world has structure and is therefore predictable. There are patterns in the world: faces have eyes, eyes have pupils, fires are hot, gravity makes objects fall, doors open and shut, and so forth. The world is not random, nor is it homogeneous. Memory, prediction, and behavior would be meaningless if the world was without structure. All behavior, whether it is the behavior of a human, a snail, a single-cell organism, or a tree, is a means of exploiting the structure of the world for the benefit of reproduction.

Imagine a one-cell animal living in a pond. The cell has a flagellum that lets it swim. On the surface of the cell are molecules that detect the presence of nutrients. Since not all areas of the pond have the same concentration of nutrients, there is a gradual change in value, or gradient, of nutrients from one side of the cell to the other. As it swims across the pond, the cell can detect the shift. This is a simple form of structure in the world of the one-cell animal. The cell exploits its chemical awareness by swimming toward places with higher concentrations of nutrients. We could say that this simple organism is making a prediction. It is predicting that by swimming in a certain way it will find more nutrients. Is there memory involved in this prediction? Yes, there is. The memory is in the DNA of the organism. The one-cell animal did not learn, in its lifetime, how to exploit this gradient. Rather, the learning occurred over evolutionary time and is stored in the animal's DNA. If the structure of the world changed suddenly, this particular one-cell animal could not learn to adapt. It could not alter its DNA or the resulting behavior. For this species, learning can occur only through evolutionary processes over many generations.

Is this one-cell organism intelligent? Using the everyday notion of human intelligence, the answer is no. But the animal does lie at the far edge of a continuum of species that use memory and prediction to reproduce more successfully, and by that more academic measure the answer is yes. The point is not to

label some species as intelligent and others as not intelligent. Memory and prediction are used by all living things. There is just a continuum of methods and sophistication in how they do it.

Plants also use memory and prediction to exploit the structure of the world. A tree makes a prediction when it sends its roots down into the soil and its branches and leaves up toward the sky. The tree is predicting where it will find water and minerals based on the experience of its ancestors. Of course a tree doesn't think; its behavior is automatic. But the species is exploiting the structure of the world in the same way as the one-cell organism. Every plant species has a distinct set of behaviors that exploit slightly different parts of the structure of the world.

Eventually, plants evolved communication systems, based mostly on the slow release of chemical signals. If an insect damages part of a tree, the tree sends chemicals through its vascular system to other parts of the tree, which triggers a defense system, such as making toxins. Through such a communication system, the tree can exhibit slightly more complex behavior. Neurons probably evolved as a way to communicate information more quickly than a plant's vascular system. You could think of a neuron as just a cell with its own vascular appendages. At some point, instead of slowly moving chemicals along these appendages, the neuron started using electrochemical spikes, which travel much faster. In the beginning, fast synaptic transmission and simple nervous systems probably did not involve much if any learning. The name of the game was simply faster signaling.

But then, in the march of evolutionary time, something really interesting happened. Connections between neurons became modifiable. A neuron could send a signal or not send a signal, depending on what had happened recently. Behavior could now be modified within the life of an organism. The nervous system became plastic, and so did behavior. Because memories could be rapidly formed, the animal could learn the