THREE

THE PSYCHOLOGY OF THINKING
Embedding Artifice in Nature

We watch an ant make his laborious way across a wind- and wave-molded beach. He moves ahead, angles to the right to ease his climb up a steep dunelet, detours around a pebble, stops for a moment to exchange information with a compatriot. Thus he makes his weaving, halting way back to his home. So as not to anthropomorphize about his purposes, I sketch the path on a piece of paper. It is a sequence of irregular, angular segments—not quite a random walk, for it has an underlying sense of direction, of aiming toward a goal.

I show the unlabeled sketch to a friend. Whose path is it? An expert skier, perhaps, slaloming down a steep and somewhat rocky slope. Or a sloop, beating upwind in a channel dotted with islands or shoals. Perhaps it is a path in a more abstract space: the course of search of a student seeking the proof of a theorem in geometry.

Whoever made the path, and in whatever space, why is it not straight; why does it not aim directly from its starting point to its goal? In the case of the ant (and for that matter the others) we know the answer. He has a general sense of where home lies, but he cannot foresee all the obstacles between. He must adapt his course repeatedly to the difficulties he encounters and often detour uncrossable barriers. His horizons are very close, so that he deals with each obstacle as he comes to it; he probes for ways around or over it, without much thought for future obstacles. It is easy to trap him into deep detours.

Viewed as a geometric figure, the ant's path is irregular, complex, hard to describe. But its complexity is really a complexity in the surface of the beach, not a complexity in the ant. On that same beach another small creature with a home at the same place as the ant might well follow a very similar path.

Some years ago Grey Walter built an electromechanical "turtle" capable of exploring a surface and periodically seeking its nest, where its batteries were recharged. More recently goal-seeking automata have been under construction in several laboratories, including Professor Marvin Minsky's in Cambridge, Massachusetts. Suppose we undertook to design such an automaton with the approximate dimensions of an ant, similar means of locomotion, and comparable sensory acuity. Suppose we provided it with a few simple adaptive capabilities: when faced with a steep slope, try climbing it obliquely; when faced with an insuperable obstacle, try detouring; and so on. (Except for problems of miniaturization of components, the present state of the art would surely support such a design.) How different would its behavior be from the behavior of the ant?

These speculations suggest a hypothesis, one that could as well have been derived as corollary from our previous discussion of artificial objects:

An ant, viewed as a behaving system, is quite simple. The apparent complexity of its behavior over time is largely a reflection of the complexity of the environment in which it finds itself.

We may find this hypothesis initially plausible or implausible. It is an empirical hypothesis, to be tested by seeing whether attributing quite simple properties to the ant's adaptive system will permit us to account for its behavior in

the given or similar environments. For the reasons developed at length in the first chapter, the truth or falsity of the hypothesis should be independent of whether ants, viewed more microscopically, are simple or complex systems. At the level of cells or molecules ants are demonstrably complex, but these microscopic details of the inner environment may be largely irrelevant to the ant's behavior in relation to the outer environment. That is why an automaton, though completely different at the microscopic level, might nevertheless simulate the ant's gross behavior.

In this chapter I should like to explore this hypothesis but with the word "man" substituted for "ant."

A man, viewed as a behaving system, is quite simple. The apparent complexity of his behavior over time is largely a reflection of the complexity of the environment in which he finds himself.

Now I should like to hedge my bets a little. Instead of trying to consider the "whole man," fully equipped with glands and viscera, I should like to limit the discussion to Homo sapiens, "thinking man." I myself believe that the hypothesis holds even for the whole man, but it may be more prudent to divide the difficulties at the outset, and analyze only cognition rather than behavior in general.[1]

I should also like to hedge my bets in a second way, for a human being can store away in memory a great furniture of information that can be evoked by appropriate stimuli. Hence I would like to view this information-packed memory less as part of the organism than as part of the environment to which it adapts.

[1] I have sketched an extension of this hypothesis to phenomena of emotion and motivation in "Motivational and Emotional Controls of Cognition," *Psychological Review, 74*(1967):29–39, and to certain aspects of perception in "An Information-Processing Explanation of Some Perceptual Phenomena," *British Journal of Psychology, 58*(1967):1–12. Both papers are reprinted in my *Models of Thought,* chapters 1.3 and 6.1. Both of these areas would seem to require, however, more specification of physiological structure than is involved in the cognitive phenomena considered in this volume.

The reasons for assigning some a priori probability to the hypothesis of simplicity have already been set forth in the last two chapters. A thinking human being is an adaptive system; man's goals define the interface between his inner and outer environments, including in the latter his memory store. To the extent that he is effectively adaptive, his behavior will reflect characteristics largely of the outer environment (in the light of his goals) and will reveal only a few limiting properties of the inner environment—of the physiological machinery that enables a person to think.

I do not intend to repeat this theoretical argument at length, but rather I want to seek empirical verification for it in the realm of human thought processes. Specifically I should like to point to evidence that there are only a few "intrinsic" characteristics of the inner environment of thinking man that limit the adaptation of thought to the shape of the problem environment. All else in thinking and problem-solving behavior is artificial—is learned and is subject to improvement through the invention of improved designs and their storage in memory.