all cars, water bottles, power plants, software interfaces, etc. Along with function, the design of an artifact must be explained in terms of explicit or implicit value choices made by its designer. Indeed, the mere fact that an artifact exists suggests that someone made the value judgment that it was worth having in the first place. Such value judgments can be aesthetic, moral or both. But they are always part of design. So the mixing of human purposes with the stuff of nature results in artifacts that necessarily reflect the intentions and the values of their makers.

Yet, to understand better how socio-technical systems are embedded in the human world, including the formative role that value judgments play in that world, I believe our conception of socio-technical systems must be expanded. In particular, we need to see how the design of our artifacts, particularly the complex ones upon which life as we now live it depends, is bound up with three distinct but interdependent kinds of systems: natural, artifactual, and human. Accordingly, in what follows, I explore some of what I believe is called for in a broader understanding of what we do when we impose human purposes onto nature.

2 Systems and Design

In his 1893 essay, "Evolution and Ethics," T. H. Huxley (2002 [orig. 1896]) considers the difference between a jungle and a garden in his exploration of the mechanisms of evolution. Today, with developments in evolutionary theories and the broad establishment of environmental studies, the difference between a jungle and a garden may seem obvious or even trivial. I think the distinction is well worth revisiting, however, because it holds implications that are vital to understanding how the world upon which modern life depends is constituted.

In modern terms, a jungle can be explained by appeal to the push and pull of evolutionary adaptation, the vagaries of weather, and other workings of nature. We can also easily point to jungles as one of several kinds of "ecological niches." Indeed, they can be seen as exemplars of what I would like to call "natural systems." That is, they are systems whose activities can be explained by appeal to natural factors (in a way, at least, that distinguishes those factors from ones rooted in human agency or activity). The field of environmental studies has given us ever greater sophistication in specifying the characteristics of natural systems, including how they operate under the impact of human activity, reflecting the distinction Dewey (1938) notes between our "living in" and "living by means of" the environment.

Natural systems, like all systems, have their own unique requirements for sustenance and stability. In the short-term, a jungle needs water, nutrients and sunlight to sustain itself as a healthy living system. For its long-term stability, that is, its ability to maintain the crucial balance between stagnation and chaos that enables it to remain a jungle, a jungle needs internal regulators that are resilient in the face of broader changes in the climate, encroachment of new species, etc.

Significantly, the natural forces we can find at work in a jungle are no less present in a garden. Indeed, if we fail to look after a garden's stability and sustenance

needs as part of the plant kingdom, providing water and sunlight, for example, it will fade or die. In this sense, a garden is as much a natural system as a jungle is. Unlike a jungle, however, what goes on in a garden cannot be explained solely by appeal to the workings of nature because a garden is also an artifact. It is a human creation, a jungle upon which a design of uniquely human origin has been imposed. Any particular characteristics or requirements it may have that arise from it being a garden rather than a jungle (tilling, weeding, fertilizing, etc.) find no origin or criteria in nature. Rather, they are utterly human. And if we fail to look after a garden's stability and sustenance needs as an artifact, it will revert all too quickly to the state of nature from which it was drawn. Accordingly, any satisfactory explanation of the form and function of a garden requires appeal to the requirements of nature and to the requirements of its design as an artifact.

This is true of all artifacts. Whether gardens or cities, tools or technologies, automobiles or the Internet, all human creations are a mixture of natural materials and human purposes, and both aspects demand our attention. A bridge must be understood equally in terms of the functions its design affords, and the properties of its raw materials that afford its design (Cook and Brown, 1999). One the one hand, the form a particular bridge takes can by keyed to the functions of spanning a particular distance, supporting a range of loads, etc. On the other hand, its form needs to be accounted for in terms of what the bridge is made of. A bridge built to serve a specific set of requirements for span and load would look quite different if its raw materials were different – stone would afford one range of design possibilities, steel another.

Because such systems are artifacts, and because their forums and functions cannot be adequately explained in terms of the properties of natural systems alone, I call them "artifactual" systems. (I prefer this term to "man-made" since it is gender-neutral, and to "artificial" because that can suggest "phony," which artifactual systems clearly are not. "Artifactual" is also meant to remind us that such systems are human creations.)

As human beings, we interact not only with nature and our artifacts but also with one another. This includes all forms of intra-human interaction, from dialogue to teamwork to organizational behavior to the modes of discourse and forms of activity necessary to vital public life. That aspect of human interaction that is distinct from the mediation of natural or artificial systems is what can be understood, following Vickers (1996 [orig. 1965]; 1983), as the workings of "human systems." If I communicate with you by yelling across a field or speaking over the telephone or sending an email over the Internet, there are natural and artifactual systems that afford our communication. But they alone cannot account for the meaning of what we say or for the net of expectations that the communication fulfills or for the value that we place on what is said. All of that transpires within a human system that you and I share, that we most likely inherited from any common social groups to which we belong and from human culture in general. We may speak over the telephone, but we communicate with each other. The success of our communication is at least as much dependent upon the presence and stability of a set of human norms that make our communication meaningful and actionable, as it is on the clarity of the signal carried through the telephone.