may be described as mutation, and that some process of recombination also occurs, when a combination of memes gives rise to new artifacts.

Unlike Basalla's and Mokyr's theories, Aunger adheres to the blindness principle: he holds that the basic processes of meme and artifact variation and selection are not properly understood as conscious and goal-driven, even if conscious decisions and goals play a role in them. This is, indeed, a basic tenet of memetics: the evolution of memes, or ideas, is not explained as the result of conscious cognitive processes and actions by human agents, but rather as a process of blind variation and selection of memes in human beings who function as passive hosts to this process. Memetics therefore takes Darwinism significantly farther than Darwin ever did: even the watch found by William Paley turns out to be not the result of conscious design but rather the result of blind variation and selection. Just like biological organisms, memeticists hold, human-made artifacts are the result of processes of evolution by natural selection.

6 Designers and Technological Evolution

What, according to these three evolutionary theories of technology, is the nature of engineering design? I will start with answering this question for Basalla's and Mokyr's theories, which, unlike Aunger's, construe technological change as dependent on the conscious deliberation and foresight of human agents. On their view, then, evolutionary processes are not necessarily blind, and the design of technology is part of an evolutionary process while simultaneously involving foresight by designers. Their view seems to run counter to the blindness principle outlined in section 2. However, as I will now argue, this principle is too strong in its current form even for biological evolution and therefore needs to be modified. Evolutionary processes of variation and selection sometimes do involve foresight and conscious choice.

Natural selection is often contrasted with artificial selection, which is the selection by humans of animal and plant phenotypes, which creates new breeds within a species, and may even yield a species. The dog is a domesticated species upon which artificial selection has been worked for thousands of years, resulting in hundreds of different breeds. Clearly, these breeds are the result of processes of variation and selection that resemble natural selection in every way, except that they involve human foresight and choice working in conjunction with "natural" processes of variation and selection. Yet, does the dependency of the evolution of dogs on human foresight really differentiate it from ordinary, natural evolution?

Closer consideration shows that in natural selection, foresight and choice also frequently play a major role, because natural selection often depends on intentional, forward-looking actions by animals and humans. Animals select their mate, predators select their prey, and animals choose the immediate environment in which they live and the things and animals with which they interact, and parents choose which offspring they give the most food or are most protective of. These choices are generally

guided by expectations about the future. They are a large factor in the processes of selection, variation, and reproduction that occur in natural selection.

It may be objected that there still is a major difference between artificial and natural selection: artificial selection is selection with the explicit aim to grow or breed certain species with predefined properties (phenotypic traits), whereas the foresight in natural selection is not similarly aimed at designing the traits of offspring. A rabbit breeder may successfully breed a rabbit with a white body, black head and red eyes, but it would seem that two rabbits in the wild do not mate because they aim to realize offspring with certain phenotypic properties. Rather, they mate because they lust for each other and desire to copulate.[1]

In spite of this difference, however, there is no reason why artificial selection could not be described using the same concepts and principles used in natural selection accounts. In both cases, selection involves both forward-looking intelligence and events that involve no foresight. A rabbit breeder cannot completely control the circumstances that determine the phenotype or genotype of new generations of rabbits, so his foresight is just part of the explanation of why a bred rabbit looks the way it does. Conversely, an explanation of why a certain generation of rabbits in the wild has the phenotypic traits it does may include, amongst others reference to the intentional states of parent rabbits, predators, and other animals that played a role in selection.

In the evolution of technology, a designer or maker has the same relation to technical artifacts as a breeder has to the animals he breeds. The designer attempts to create a certain artifact with desired properties, but is not in full control of the outcome. Concrete artifacts are a compromise between the designer's ideals and the contingencies of the physical and social world through and in which the designer operates. While a designer is not fully in control of the outcome of his designing activity, he is even less in control of the success of his artifact once let loose in the environment, i.e., the marketplace and the world of users. Once a certain brand of artifacts leaves the factory, it is the intentions and choices of sellers, users, regulators, and others, as well as random events, that determine whether it successful as a brand (or species) and whether it proliferates.

In the evolutionary process of variation and selection, the designer is the main agent of variation. He produces new types of artifacts, after which various selection constraints in the environment determine whether they are successful. In the production of these variations, forward-looking intelligence has a large role, much greater than it has in the production of new variants in biological evolution. In contrast, the designer's forward-looking intelligence normally has a much less significant role in subsequent selection. As many product designers have found out the hard way, it is often very difficult to predict or control which products will be successful in the marketplace.

[1] It may occur that humans consciously or unconsciously select a certain mate to generate offspring with certain phenotypic properties, but this does not seem to be a major factor in mate selection. Possibly, such considerations also play a role in mate selection by animals.