Mammalian Echolocation

Imagine a pool of water so murky that you are only able to see a few centimeters below the surface. Also imagine a clear Plexiglas sheet with a dolphin-sized opening in the middle, dividing the pool in half. At one end of the pool is an eager dolphin; at the other end is a trainer. The trainer throws a dead fish into the water, and on signal, the dolphin unhesitatingly finds its way through the murky water to the opening in the Plexiglas and then finds the fish at the other end of the pool.

Although the dolphin in this account was trained to find the fish, it relied on a sense that it shares with a few other mammals. Toothed whales, bats, and some shrews use the return echoes of high-frequency sound pulses to locate objects in their environment. This mechanism is called **echolocation.**

Zoologists have studied echolocation in bats more completely than in any other group of mammals. Italian scientist Lazzaro Spallanzani discovered in the late 1700s that blinded bats could navigate successfully at night, whereas bats with plugged ears could not. Spallanzani believed that bats used echoes of the sounds that beating wings made in echolocation. In 1938, however, ultrasonic bat cries (inaudible to humans) were electronically recorded, and their function in echolocation was described.

Insect-eating bats navigate through their caves and the night sky and locate food by echolocation. During normal cruising flight, they emit ultrasonic (100 to 20 kHz) "clicks" approximately every 50 msec. As bats detect insect prey, the number of clicks per second increases, the duration between clicks decreases, and the wavelength of the sound decreases, increasing directional precision and making small, flying insects easier to detect. On final approach, the sound becomes buzzlike, and the bat scoops up the insect with its wings or in the webbing of its hind legs.

Modifications of the bat ear and brain allow bats to perceive faint echoes of their vocalizations and to precisely determine direction and distance. Enlarged ear flaps funnel sounds toward particularly thin eardrums and sensitive ear ossicles. The auditory regions of the bat brain are large, and special neural pathways enhance a bat's ability to determine the direction of echoes.

Bats must distinguish echoes of their own cries from the cries themselves and from other noises. Leaflike folds of the nostrils direct sound emitted from the nostrils forward, rather than in all directions from the head, much like the megaphone of a cheerleader. The ears, therefore, receive little stimulation from direct vocalizations. Fat and blood sinuses surrounding the middle and inner ears reduce transmission of sound from the mouth and pharynx. Some bats temporarily turn off their hearing during sound emission by making the ear ossicles insensitive to sound waves and then turn on their hearing an instant later when the reflected sound is returning.