appeal to Darwin. Here, features that are not directly valued by consumers (or required by law) are as ruthlessly stripped off as those that are positively dysfunctional until only features that are "selling points" remain. Here, in the name of increasing affordability, efficiency rules. Corners are cut till they hurt. No density or play or idleness is allowed, no unused capacity tolerated. No gift inside the box, no something for nothing. Here, all too often, an economy of means serves a poverty of ends justifying a new and greater economy of means, in round upon round of *de*volution.[xlvi]

If biological evolution has any regard for efficiency at all, it is embodied in the trial-and-error discovery of the general functionality of near-maximum Ω for a given magnitude of C_{pot}, and then of "cheap" ways to add to C_{pot} (like waiting patiently for something to stick). Of course, Nature has taken uncountable missteps precisely because she will not leave things well enough alone. Millions of species have gone over the edge, unable to cope with a suddenly-changed environment or unable to prevail over other species with appetites for the same limited resources. So, too, must individuals die of old age, this as critical chromosomes become ragged-ended from repeated self-repair and replacement. But Nature *will* decorate the survivors and the survivors' descendants, again and again.

Not just peacock's tails and goldfish fins, then, but every ability that does not now contribute to species survival—from the shark's ability to see things other than fish to our ability to whistle Bach and fly balloons—is a gift, a "freebie" of small if any immediate utility, a come-with of some solid evolutionary advance perhaps, but not, itself, an evolutionary advance at all.[xlvii] From a strictly reproduction-efficiency point of view, every living thing more than a micron wide is a Rube Goldberg device of almost ludicrous proportion, a dance of delays—no, a whole *dance company* of delays. Indeed, from an informational-efficiency point of view, most of the physical properties of things all the way down to simply *having mass* are an embarrassment, an unfortunate "overhead" expense.

This last insight has not been lost on digital-age entrepreneurs.

What all this betokens can be readily observed. Contrary to popular wisdom and the tenets of modern design and engineering, in nature, most extant species are *not* as simple and efficient as they can be and still get by. On the contrary, they are as *complex* and *inefficient* as they can be and still get by. Ecosystems support not the *minimum* number of species and varieties but the *maximum* number they can. In field and jungle, the beauties of Minimalism are unknown. Nature, it seems, will get her frills any way she can, while in efficiency-driven, free-market economies, it is often (but not always) the other way around.

This ought to make us think twice about how value is manifested in the products that are bought and sold in the marketplace, that paragon of efficient "resource-allocation" mechanisms. How the market works in this context is a important subject. We discuss it at some length in Chapters Eight through Ten.

<u>Back to our second question</u>.

What prevents a system from "leaping about" on the Ω-surface, i.e. from taking large steps between two distant points without moving through any of the points in between?

The answer is: two unlikelihoods. First, the unlikelihood of landing upon (reproductive) success even if arbitrary leaps were possible, and second, the unlikelihood of "leaps" happening in the first place. Both are linked by the logic of evolution, and they can be thought of together:

Consider the part of the borderline area to viable life that is at the bottom left in Figure 2.7, (i.e. "southwest" sector of the Ω-surface). It is unlikely that a long leap in any random direction from the proto-life zone would be a leap up into the higher-Ω "white" zone of viable, self-reproducing life, if only because only a small fraction of directions *go* that way. Most leaps would take the system back into the grey, "inanimate" zone. (To make matters worse, to the extent that the system is closed, the Second Law would favor skips toward the southeast, making those to the northeast, toward viable life, even less likely.[xlviii])

<u>Figure 2.8 Possible directions of leaping from the zone of proto-life in Figure 2.7</u>

This concurs both with intuition and what we know about the improbability of the origin of life. But what about the higher-altitude borders of the viable-life zone, the boundaries across which already-living systems would step only to their detriment or death? Along these boundaries, according to our diagrams and given random jumps, the chances are roughly 50-50 of dying or continuing to live.[xlix] But consider Figure 2.9, which is a magnification of the central portion of Figure 2.7. In position A, a living system may jump in any direction and stay viable. In positions D and E, very few jumps would transform the system into a viable and/or living one, while from positions B and C the odds would seem to be about equal.

Figure 2.9 Enlarging the central portion of Figure 2.7, five positions in and near the "white" zone of viable life.

Equal? Surely not. Our diagram says that jumping *into* full-blown life from a place just outside of it is just as likely as going the other way, and this does not seem right. After all, inanimate, highly complex-and-organized systems do not just *leap into life* as they hit some narrow, if ideal, combination of complexity and organization. Do they? One thinks here of Dr. Frankenstein's Creature, Rabbi Löw's Golem, or Philip K. Dick's replicants in "Do Androids Dream of Electric Sheep?" (the story made into *Blade Runner*). One thinks of Moses or Asklepios turning sticks into snakes (and vice versa), or of mummies, corpses, puppets, dolls, and robots suddenly come alive in a hundred chidren's stories and horror movies.

But these uncanny happenings are all fictions exposing our anxiety about what thin line might separate the living from the dead, the animate from the inanimate. And so we ask again: is there something wrong with Figures 2.7 and 2.9, which seem to say that jumping into life, fully fledged, would be as common as jumping out of it, into death?

The answer is that there is nothing wrong with Figures 2.7 and 2.9 in this regard—except that they omit making a point of the fact that *the shaded regions* of the graph close the white zone *are unpopulated.* There *are* no systems anywhere near as complex-and-organized as biologically living ones. There *are* no systems at positions D and E. Such is the "miracle" of evolution. Such is the marvel of what the blind, algorithmic processes of variation, selection, and reproduction have produced over a period of three and a half billion years—processes which, once they had breached the wall of what inanimate, non-evolving systems are capable of, embarked upon a self-made journey to heights of complexity-and-organization unparalleled, as far as we know, anywhere else in the universe. There exists, as yet, *no other path up this mountain than along the ridge of* Ω*, and no other way to enter it than from the south-west.*[1] It is from this lower staging area, as it were, that all higher encampments on Mount Omega were reached. It is from this lower staging area that all higher encampments *are* reached to this day, along a trail the directions to which are locked up in the DNA of every germinating seed and every fertilized egg in every mother's womb.

And so when an animal dies it does not just slip off the ridge and onto a rocky shoulder, as it were, there to rest in peace. It collapses swiftly back to the beginning, to a total magnitude of Ω comparable, perhaps, to a large computer or a leaf, where it de-composes further—friend to bugs, bacteria, and the Second Law. It is so much easier to kill than to create life.

Figure 2.7, our abstract picture of the course of evolution in terms of complexity and organization, is essentially correct. Improved, though, and more to scale, it should look like Figure 2.10.

Figure 2.10. Omega: The larger view

Here, C and R are compared for systems of the same size, i.e. made up of the same number of elements or molecules. We see living systems issuing like a jet from the lower left hand corner...and suddenly we realize that all of the figures and diagrams shown in this chapter up to and including Figure 2.7, insofar as we have imagined them to be populated more or less uniformly with dots representing actual physical or social systems, have been contained in the southwest sector, i.e. the area shown as a dotted rectangle in Figure 2.10. This rectangle maps the limits of our ability to comprehend the true complexity and organization of the world. Just as stars were once thought to be pin-pricks of light on a relatively nearby vault of heavens, so almost every large or living system's true complexity (and organization) appears to us, in our little rectangle, like a spot of light from a far away sun lensed onto a carpet at our feet.[li]

Although our full neural and chemical complexity-and-organization lies far, far up the ridge in high Ω territory, with the animals toiling just below us on the very same ridge, this is not something that can be seen like a tableau. It is a picture we construct through science, reasoning, and the imagination. It is not something we *experience* either, except insofar as the curious, quiet, thrumming quality of our own experienc*ing* is some fraction of our own complexity-and-organization reflected back to us from the lifefulness we perceive in other things.[lii] We do not, from our roost on Mount Omega, gaze down and across the unpopulated southern slopes toward clouds of interstellar gas, for example, or across the barren eastern slopes to stones and ice. We experience both of these only at those scales and those degrees of complexity-and-organization *of them* that happen to fall within the window—or to use the earlier metaphor, that fall onto the carpet—framed by our limited senses and limited capacity to report not only *what* we are seeing but *that* we are seeing.

And let us remember: no object in the real world is mappable into one dot—and one dot only—in the space of complexity and organization, despite our representing them thus for simplicity's sake in our diagrams. Just as complexity and organization can exist in different amounts at different scales in the very same system, as we learned in Chapter One, so can Ω exist in different amounts at different scales in the very same system. To represent a system completely would mean putting a large *constellation* of dots on the Ω-surface, each dot representing the degree of complexity-and-organization operating at a certain scale. *Some* of these dots would, perhaps, fall into the window of comprehension while others would not. The former dots alone are what we really see of things.[liii]

What we experience of mountains and stars then, what we experience, for that matter, of toasters and tigers and other people, is but a sliver of their fullness. It can take years of study to know more, and further years of study to build the more-that-is-known into our everyday acts of perception. Short of this, we are left with what amounts to a moral injunction: *credit all things with an as-yet-unknown, and perhaps unknowable, interior complexity*. Only with the likes of Easter eggs are we permitted to break the rule.

In summary: whence "work"?

Let us return to the question of why leaps on the Ω-surface are small, so small in fact that we can usually consider them not leaps at all but continuous motion.

One reason we covered earlier: all biological systems depend on DNA-instructed protein assembly, and the rate of addition to DNA's length in the genome, and therefore to the genome's potential complexity, is very slow indeed. Not only are mutations infrequent, but most are not expressed and those that are expressed have small and usually inconsequential outcomes.[liv]

The second reason is this: large steps are dangerous. Imagine a drunkard dancing on a pool table. He staggers unpredictably first in this direction, then that. The larger his steps, the smaller, effectively, is the table and the sooner is he likely to fall off it. It's as simple as that. Moreover, to stretch the analogy somewhat for an evolutionary perspective: drunkards that take very small steps stay on the table long enough to beget baby-drunkards that take small steps too—like dad. This is how and why you and I are still up on the table.[lv]

A third reason is mathematical. The Ω-surface is not really continuous: Recall that $C_{pot} = \log_2 N$ and that N is a finite positive integer ≥ 2 by definition. This means that although C and R can vary smoothly and continuously, they can do so only along a certain arc of C_{pot} and not between two such arcs. Some "steppiness" is thus inevitable, with the steps getting relatively smaller—i.e. C_{pot} arcs getting closer together—as C, R and Ω increase in absolute magnitude.[lvi]

We have travelled a long way to answer the question that this whole subsection was dedicated to answering. "Whence," we wanted to know, "...comes the gravity...the resistance to our infinite improvement? Whence the *difficulty* of it all?" In sum, why is life *work*? We have four answers already, listed in no special order below. We will then add a fifth.

(1) *Disorder*: the action of the Second Law of Thermodynamics (but which, we discovered, sometimes helps rather than hinders increase in Ω);

(2) *Inertia*: the fact that long-evolved systems have usually accumulated enough redundancy in their operating codes (like DNA) that only a tiny number of random adjustments at the small scale would actually make any survival-value difference to the organism or complex-system's behavior;

(3) *Competition*: the fact that reproductive success often breeds greater competition for resources and especially healthy mates among members of succeeding generations, and

(4) *Risk*: the fact that when systems are doing "very well, thank you" parked on the ridge of Ω, large steps away from these spots are inherently risky.

The sense of difficulty accounted for by the first factor—spontaneous disordering though the Second Law of Thermodynamics—seems as evident as it is pervasive. As I recounted earlier, when things keep falling apart it's *work* to keep putting them back together again. When things keep muddying or losing focus it's *work* to keep them clear and in focus. And it can be equally difficult to dissolve habits, dismantle structures, or equalize priorities and probabilities when these have been frozen in place for long stretches of time and when simple neglect, through the Second Law, will not work fast enough or at the right scales.

The sense of difficulty pictured by the second factor, inertia, is also easy to appreciate. Long-evolved natural systems gather a sort of informational mass. They are moved, eventually, only by the most precise application of informational "pressure" to sensitive points in the system: genetic tinkering, a virus, an idea aired to the right person at the right time. Either this or massive reconstruction must be undertaken. The first of these is rare, the second most likely destructive, and thus time-consuming to render harmless.

The sense of difficulty referred to in the third case, competition, seems self-evident. Unless territory expands or food supplies and other resources keep pace with the population growth of a species, the life of any one member of that species is going to become crowded—crowded by equally-intelligent and not-necessarily-well-wishing others. This causes stress, which might be intensified by shortage-induced physiological weakness.

The sense of difficulty mentioned as the fourth factor, summarised as risk, we just discussed with the example of the drunkard on the pool table. Large steps could get him killed, whereas small steps (probably) would not. Awareness of this risk causes frustration in any self-regarding, self-preserving creature (or organization) that is constitutionally capable of large steps.

Partner to the frustration of needing to be cautious is impatience. *Impatience* is fifth in our list of factors that makes work "difficult." And because this factor touches so directly on the psychology of value, it is worth expanding upon.

To a person in a hurry, enforced small steps are thwarting, like moving through sludge. Be it through real space or through the mathematical phase space of Ω, when the environment is in flux and large movement is necessary for survival, the ability to carry out such movements *in time* is critical. Consider how many of our nightmares revolve around appointments missed, races lost, or escapes frustrated because of a strange paralysis of our bodies or by successive confrontations with idiots and gatekeepers. Sleeping dogs seem to have the same fears.

Of course, for impatience to have any meaning, any power, not just time but *intentionality* is essential. To be "in a hurry" is to have some goal in mind and at the same time to think of time as a cost or as a finite resource that is running out. Some critical, future state is to be reached (or maintained) against a backdrop of circumstances that are changing for the worse, as when trying to get indoors before it starts to rain.

Now, it is very likely that the capacity to act and think in this way in deadline situations—i.e. with intentionality and urgency—is restricted to humans and some of the higher mammals. *For the bulk of nature is clearly not in a hurry.* In nature, almost everything takes its sweet time. Clouds go no faster than the wind. Creepers creep. Bacteria graze and divide, graze and divide. Rabbits do not carry fob watches; they are never late for any important date. Twelve billion years for cosmic evolution to come up with an "earth," and four billion years of tinkering thereafter to arrive at *homo sapiens*, hardly represents a blistering pace. Nor, given the enormous number of casualties sustained and the high degree of frippery tolerated, has natural evolution on earth been very efficient.

From this I think we can conclude that microbes, plants, and most animals (in the wild) do not *work*. Bees are busy in a way we can only envy: quick but unhurried, organized without plans, patient without having patience. They have no idea that they are pollinating flowers and that the whole ecosystem depends on them. Birds do not find what they do difficult or worthwhile: they just do it. And so on.

Indeed, the non-urgent but unceasing productiveness typical of nature has long represented something of an ideal for humans, at least in certain cultural traditions.[lvii] The Buddha taught non-striving, the Taoist sages taught *wu-wei* ("no-mind"), the Zen masters the pleasures of "activity-less activity." Nike suggests we just *do it*. Coaches warn against *trying* too hard. There is even an element of this sort of nature-envy in Christianity. Jesus asked his followers to "consider the lilies, how they grow: they neither toil nor spin, (yet) even Solomon in all his glory was not clothed like one of these" (Luke 12:27). Romantic poets from William Wordsworth to Frederick Turner have admired nature's impersonal and patient fructitude. In modern times, psychologist Mihaly Csikszentmihalyi finds a large audience for his idea of *flow*—that ideal state of being in which one's personal skills and the demands of the task-at-hand are so perfectly matched that the day flies by in pleasurable activity, value created without work.[lviii] Set scholarliness aside: consider the esteem in which ordinary people hold those artists, athletes, and business leaders who make the difficult things they do seem effortless, unhurried, perfectly appropriate and yet unpremeditated...in a word, "natural."

If it is only impatience that makes work feel like work, then we are obliged to ask next: whence the impatience? Why can we not be more like the lilies, or like a Zen master?

Perhaps with suitable training and in the right environment, we could. We could try to eliminate *competition* wherever beating the clock, or beating some other person (or animal) to some prize, is in fact not essential. But even with competition eliminated by some clever social arrangement, our impatience would find basis still in the realization of the finitude of our own lifetimes.[lix] For without a powerful belief in personal immortality (or, paradoxically, belief in the utter *un*importance of personal identity), time pressure stems from our realization of our own temporal finitude. Consider: Western popular culture everywhere urges us "to get *more* out of life," and most of us find very little to object to in the exhortation. Does our acceptance of it indicate that we are morally reprobate, insufficiently enlightened or lily-like? Perhaps. But neither monks (Buddhist or Christian) nor followers of today's "voluntary simplicity" movement find anything to object to in the exhortation either: they merely want that "more" *not* to consist in money, property, power, or material goods. What they want out of their life is greater closeness to God, more insight, freedom, peace, happiness, beauty, health...you name it. Fortunately or unfortunately, there is nothing simple about these desiderata once set, nor anything simple about the perceptual and cognitive realm one enters with success at achieving them.

The point, though, is this: only to a creature that knows that it *has* a life—and only *one* life—would an appeal to get more or greater *any*thing out of life make any sense. Knowledge of the fact that the very process of obtaining, incorporating, and even enjoying things of value has a price associated with it—a difficulty, a risk, a saying-no to other things-of-value while the clock of life ticks on—constitutes one of the peculiar blessings and curses of being human, namely, imagining that things could be otherwise. So too does the culturally-imparted knowledge that the best thing to do for the sake of the long run is often not the best thing to do for the short run. Inner conflict between prudential and immediate concerns induces another element of stress, the stress we associate with work. (We will do more with this line of thinking in Chapter Six.)

The conscious experience of work, then, is a purely human phenomenon. It is knowing of the link between time, work, and value that delivers Man from Eden: first into an economic universe, and then, when consideration for the well-being of others is added, into a moral *and* economic one. When it comes to money, as we will see in Chapter Ten, the price of eliminating impatience is *interest*.

This concludes for now my disquisition on the origin of the effortfulness we associate with realizing positive value. It also concludes our screen test of *V*. I have not proposed a labor theory of (economic) value *à la* Adam Smith, David Ricardo, or Karl Marx—although, clearly, ground has been laid to make just such a move. In fact, in the following chapters, I will put equal store in Utilitarian ideas from Jeremy Bentham's to Karl Menger's.[lx]

I will return once more the idea of "worthwhile difficulty" when I ask how it is that in everyday life we seem intuitively to *know* which way is "up" on the Ω-surface. But we should note that with the idea of worthwhile difficulty and the continuing implication of the desirability of reducing (or at least optimizing) effort, risk, time, etc. relative to the amount of value being realized, the discipline of *economics* has already been broached in its most fundamental form.

We turn now to what evidence outside of our theory can be found to justify some of our confidence in the formula $V = \Delta\Omega$.. •

NOTES to Chapter Two, *Value in the Largest View*

i According to the last Gallup poll on the issue (1991), 47% of all Americans believe that God created man in his present form roughly 10,000 years ago, 40% that man evolved "naturally" but with God's design and blessing of the process, and 9% that man evolved entirely naturally, i.e. without God. Among college graduates, the respective percentages are 25%, 54%, and 16.5%. (See *http://library.thinkquest.org/19012/gallup.htm*).

More recently, the National Opinion Research Center reported that 47% of all Americans believe "that the theory of human evolution is 'probably' or 'definitely' not true" and that 48% of Americans believe that "the tenets of astrology 'probably' or 'definitely' have some scientific truth." (Cited in "Harper's Index", *Harper's Magazine*, January 2002, p. 11).

ii Here is Stephen Jay Gould in *Bully for Brontosaurus* (New York: Norton, 1991), 63:

> I am convinced that comparisons between biological evolution and human cultural evolution or technological change have done vastly more harm than good—and examples abound of this most common of intellectual traps. Biological evolution is powered by natural selection, cultural evolution by a different set of principles that I understand only dimly.

Here is Richard Dawkins (*The Blind Watchmaker* [London: Longmans, 1986] p. 216, the person whom Gould is chiefly attacking:

> Cultural 'evolution' is not really evolution at all if we are being fussy and purist about our use of words, but there may be enough in common between them to justify some comparison of principles.

Both of these citations are found in Daniel C. Dennett, *Darwin's Dangerous Idea* (New York: Simon and Schuster, 1995). For a reconciliatory view comparable to Dawkins's, see W. H. Durham, *Coevolution: Genes, Culture, and Human Diversity* (Stanford, Calif.: Stanford University Press, 1991). Gould made his position clearer in *Rocks of Ages : Science & Religion in the Fullness of Life* (New York: Ballantine Books, 1999): science (read: evolution) and religion (read: morality) operate in separate and non-interfering realms, the one not in the least derivable from the other, even in contrast. The book in your hands takes the opposite position.

iii Certainly, the age-old human practice of breeding certain animals while hunting others to extinction, or of cultivating certain plants while eradicating others, are both examples of man's needs being met by direct intervention in nature's evolutionary processes. Add to these today's techniques for cultivating medicinal microbes in the laboratory, cloning animals, and so forth. In preparing *Origin of Species*, Darwin went to great lengths to find out how much plant and animal breeders already knew (which was a great deal) about how traits were inherited. Neither Darwin nor his contemporaries knew anything, however, about genes or about the mechanisms of inheritance at the molecular level.

iv The literature of "complexity" is huge, still growing, and largely repetitive. In addition to the voluumes mentioned in Chapter One, one might read the papers and discussions found in the series published in The Santa Fe Institute's "Studies in the Sciences of Complexity" series, or refer to seminal studies such as Charles Lumsden and E. O. Wilson's *Genes, Mind, and Culture* (Cambridge: Harvard University Press, 1981) or Richard Dawkins' earlier *The Selfish Gene* (New York: Oxford University Press, 1976). A recent book on the idea of memes, or cultural-informational genes, a term first coined by Dawkins in the above work, is Susan Blackmore, *The Meme Machine* (New York: Oxford University Press, 1999). See also Melvin Konner, *The Tangled Wing* (New York: Henry Holt, 1990), and Steven Pinker, *How the Mind Works* (New York: W. W. Norton, 1999).

v This line of thinking, which often goes by the name of "neural Darwinism" was probably started with Karl Popper's A. H. Compton lecture "Of Clouds and Clocks," reprinted in his *Objective Knowledge* (Oxford: Oxford University Press, 1972), pp. 206–255. See Gerald Edelman, *Neural Darwinism* (New York: Basic Books, 1987), Daniel Dennett, *Brainstorms* (Cambridge: MIT Press, 1978), and William H. Calvin, *The Cerebral Code* (Cambridge: MIT Press, 1996).

vi The pioneer of what is now known as "evolutionary computation" and of the art of programming "genetic algorithms" is Danny Hillis, erstwhile professor at MIT and director the Thinking Machines Corporation, and at the time of writing a vice president at Walt Disney's Imagineering. For more information about evolutionary computation, visit *www.natural-selection.com/eps/l* or *www.red3d.com/cwr/evolve.html*. See especially the work of Karl Sims at *http://www.genarts.com/karl/*.

vii This is a fairly recent discovery. See Tim Beardsley, "Evolution Evolving," *Scientific American*, September 1997, pp.15, 18.

viii One is reminded here of the neo-Aristotelian principle of Plenitude. On this doctrine, everything that is possible (for God or nature) is actual. Every slot is filled, every ecological niche occupied, every creature realized, every atom of void filled, every scale of structure articulated. See Arthur O. Lovejoy's *The Great Chain of Being* (New York: Harper & Row, 1960 [1936]). For nicely expressed skepticism as to whether economies can usefuly be understood as evolving systems (in the biological sense), see Robert Solow's review of Jane Jacobs' *The Nature of Economies* (New York: The Modern Library, 2000): "Economies of Truth," *The New Republic*, May 15, 2000.

ix Perhaps the most chilling example of the *more life* principle misunderstood, and later mis-applied, can be found in the writing of Friedrich Nietzsche:

> Let us look ahead a century and assume the case that my attempt to assassinate two millennia of anti-nature and human disfigurement has succeeded. That new party of life which would take the greatest of all tasks into its hands, the higher breeding of mankind, including the merciless extermination of everything degenerate and parasitic, would make possible again that excess of life on earth from which the Dionysian state will grow again.

The mildest rebuke one could offer here is that Nietzsche was no naturalist, or he would have seen that such powerfully moralizing terms as "degeneracy" and "parasitism" have no place in talk about life as a principle, at least not without demanding strict proof that the sacrifice of form-of-life A was absolutely necessary for the flourishing of higher form-of-life-B-*without-A*—which, given that life *is* complexity-and-organization at its limit, is unlikely. The above passage is from *Ecce Homo*, "The Birth of Tragedy," Section 4, translated by Edward T. Oakes in *German Essays on Religion* (New York: Continuum Books, 1994), p. 124.

A thought experiment. Consider two possible universes. The one is as we see it through our telescopes: galaxies of burning, exploding, and imploding stars permeated by whirlwinds of gas and flying debris...and not a jot of life. The other is just like that too, but here and there (and apparently here), on one or two grains of cosmic sand, *life* in some form has emerged, and perhaps consciousness... If, given a choice between these universes, it is truly a matter of indifference to you as to which is—or becomes—the *actual* one, then you have no basis for ethical feeling, valuation, or a moral system. On my view, these come into being only *with* life, *in* life, and on behalf of its continuation. It is Man who sees that Creation was good—retroactively, and largely self-interestedly.

x The idea that the visible universe is one of many that has evolved since the Beginning, with every black hole a new Beginning, is Lee Smolin's in his remarkable book *The Life of the Cosmos* (New York: Oxford University Press, 1997). Smolin is the man who has perhaps taken Darwin's idea further than anyone since Teilhard de Chardin, but see also David Layzer, *Cosmogenesis* (New York: Oxford University Press, 1990).

xi One can, of course, err by going too far in this direction too. If one allows *no* quarter to nature, then humans' infinite malleability by culture (nurture) tempts tyrants and demagogues to make people over in ways that suit them, this through control over media, education, culture, and of course, government. The lesson of Darwinism to Marx (based as Marxism was on Darwin's concluding remarks in *The Descent of Man*) was precisely this: that human nature itself was changing in time, that *progress* depended on it, and that human desire for, say, private property, could and should be transcended rather than accepted.

xii I have no reason, given the very general nature of the theory at this point, to look for a more complex mathematical expression than the one presented. This does not mean that "$\Omega = \sqrt{CR}$" is correct or the last (mathematical) word on the subject. On the contrary. Future researchers will likely find that normalized, parameterized, or elaborated versions of our basic formula, with an assortment of constants and exponents, will fit empirical data more perfectly and/or produce better predictions. Even the basic, unparameterized, formula might be improved upon. For example, the expression

$$\Omega = \sqrt{\frac{CR}{1+[C-R]^2}}$$

tempted me for some time. It has certain attractive properties. For one, it emphasizes something I will soon call "the ridge of omega" while retaining the fundamental argument inherent in $\Omega = \sqrt{CR}$. In doing so, it gives slightly higher value to *balancing* C and R than to increasing them which is probably reasonable. But I thought that it would ask too much of the general reader to keep track of Ω's behavior using this more complex expression when almost everything I was going to claim about value's "tendencies" and "directions" could be found adequately represented in and by the simpler formula $\Omega = \sqrt{CR}$.

The normalized expression "$\Omega = 2CR/(C + R)^2$" also had its charms, but, of course, it fails to let Ω increase absolutely with increase in C and R. A better formula for Ω might also build in the fact that states of nature where C or R are truly equal to zero are non-existent.

On a related matter: To my knowledge I am the only author to attempt a formal model of complexity-and-organization as a single dependent variable, and the only one foolhardy enough to try to build a theory of value upon the manner of its increase and decrease. I am not, however, the first or only author to conclude that high levels of complexity *and* high levels of organization (or "order"), found together, are characteristic of living or highly evolved systems. Richard Dawkins, for example, talks of "organized complexity" and Daniel Dennett, following Dawkins, does the same. (See Richard Dawkins, *The Blind Watchmaker*, Daniel C. Dennett, *Darwin's Dangerous Idea*). Dawkins may have borrowed the term "organized complexity" from none other than Warrren Weaver, co-inventor with Claude Shannon of information theory, which we explored in Chapter One. (Weaver used the term in an article in *American Scientist* [Vol. 36, 1948] where he contrasts "organized complexity," which he said describes biological and social complexity, with "disorganized complexity," which applies best to physical systems consisting of many identical parts, like a gas. We will follow him in this shortly.) But others since have used the terms "ordered complexity," "complex organization," or "complex order" to mean the same thing.

I have gone my own way, terminologically, preferring not to demote one of the two components—"complexity" or "organization"—to the role of adjectivally qualifying the other. This is not just because they are both equally important variables, but because double-noun "complexity-and-organization"—shortened when convenient to "Ω"—it is grammatically more manageable. Otherwise one will find onself calling for "more organized complexity," which is ambiguous, or "more organized organized-complexity" or "more complex organized-complexity." Similarly, the phrase "more complex organization" is ambiguous, and might mean "more complex complex organization," or "more organized complex organization" etc. etc. In my usage, *complex-and-organized* is the adjectival form of complexity-and-organization, and a system can be "more complex-and-organized" or "less complex-and-organized." It's as simple as that.

Note, finally, that Ω in this book bears no relationship to Teilhard de Chardin's "Omega Point," which is that point in the distant future when both human and cosmological history converge and culminate together in a burst of pure holiness—with Christ returned, God, Man, Matter, and Energy finally united into a single spiritual entity, a glorious One. Teilhard's is a beautiful moral vision, not *meant* to be taken literally. Our Ω also has nothing to do with the Ω of astrophysics, where it designates the ratio of matter in the universe to the critical amount of matter in the universe required for its expansion to halt and perhaps reverse; but it might—just might—have some relation to the Ω of Gregory Chaitin, which is an infinitely-long, unknowable, truly-random number that represents the probability of computer halting in the computation of an NP-incomplete problem. This Ω imposes certain limits on what can be known by mathematics at all.. For a fairly accessible account of Chaitin's Ω, see *www.newscientist.com/features/features.jsp?id=ns22811*, *www.cs.umaine.edu/~chaitin/cmu.html,* or see his book *The Unknowable* (New York: Springer Verlag, 1999). See Notes 13, 14 as well as the end of Note 31 of Chapter One of this volume.

xiii By simple substitution we can write: $\Omega = [C^2(C_{pot}^2 - C^2)]^{0.25}$

xiv How derived? If $R = (C_{pot}^2 - C^2)^{0.5}$, then $C_{pot}^2 = R^2 + C^2$. The reader might recognize in the form of this equation the ancient Pythagorean formula for the length of the hypoteneuse of a right triangle, namely $c^2 = a^2 + b^2$. Taking the square root of both sides to get C_{pot} (c in the Pythagorean formula), we arrive at $C_{pot} = (R^2 + C^2)^{0.5}$. A particular value of C_{pot} can therefore appear on the graph of Figure 2.1 as the locus of points equidistant from the origin, which is to say, as a quarter-circle centered on the origin {0,0} and with radius equal to C_{pot}. So, in order to "read off" the potential complexity associated with any point on a graph like Figure 2.1 (that point representing particular magnitudes of actual complexity, organization, and omega), we need only measure how far that point is from the origin.

xv Note that if $C_{pot} = R$, then $C = 0$, and that if $C_{pot} = C$, then $R = 0$. Note too that Ω is a maximum for a given value of C_{pot} when $R = C$, which is also when $C/C_{pot} = 1/\sqrt{2}$ (= 0.70711... ≈ 0.71). In Figure 2.3, the "rigidity" region is characterized by $C/C_{pot} < 1/\sqrt{2}$, the "chaos" region by $C/C_{pot} > 1/\sqrt{2}$, and the "life" region, the ridge of Ω, by $C/C_{pot} \approx 1/\sqrt{2}$.

Because $C_{pot} = \log N$, and because N is a positive integer by definition, the phase space of C and R cannot be a continuous one; nor can the Ω-surface be smooth and continuous. All systems must have potential complexities (at given scales) that lie on a C_{pot} arc exactly. For the purposes of exposition, however, I treat the Ω-surface as smooth and continuous everywhere.

[xvi] A rough analogy might also be drawn here to the three phases of matter, namely, solid, gas, and liquid respectively. On this analogy, ultimate rigidity would occur at ultimate *frigid*ity, i.e., a the theoretical temperature of zero degrees Kelvin (-273.15^0C)—which is physically unattainable. Conversely, ultimate chaos would occur at infinite temperature, which is equally unattainable. (As we discussed in Chapter One, when closed systems drift towards maximum entropy in accord with the Second Law of Thermodynamics—or, in our terms, towards maximum actual complexity—it is towards maximum entropy for that system at a given, finite temperature and pressure. For more on this, see Appendix Two.)

[xvii] Erich Fromm, *The Heart of Man* (New York: Harper & Row, 1964), p. 47. Viruses are bad (for us). But viruses that kill their victims quickly do not spread very far or fast. This is not good for the viruses either; so few of them do so.

[xviii] To avoid confusion, I will use the word "magnitude" instead of "value" when referring to the numerical size of variables rather than *value*, the larger concept we are developing. Thus "the magnitude of x" rather than "the value of x" whenever x does not represent or identify an act or object of value as such. V itself, on this usage, has a magnitude but not a value. Also, mathematicians please note: the paucity of subscripts (for time, for identifying particular systems, and the scales of operation therein) is deliberate. It's bad enough, my friends and editors tell me, that this book needs equations at all.

[xix] This raises some interesting, quantum-physics-like questions: is it possible to measure the intrinsic value (Ω-as-found) of a system without affecting it, or affecting oneself, in the process? Probably not. This is a problem for all the social sciences, however, and I shall not attempt to solve it here. We have bigger problems yet: figuring out how to estimate Ω scientifically at all. For a discussion of the idea of "existence value" in the context of environmentalism, see Peter Hill and Roger Mainers, eds., *Who Owns the Environment*?(New York: Rowman and Littlefield, 1998).

[xx] When it comes to the scales of interest to molecular physicists and biochemists, the pattern seems to reverse. Here, the relatively larger scales are more complex-and-organized than the smaller, physically constitutive ones.

This is especially evident with large organic molecules (of which DNA is an extreme case) whose complex behaviors as a whole derive from the fact that they are comprised of a handful of (kinds of) identical and relatively simple atoms (or submolecules) constrained to doing very simple things to each other (like: bond together or not). Indeed this distribution of complexity "smaller = simpler, bigger = more complex" constitutes the structure that supports *atomism* as both a scientific method and a worldview.

At scales smaller than the atom, however, complexity seems to return with a vengeance. With quantum physics, the pattern becomes: more complexity wrapped in smaller things than in the larger ones they together make up. Atomism is challenged. As one breaks through to quantum microworlds, the universe paradoxically swells again in complexity-and-organization.

A system's *total* level of complexity-and-organization, then—which is mostly what we have been talking about and what we will continue to mean, by default, when we talk about systems as a whole—would properly be the sum of the magnitudes of Ω at each and all relevant scales. How to calculate and graphically represent differing degrees of complexity-and-organization operating simultaneously at different scales in a single system is an important topic, one that I address in the next section of this chapter and elaborate upon in Appendix Three. But one consequence of this idea is to help us see how happiness is always an on-the-whole measure in addition to being a cross-temporal measure. For happiness, which is the experience of value, is rarely "un-alloyed" or without setback or sacrifice between time one and time two, as we shall look into in Chapters Three, Four, and especially Six. It is computed across several spatiotemporal "scales" of our existence.

With regard specifically to time, we can construct a quantity which we might call a life's*plenitude*, the product of lifefulness, as measured by average Ω, and the time over which this average Ω holds for a system. That is, *plenitude* = $\Omega_{avg}\,\Delta T$, or, more accurately, *plenitude* = $\int_{T=0}^{T} \Omega\, dT$. I will make reference to this measure again in Chapter Six when we discuss the value of decisions that have whole-life effects (such as for example, extending it—living longer—at the price of decreasing its average complexity-and-organization, or lifefulness). Here we depend on the simpler rule that, all other things being equal, increasing Ω over any given period of time, ΔT, is a Good Thing (i.e. has positive value). If, let us say, an increase in Ω now definitely entailed a drop in Ω later such that, over the entire period, that life's plenitude was decreased, then we would let ΔT be larger in order to capture the net result, and attribute net value to it.

[xxi] In the search for extraterrestrial intelligence using radio astronomy (the SETI project) I would suggest looking not for order or non-randomness in signals from deep space—these are easy to find—but for that peculiar balance of organization ("order") and complexity ("randomness") that characterizes Ω-optimality. Of course, future research might discover that Ω is one of many interesting statistical measures of lifefulness.

xxii Notice that these vectors themselves have different lengths in the diagram, lengths equal to $[(\Delta C)^2 + (\Delta R)^2]^{0.5}$ depending on where they are, and would have different real lengths again if thought of as laying directly on the Ω-surface, like arrows fallen upon a hillside. It is important to observe from this that we canno read V from the absolute length of value vectors in Figure 2.4. To read V we must count the actual Ω-contours beneath. V is a *vector field*.

xxiii In general, the steeper the slope of the Ω-surface, the greater, potentially, is the value of small changes in complexity and/or organization. The Ω-surface is least steep, we notice, along its 45^0 ridge from the origin, and most steep near the two axes. It is in the regions of rigidity and chaos that "moves" of the greatest value are to be found. Note also that increasing C_{pot} almost always produces *some* positive value, while decreasing it almost never does. Also, away from the X- and Y-axes, increasing C by itself or R by itself always increases Ω, while decreasing them each alone never does. The mathematics underlying these observations is this: for any point on the Ω-surface (C, R), the maximum slope, or *gradient*, of V,

$$\mathrm{grad}V = \frac{(C^2 + R^2)^{0.5}}{2(CR)^{0.5}}$$ in the direction parallel to [(R, C) from (0, 0)].

xxiv Cf. Chapter Ten, p. 22 and Note 23. Cf. also Note 119 of Chapter Nine, where the measure of freedom is studied again using a composer/piano metaphor described in Note 8 of Chapter Three.

xxv Adopting the rule "act so as to increase C and R always equally" (i.e. regardless of context) will yield positive value and, over the very long run, bring one relatively closer to the ridge of Ω. The context-dependent rule "cross Ω-contours at right angles" is simply a faster, steeper route up the Ω-surface to the ridge. One might, therefore, adopt this rule: "When uncertain of the complexity-state of the context, increase C and R equally; when certain, increase C and R in such proportion as to climb the Ω-surface most steeply." This is given by grad$V$ (see note 23 above).

Communitarians like Amitai Etzioni, John Gardner, Betty Friedan, John Neuhaus and others, propose policies they call "radically centrist." The term "centrist," however, can have two meanings: first, an eclectic mixture of liberal and conservative policies that, taken together, cancel each other out in some sense, yielding no drift in one direction or the other for society as a whole; and second, the attempt to find a middle path, the "third way," for each and every policy issue, which gives the same overall result. I believe that the metaphor of motion on the Ω-surface could offer a way of understanding what is going on with "centrism" at a deeper level—one that connects it to nature and evolution. See David G. Myers, *The American Paradox* (New Haven: Yale University Press, 2000) pp. 188–192, for a compatible reading of communitarianism, the "bible" for which is probably Amitai Etzioni's *The Spirit of Community* (New York: Crown Publishers, 1993).

xxvi Richard Dawkins is eloquent on this point (Richard Dawkins, "An Open Letter to Prince Charles," *The Edge*, May 21, 2000) available at *www.edge.org/documents/archive/edge69.html*:

> Loggers, whalers, and other profiteers who squander the future for present greed, are only doing what all wild creatures have done for three billion years.
>
> No wonder T.H. Huxley, Darwin's bulldog, founded his ethics on a repudiation of Darwinism. Not a repudiation of Darwinism as science, of course, for you cannot repudiate truth. But the very fact that Darwinism is true makes it even more important for us to fight against the naturally selfish and exploitative tendencies of nature. We can do it.
>
> Probably no other species of animal or plant can. We can do it because our brains (admittedly given to us by natural selection for reasons of short-term Darwinian gain) are big enough to see into the future and plot long-term consequences. Natural selection is like a robot that can only climb uphill, even if this leaves it stuck on top of a measly hillock. There is no mechanism for going downhill, for crossing the valley to the lower slopes of the high mountain on the other side. There is no natural foresight, no mechanism for warning that present selfish gains are leading to species extinction—and indeed, 99 per cent of all species that have ever lived are extinct.
>
> The human brain, probably uniquely in the whole of evolutionary history, can see across the valley and can plot a course away from extinction and towards distant uplands. Long-term planning—and hence the very possibility of stewardship—is something utterly new on the planet, even alien. It exists only in human brains. The future is a new invention in evolution. It is precious. And fragile. We must use all our scientific artifice to protect it.

[xxvii] Some readers may wonder at my not referring to Richard Dawkins's *Climbing Mount Improbable* (New York: Norton, 1996). Surely Mount Omega and Mount Improbable share one and the same abstract topography. I do not refer to Dawkins's book for two reasons: first, because I do not agree that life is *that* improbable (see Note 10 of Chapter Three), and second, because metaphor of a mountain or hill up which evolution climbs to greater X (where X is some measure of cleverness, size, complexity, or success) is not an uncommon metaphor the literature of evolutionary theory. Stuart Kaufmann, for example, could see in our Ω-surface an idealized picture of what he calls the "*fitness* landscape." Kaufmann also argues that life is not highly improbable. See his *The Origins of Order* (New York: Oxford University Press, 1993).

[xxviii] Daniel Dennett in *Darwin's Dangerous Idea* refers to this amplification of biological evolution by psychological foresight and cultural wisdom as the Baldwin Effect, after turn-of-the-century biologist James Mark Baldwin, the first to make note of it.

[xxix] The reader may wish to consult Appendix Two, which gives a short account of the Second Law.

[xxx] Roger Penrose, *The Emperor's New Mind* (New York: Oxford University Press, 1989)

[xxxi] For more on entropy and Figure 2.4, see Appendix Two.

[xxxii] Atomists, of course, believe that *insideness* and its associated further complexity eventually stops. There is nothing inside and smaller than an atom or, better, an *elementary particle*. For the atomist, everything in the universe is built up from the agglomeration and interaction of particles that each, themselves, (a) have only one, singular property (like unit-energy or -mass), and (b) have this singular property regardless of when and where and amongst which other things they exist and (c) consist of no smaller parts that could take up different arrangements among themselves. This is what it means to be "elementary," to be a true atom.

But this view has lately come under review. Some hypothesize that although unimaginably tiny particles do exist, such as quarks, their properties are neither stable nor, strictly speaking, their own. Rather, they depend on the position and properties of all the other (similar?) particles in the universe. Hence, complexity re-enters, folded into the very heart of every "point" in space. This idea and its Western origin in Leibniz (contra Newton), are cited throughout Lee Smolin's *The Life of the Cosmos,* especially, 245–254.

[xxxiii] See for example Nicholas Georgescu-Roegen, *The Entropy Law and the Economic Process* (Cambridge: Harvard University Press, 1971), and Jeremy Rifkin, *Entropy: a New World View* (New York: Viking Press, 1980).

[xxxiv] R. G. H. Siu, *The Tao of Science* (Cambridge: MIT Press,1974). See also his *Ch'i: A Neo-Taoist Approach to Life* (Cambridg: MIT Press, 1974) and *Transcending the Power Game: the Way to Executive Serenity* (New York: Wiley, 1980).

[xxxv] I read this story a long time ago, and, try as I might, I cannot find its source. Many Zen stories have this flavor, though. "Letting things go" from an original position of great purity and discipline is very much part of the Zen Buddhist spirit. This is what has happened in this story: notice that the master *did* ask for the garden to be swept rather than be left natural.

[xxxvi] Indeed, if the system is progressing by equal increments of C, Ω declines precipitously at the last. If the system were to progress at a constant *angular* velocity along the C_{pot} contour, however (think of a clock with the tip of its second hand advancing by tiny steps from 12 to 3) then the ascent from A to B would be mirror image to the descent from B to C.

To see this curve's symmetry directly, on must look at it with an X-coordinate set at 45^0 to the current one. The X-axis must be $|C - R|$

[xxxvii] Even if some little genius-creature within the system were to wake up and start organizing things, a magnitude of Ω of 4.95 would still the best that could be achieved. Some readers might know this little genius's name: it is Maxwell's Demon. As Leo Szilard showed, since it would take energy from the outside for Maxwell's demon to do his job (not to say an intelligence of some small sort, and therefore computational complexity), the system could no longer be considered to be perfectly closed. And with this, the Second Law's inexorable ushering of all closed systems to a chaotic fate is saved.

[xxxviii] Increasing C_{pot} by itself does not necessarily increase Ω, of course, but it raises the ceiling of Ω, to $C_{pot}/\sqrt{2}$

[xxxix] Some technical remarks about the relationship bwtween *information, **I**,* and *organization, R,* first layed out in Chapter One (p. 9). There we showed that information, ***I***, first conceived of as a measure of changing uncertainty was equally a *measure* and *consequence* of change in degree of organization, i.e., of ΔR. Although in

this chapter we have defined R in a slightly different way (as the square root of the difference of the squares of potential and actual complexity rather than the simple arithmetic difference between them) a monotonic relationship between ΔR and $\boldsymbol{I}$ remains in effect. To wit: any net increase in the R of a system (at some or many scales) implies the importation of positive information (or the loss to the environment of negative information); and likewise, any net decrease of R implies the importation of negative information (or the loss to the environment of positive information). Notice that under the condition that C_{pot} remain a constant, importing information—or more accurately, importing *positive* information—will move a system along the C_{pot} contour *in exactly the opposite direction as entropy does* via the Second Law. Reverse the arrows in Figure 2.6.

We now see the significance behind the often-proffered definition of information as "negative entropy ('negentropy')." But we can see that this definition only a partial truth, requiring quite a lot of interpretation. We can see that *any* movement of a system "northwards" on our graph, whether constrained to follow a C_{pot} arc or not, represents an increase in the system's information content. If we hold C constant and allow R to increase, then that increased information content casts the movement's *value* as positive (albeit ever less positive as R increases alone, with fixed C, takes us out of the trench of chaos and past the ridge of Ω*)*. Of course, if we allow C to vary and hold C_{pot} constant, any system starting on the chaotic side of the ridge of Ω and proceeding northwestward and finally due westward, increasing R all the while, would diminish in Ω, and rigidify. Here positive information is "positive" in a mathematical sense only, for *once past the ridge of* Ω*, persisting in adding "positive" information generates only negative value* in ever larger chunks.

[xl] The evocation of John Gardner's classic work *On Moral Fiction* (New York: Basic Books, 1978) is intentional. Moral fictions are not those that necessarily teach morals, as in "the moral of the story is: Don't Lie." Nor are they necessarily stories about how good people win over bad people. Etc. Moral fiction is fiction that helps its readers adapt to greater complexity. If not a word of the bible were histocially accurate, and if it contained not a word of explicit moralizing, it would be great work of moral fiction. Shades of Hegel's *Phenomenology of Spirit*?

[xli] See also the discussion of this point in Chapter One (p. 18), and in Note 30 to Chapter One. Although what I say below is phrased for animals, which are mobile, very similar things can be said of plant evolution. Note also that less-than-prerequisite-Ω in a newborn individual is, in higher species, compensated for by a period of protection and education. Here, until the young one is viable individually, the requisite Ω is contained in the behavior of the family unit.

[xlii] For a scholarly treatment of how cognitive complexity tracks cultural evolution, see H. Werner, *Comparative Psychology of Mental Development* (New York: International Universities Press, 1957), and H. Werner and B. Kaplan, "The Developmental Approach to Cognition: Its relevance to the psychological interpretation or anthropological and enthnolinguisitic data," *American Anthropologist* 58 (1956): 866–880. For a passionate and richly informed popular account, see Robert Wright, *Non Zero* (New York: Pantheon Books, 2000), about which more in Chapter Four. See also Jerome Barkow, Leda Cosmides, and John Tooby, eds.,*The Adapted Mind: Evolutionary Psychology and the Generation of Culture* (New York, Oxford Univeristy Press, 1995). On the role of *art* in the evolution of culture, seen as an overlay on biology, see Ellen Dissanayake, *Homo Aestheticus: Where Art Comes From and Why* (Washington, University of Washington Press, 1992), and Geofffrey Miller, *The Mating Mind* (New York, Doubleday, 2000).

[xliii] This one included? These stretches are sometimes called "junk DNA," which is an unfortunate term given how little is still known still about how the genetic machinery works. Today's junk might be tomorrow's treasure and vice versa, not just in the view of observing scientists but in organisms themselves as they evolve in changing environments over evolutionary time. See, for example, Carl W. Schmid et. al., "Potential *Alu* Function: Regulation of the Activity of Double-Stranded RNA-Activated Kinase PKR," *Molecular and Cellular Biology* 10, no. 2 (Jan. 1998): 58-68, reported in *Nature* online at *www.nature.com*. The "Alu" sequence was considered prototypical junk DNA until research showed how it became non-dormant when the organism is under viral attack.

[xliv] It is often estimated that some 90% of the length of human DNA is non-coding or "junk" DNA, with similar percentages for the higher animals. As I noted above, one needs to be cautious about the meaningfulness of these estimates. While there is no doubt that DNA is redundant to some extent (all real information is), and while there is little doubt that there are many unused stretches of it, like unused rooms in a gigantic house, so little is known about the molecular-genetic process in detail—about how and where the choreography is written that guides DNA and RNA and a thousand other chemicals to perform their fabulously intricate dance—that the "90% junk" status of DNA more likely reflects our ignorance than it does nature's spendthrift ways. The arguments I am making for nature's intrinsic "extravagance" would stand just as well with, say, a 20 or 30 percent "true junk" count, and even then I would argue that that junk DNA might be serving as insurance of a kind, like the stuff in your garage: DNA code waiting to become expressed, presently-useless skills and old anatomical features that might become useful and lovely in the future.

Though their results have been challenged, physicist H. Eugene Stanley and his associates at Boston University and the Harvard Medical School claim, for example, to have discovered fractal-like patterning in junk

DNA, implying some definite information content in it. More startlingly yet, they report a great similarity, across all species, between the way the statistical frequency of nucleotide "words" are correlated with each other and the way the statistical frequency of real words, in languages, are correlated with each other. Both obey Zipf's Law where, in a variety languages, "the most common word (*the* in the English language) occurs 10 times more often than the 10th most common word, 100 times more often than the 100th most common word, and so forth." (Philip Yam, "Talking Trash: Linguistic patterns show up in junk DNA," *Scientific American*, March 1995, 24)

xlv Adding genetic material is the chief way that harmful bacteria and viruses finally get around our antibiotics and anti-viral medicines. New strains appear that are immune to our defences.

We are not surprised to learn that research with computer simulations of genetic replication suggests "that size and complexity—in this case the length and computational power of the digital organism—protects organisms against the harmful efffects of mutations." (Sara Robinson, "Evolving Digitally Into Respectability," *New York Times,* September 2, 1999, p. D12) The AL (artificial life) program used is called *Avida* (see *www.krl.caltech.edu/avida/*).

Scientists know that insufficient diversity of species in an ecosystem make it vulnerable to degradation as a whole, with such higher species as do (for a while) subsist rapidly migrating away or dying out. On the other hand, scientists also know that not all species in a given ecosystem are equally critical to its overall health. Prescriptions for at-risk ecologies thus differ: maintain biodiversity in principle? or identify and save the critical species? What this really asks is: how important is potential complexity, that is, the "un-used" complexity of low-frequency, low-probability interactions? The lesson from evolution and DNA growth is this: you never can tell when potential complexity will become actualized and take Ω a stride upward. Yesterday's "junk DNA" might be tomorrow's expressed DNA. Nor, really, unless you understand a system's every tiny mechanism, can you tell which low-probability event is the beginning of an important chain of cause and effect. The conservative conclusion? Keep the C_{pot} boiling. The progressive conclusion? Keep *C* active. Both are right. In the long run, Ω rules.

xlvi The book you have in your hands is one attempt to combat this trend: it tries to exemplify as much as expound its theory that value is more, and better, Ω. By "*better* Ω" I mean nothing mysterious or additional to what we have already studied: I mean "Ω-near-the-ridge" where complexity, *C*, and organization, *R*, are closest to equal in magnitude. See also Chapter Nine, p. 23.

xlvii By "evolutionary advance" I mean some new feature of an organism and/or its behavior that allows it to reproduce more quickly or prodigiously in a given environment. Part of this process is sexual selection: the process by which (usually) the female of the species judges the fitness-to-be-a-father of competing prospective mates. In the animal kingdom, sexual selection can explain some of nature's proclivity for ormamenation (peacock tails being the canonical example). As Darwin explored in *The Descent of Man*, when females choose the most attractive, visually button-pushing males to mate with, males evolve to suit. But nature's over-the-top complexity in every quarter, it seems to me, cannot *all* be explained this way. On a broader view of what evolution is "up to," all else being equal, singing in the shower needs no further justification: it is more complex-and-organized than showering quietly.

For a modern account of the underestimated effects of sexual selection on human evolution, see Geoffrey Miller, *Mating Mind* (New York: Random House, 2000), especially, in the context of this book, page 61, where Miller discusses how the Modernist/Puritan prejudice against ornamentation was a factor in the almost century-long neglect and/or rejection by biologists of Darwin's sexual selection theory.

xlviii Cooling and fracturing represent movement to the "southwest," accumulating unincorporated pieces represents movement to the "north," and so forth: all the directions have certain characteristic processes as their cause.

Actually we need not argue for non-randomness in the direction of skipping in order to conclude that the transition from proto- to viable life is (or was) unlikely. Let us suppose that the direction is/was random (i.e. too complex to figure out). Scientists often visualize random motion as a "drunkard's walk" thusly: How far a drunk staggers from his starting point generally increases with the time spent staggering, but the directional bearing of his current position relative to his starting point is quite uncertain. He is as likely to be north, south, east, or west from where he started.

Now imagine, as Stephen Jay Gould asks us to do in *Full House* (New York: Random House, 1997), that there is a long precipice like a canyon edge immediately to one side of the starting point, say to the left, and imagine that there are a large number of drunkards who serially pop into existence at the starting point. After a period of time, we should not be surprised to find half of them spread out to the right of the edge. Why? Because the other half, of course, have gone over the precipice. What looks like an innerly-guided or God-led trend to the right is merely the conspicuous absence of those unlucky enough to have staggered, on average, more leftward. In Gould's thought experiment, the precipice represents biological non-viability. Systems that change their state at random and that happen to change it towards insufficient-complexity-to-be-alive...well, don't get to be alive or reproduce.

xlix I say "roughly" 50-50 because to the extent that the Second Law makes itself felt, it would favor skips *into* viability from along the upper, "northwesterly" border, and *out of* viability along the lower "southeasterly" border.

[l] I say "as yet" because the day may come when human beings are capable of *engineering* a truly living system from scratch, from components. These creatures would "jump the line" of evolution; they would surmount the ridge of Ω from the side, as it were. Current explorations in what is called artificial life (AL) are extremely interesting in this connection, and we shall soon dip into that literature. However, even the most elaborate AL systems to date do little more than *model* living systems—cells, ant colonies—at an extremely abstract level.

[li] Figure 2.10 can also be deceptive if the remoteness at which it places humans—there, at the far top right of the diagram, at the end of a long and narrow road of evolution—is understood to be a spatiotemporal, geographical remoteness. We are not far from other things at all, not literally. The space of complexity and organization, of *C* and *R*, is not a real space but a mathematical one—a "state space" or "phase space," as scientists call it—and the Ω-surface exists nowhere but in abstraction. In actual space and time humans are far from alone. Indeed, we are surrounded to the point of claustrophobia by co-surviving, co-persisting, co-reproducing, co-evolving animals, plants, and microbes. We are constantly immersed in air or water with complex chemical compounds, constantly pushed, pulled, and vibrated by impacts from solid matter, and ceaselessly passed-through by countless information-carrying electromagnetic waves, each a different "channel" bearing data from a different direction. In real space, in other words, we are fully embedded in all the world's goings-on. We live in a plenum.

[lii] "Ask not what is inside your head; ask what your head is inside of." This is the title of a paper by William Mace [in W. H. Warren and R. E. Shaw, Eds., *Persistence and Change* (Hillsdale, N.J.: Lawrence Erlbaum, 1984)] explaining the contrarian orientation of perception psychologist J. J. Gibson of Cornell. Gibson proposed that the "contents of consciousness" were nothing other than the structure of the world as it is, insofar as our senses, in a physical sense, permit entry of the information. Implausible? Not after you've read Gibson. Cf. Coda, Note 128 and the text it supplements.

[liii] The reader who wishes to explore this last idea in more detail is invited to peruse Appendix Three, "On Omega at Different Scales." "There are more things in heaven and earth, Horatio, than are dreamt of in your philosophy," avers Hamlet (*Hamlet*, I.,v.).

[liv] Large changes in the phenotype—i.e. in the actual living organism—are possible, of course, but highly unlikely given the incredible precision with which the genetic machinery, at the molecular scale, routinely does its transcribing and replicating work.

[lv] Two notes. First, the probability of falling off the table with the next step goes up as $1/\sqrt{2}$ of the average step size. Second, it is true that our viable-life zone is much narrower than it is long, making relatively large steps to the northeast (and even to the southwest if one his already high up enough to start with) quite safe. Large steps to the northeast are rare to impossible, however, for the physico-chemical reasons just mentioned, while large steps to the south-east can and do occur: every time a living thing is severely injured but survives, and every time a retarded child is born.

[lvi] I made note of this earlier too. See Note 15 above.

[lvii] We must consider one possible exception to the rule: predator and prey in the last moments before a kill (or an escape). The predator runs after the prey with all its might; the prey runs with every ounce of speed it can muster. As the distance between them closes, and each knows what awaits...perhaps it occurs to them, in some sense, that they are working hard, that life *is* effortful, that there is a goal—continuing to live—, that matters are coming to a head as time runs out...

[lviii] Another Zen story. A wandering Zen master meets a wandering Hindu fakir at a thundering river. The fakir, instantly competitive, waves his staff and stops the river dead. Then he waves his staff again, and the river returns to flowing. Turning to the Zen master he shouts: "Now show me the miracles *you* perform with *your* religion!" Replies the Zen master: "Here are two: when I am hungry, I eat; when I am tired, I sleep."

See my discussion of Csikszentmihalyi's work in Chapter Three, 14–17, and notes thereto.

[lix] The impatience of young children is another story...but not really: they face mini-deaths all the time, like having to stop playing and wash their hands, like school on Monday morning. Cf. my further remarks along these lines in Chapter Six, where I discuss what I call *climactic satisfactions* and dissatisfactions, and Chapter Eight, where I discuss the idea of eliminating competition. See also Ernest Becker's classic studies of the consequences of knowing of our finitude, *The Denial of Death* (New York: The Free Press, 1973) and *Escape from Evil* (New York: The Free Press, 1975)

[lx] The work expended on projects and products that increase noone's Ω except the worker's deserves little or no *social* reward. The later Marx spoke of "socially useful labor" as the legitimate source of all value and not just labor-pure-and-simple; and the moment he admitted "socially useful" into the formula, he lost at least half his claim

to the priority of "labor-embodied" *per se* as the standard for measuring value. Jan Narveson makes the same point in his essay "Deserving Profit" in Robin Cowan and Mario Rizzo, Eds., *Profits & Morality* (Chicago: University of Chicago Press, 1995), 82-83.