then, however, researchers have focused primarily on semantic memory, devising theories for how semantic information is represented in memory, how it is retrieved for use, and how it is forgotten. These questions provide the basis for discussion in the next several sections.

Representation and Storage of Information

How information is represented and stored in semantic memory is a central issue in the study of long-term memory (LTM) and one that has concerned researchers for centuries. Consider the difficulty of the task. Questions must be answered such as, What is the nature of the knowledge unit that is stored in memory? How are relations among these units represented? How can we account for individual differences in memory? Is there only one kind of knowledge unit, or are visual images substantively different from verbal propositions? Try to keep these questions in mind as some of the proposed answers are presented.

Network Models of LTM. One way to conceive of long-term memory is to think of it as a sort of mental dictionary (Klatzky, 1980), but instead of words being represented alphabetically, concepts are represented according to their associations to one another. For example, if I say "black," what comes to mind? I expect you said "white," which is closely associated with *black* by virtue of being its opposite. Other kinds of associations are obviously possible. A *canary* is a kind of bird, while *has gills* is a property of fish.

Network models assume the existence of nodes in memory, which correspond to concepts, i.e., things and properties. These nodes are thought to be interconnected in a vast network structure that represents learned relationships among concepts (e.g., Collins and Quillian, 1969).

Network models have the advantage of representing individual differences among learners, because individual learning histories presumably lead to different memory networks. These models also enable predictions, which can be easily verified by the performance of learners on certain memory tasks. For example, look at the partial network shown in Figure 3.7. That memory might be structured this way can be ascertained by asking subjects to respond to sentences such as, "A bird has wings," or "A blue heron is a fish." Since the concept *bird* points to the property *has wings* (assuming this was a learned relationship), the subject should say the first sentence is true. In the case of the second sentence, however, *blue heron* and *fish* cannot be directly connected, because the search process can only proceed in the direction indicated by the arrow. Thus, this sentence must be false.

In a similar fashion, predictions can be made about the speed at which subjects should be able to verify sentences as true. For example, learners should be faster in recognizing the truth of "A blue heron has long legs" than "A blue heron is an animal." In the first case, search had to proceed across