Exploring the Cognitive World of the Bottlenosed Dolphin
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An exceptionally large brain, a high degree of sociability, and easy trainability mark the bottlenosed dolphin (*Tursiops truncatus)* as a compelling species for study of its intellectual processes and potential. Accordingly, our long-term research program into dolphin cognition, now spanning some 30 years, with as many as 22 years of study of individual animals, has been directed toward the description and analysis of these processes and potential. The philosophy guiding this approach is that the intellectual potential of a long-lived, presumptively intelligent species, like the dolphin, is best revealed within a long-term program of intensive, special education, within a culture that values education. As these conditions surely favor the emergence of the full flower of human intellect, can comparable conditions also reveal the intellectual potential of other targeted species? To this end, we have worked intensively with different individual animals, using a broad-brush multi-level approach that includes studies of sensory processes, cognitive characteristics, and communication. These different areas of study have increased our understanding of the perceptual, cognitive, and social worlds of the dolphin.

The brain of the adult bottlenosed dolphin is about 25% heavier than the average adult human brain (Ridgway 1990). Inasmuch as larger mammals tend to have larger brains, a more meaningful metric is to compare actual brain size with that expected for the species' body size (i.e., relative brain size) (Jerison 1973). Measures of relative brain size place the bottlenosed dolphin, and two or three other closely related delphinid species, second only to the human, and well above the great apes (Marino 1998; Ridgway and Tarpley 1996). The dolphin cortex has a degree of fissurization and surface area exceeding that of the human brain, although its depth (thickness) (ca. 1.3-1.8 mm) is shallower than that of the human brain (ca. 3.0 mm) (Ridgway 1990). In addition, the size of the cerebellum relative to the total brain is significantly larger in the dolphin than in the human (Marino et al. 2000). Recent work has demonstrated that the cerebellum is involved in cognitive processing in addition to its role in motor control (Leiner et al. 1995; Fiez 1996).

Social living and social pressures may be major selection forces driving the evolution of intellect (Humphrey 1976; Herman 1980); among cetaceans, as well as among other highly social mammalian species, social living can lead to the development of new behaviors and traditions through cultural transmission mechanisms, such as imitation and teaching (Rendell and Whitehead, in press). Bottlenosed dolphins, as well as many other species of toothed whales (odontocetes), live in complexly organized social units (e.g., Conner et al. 1992). To function effectively within these units, the young dolphin must undergo extensive learning about the conventions and rules of the society, about cooperative and collaborative activities, and about the identities and even personalities of group members and associates (Herman 1991). The protracted period of development and dependence of young dolphins on their mothers and other group members allows the time and opportunity for extensive social learning to take place. Dolphins maintained in oceanariums or in research facilities can readily transfer their social awareness and responsivity to the human caregivers. If the caregivers acknowledge and give proper attention to the social nature of the dolphin, a strong interest in humans can develop that allows for a close and cooperative long-term working relationship between the two species. Under these conditions, it becomes possible to work with a dolphin for protracted periods within behavioral research or training paradigms (e.g., Defran and Pryor 1980).

At the end of the 1960s, when I began to work with bottlenosed dolphins, there was little substantive material on the cognitive abilities of this species, as might be obtained from experimental studies using the rules for scientific evidence (a few exceptions were studies by Bastian 1967; Kellogg and Rice 1966; Pryor, Haag and O'Reilly 1969). Instead, there was at times relatively unrestrained speculation about such things as dolphin language, oral traditions, and philosophies, inferred from the large brain of this species (see e.g., Lilly 1961, 1967). My