What makes a reward act as reinforcement for one person and not for another? The answer is a bit complicated at this point, but behavior analysts emphasize each person’s past history of reinforcement. In one family, receiving high grades has resulted in many other reinforcing effects, such as praise and approval, which ultimately are related to basic reinforcers involving shelter and sustenance. Under these conditions, high grades (or the A+) have become a conditioned reinforcer for academic performance (see Chapter 10 for details). In another family, high grades have not led to other reinforcing effects, and grades do not act as reinforcement for academic behavior. One rat will work to turn a light on if the light has signaled food in the past; another rat without this experience will not work to activate the light. The reinforcing effects of the light for the rat and the grade for the student both depend on a prior history of reinforcement. The distinction between rewards and reinforcers is raised again in Chapter 4 in the section on rewards and intrinsic motivation.

Selection as a Causal Process

B. F. Skinner (1938) viewed psychology as the study of the behavior of organisms. From this point of view, psychology is a subfield of biology. The main organizing principle of contemporary biology is evolution through natural selection (Dawkins, 1996). Skinner generalized this concept to a broader principle of selection by consequences. Selection by consequences applies at three levels: (1) the selection over generations for genes related to survival and reproduction (natural or Darwinian selection); (2) the selection for behavior within the lifetime of an individual organism (selection by operant conditioning); and (3) the selection for behavior patterns (practices, traditions, rituals) of groups of human beings that endure beyond the lifetime of a single individual (cultural selection).

In all three cases, it is the consequences arranged by the environment that select for (or against) the frequency of genetic, behavioral, and cultural forms (see Chapter 14).

Selection by consequences is a form of causal explanation. In science we talk about two kinds of causation: immediate and remote. Immediate causation is the kind of mechanism studied by physics and chemistry—the “billiard ball” sort of process where we try to isolate a chain of events that directly result in some effect. For example, chemical reactions are explained by describing molecular interactions. In the study of behavior, an immediate causal explanation might refer to the physiology and biochemistry of the organism. For example, the bar pressing of a rat for food or a gambler playing roulette could each involve the release of endogenous opiates and dopamine in the hypothalamus (Shizgal & Arvanitogiannis, 2003).

In contrast, remote causation is typical of sciences like evolutionary biology, geology, and astronomy. In this case, we explain some phenomenon by pointing to remote events that made it likely. Thus, the causal explanation of a species characteristic (e.g., size, coloration, exceptional vision, etc.) involves the working of natural selection on the gene pool of the parent population. An evolutionary account of species coloration, for example, would involve showing how this characteristic improved the reproductive success of organisms in a given ecological environment. That is, natural selection for coloration explains the current frequency of the characteristic in the population.

On the behavioral level, the principle of selection by consequences is a form of explanation by remote causation called functional analysis. When a rat learns to press a lever for food, we explain the rat’s behavior by pointing to its past consequences (the function of behavior). Thus, the current frequency of bar pressing is explained by the contingency between bar pressing and food in the past. The rat’s behavior has been selected by its history of reinforcement.

Both immediate and remote causal explanations are acceptable in science. Behavior analysts have emphasized functional analysis and selection by consequences (remote causation), but are also interested in direct analysis of physiological and neurochemical processes (immediate causation). Ultimately, both types of causal explanation will provide a more complete account of learning and behavior.
Behavior analysis is becoming more involved with the scientific analysis of the brain and nervous system (neuroscience). That is, researchers who primarily study the behavior of organisms are often interested in the brain processes that participate in the regulation of behavior (see special issue on Relation of Behavior and Neuroscience (2005) in *Journal of the Experimental Analysis of Behavior, 84*, 305–667). The word *participate* is used because the brain shows **neuroplasticity**, or changes in the interconnections of neurons (nerve cells; Kandel, 2006) and glia (non-neuronal cells; Fields, 2009), as the organism interacts with the world in which it lives. That is, the brain is not a static structure that determines behavior, but a malleable organ that constantly adjusts to the behavioral requirements of everyday life or the laboratory (Draganski, Gaser, Busch, Schuierer, Bogdahn, & May, 2004; Kempermann, Gast, & Gage, 2002; for the role of learning experiences in modification of brain structure that in turn affects behavior, see Schlinger, 2004). For example, brain mechanisms (neurons or groups of neurons) obviously participate in the regulation of behavior (bar pressing) by its consequences (food). Describing how neurons assemble, code for, and respond to reinforcement is an important and exciting addition to a behavior analysis—telling us more about what happens when behavior is shaped by its effects or consequences (Fiorillo, Tobler, & Schultz, 2003).

At the practical level, knowing the reinforcement contingencies (arrangements of the environment) for lever pressing is sufficient by itself to allow us to predict and control the rat’s behavior. That is, we can get the rat to increase or decrease its lever pressing by providing or denying food reinforcement for this behavior—there is no need to look at neural systems. However, we gain a more complete account of how a rat’s behavior increases when the action of neurons (and neural systems) is combined with the analysis of behavior. For example, in some cases it may be possible to “sensitize” or “de-sensitize” a rat to the behavioral contingencies by drugs that activate or block the action of specialized neurons (e.g., Bratcher, Farmer-Dougan, Dougan, Heidenreich, & Garris, 2005). Research at the neural level could, in this way, add to the practical control or regulation of behavior by its consequences (Hollerman & Schultz, 1998).

Neural processes also may participate as immediate consequences (local contingencies) for behavior that had long-range benefits for organisms (remote contingencies, as in evolution and natural selection) (Tobler, Fiorillo, & Schultz, 2005). The so-called **neural basis of reward** involves the interrelationship of the endogenous opiate and dopamine systems (as well as other neural processes) (Fiorillo, Tobler, & Schultz, 2003). For example, rats that are food restricted and allowed to run in wheels increase running over days—up to 20,000 wheel turns. Wheel running leads to the release of neural opiates that reinforce this behavior (Pierce, 2001). If wheel running is viewed as food-related travel, one function of neural reinforcement is to promote locomotion under conditions of food scarcity. The long-range or remote contingency (travel produces food: travel → food) is supported proximally by the release of endogenous opiates (physical activity → release of endogenous opiates) that “keep the rat going” under conditions of food scarcity (e.g., famine, drought, etc.). In later chapters we shall see that this process also plays a key role in human anorexia.
The integration of the science of behavior with neuroscience (behavioral neuroscience) is a growing field of inquiry. Areas of interest include the effects of drugs on behavior (behavioral pharmacology), neural imaging and complex stimulus relations, choice and neural activity, and the brain circuitry of learning and addiction. We shall examine some of this research in subsequent chapters in sections that focus on behavior analysis and neuroscience (FOCUS ON sections) or in sections that emphasize applications (ON THE APPLIED SIDE sections).

The Evolution of Learning

When organisms were faced with unpredictable and changing environments in their evolutionary past, natural selection favored those individuals whose behavior could be conditioned. Organisms who condition are more flexible, in the sense that they can learn new requirements and relationships in the environment (see section on “Behavioral Flexibility” in Chapter 14 for recent evidence by Mery and Kawecki (2002) on the link between learning ability and improved fitness in the fruit fly, Drosophila melanogaster). Such behavioral flexibility must reflect an underlying structural change of the organism. Genes code for the anatomical and physiological characteristics of the individual. Such structural physical changes allow for different degrees of functional behavioral flexibility. Thus, differences in the structure of organisms based on genetic variation give rise to differences in the regulation of behavior. Processes of learning, like operant and respondent conditioning, lead to greater (or lesser) reproductive success. Presumably, those organisms that changed their behavior as a result of experience during their lives survived and had offspring, while those that were less flexible did not. Simply stated, this means that the capacity for learning is inherited.

The evolution of learning processes had an important consequence. Behavior that was closely tied to survival and reproduction could be influenced by experience. Specific physiological processes typically regulate behavior related to survival and reproduction. However, for behaviorally flexible organisms, this control by physiology may be modified by experiences during the lifetime of the individual. The extent of such modification depends on the amount and scope of behavioral flexibility (Baum, 1983). For example, sexual behavior is closely tied to reproductive success and is regulated by distinct physiological processes. For many species, sexual behavior is rigidly controlled by genetically driven mechanisms. In humans, however, sexual behavior is also influenced by socially mediated experiences. It is these experiences, not genes, that come to dictate when sexual intercourse will occur, how it is performed, and who can be a sexual partner. Powerful religious or social controls can make people abstain from sex. This example demonstrates that even the biologically relevant behavior of humans is partly determined by life experience.

The Biological Context of Behavior

Behavior analysts recognize and promote the importance of biology and evolution, but focus more on the interplay of the organism and its environment, which is behavior. To maintain this focus, the evolutionary history and biological status of an organism are examined as part of the context of behavior (see Morris, 1988, 1992). This contextualist view is seen in B. F. Skinner’s analysis of imprinting in a duckling:

Operant conditioning and natural selection are combined in the so-called imprinting of a newly hatched duckling. In its natural environment the young duckling moves towards its mother and follows her as she moves about. The behavior has obvious survival value. When no duck is present, the duckling