The Dolphin in History

Modern Whales, Dolphins, and Porpoises, as Challenges to Our Intelligence [*1962*]

The intelligence of whales has been the subject of speculation by writers since Ancient Greece.[1, 2] The discovery of the large brains of the Cetacea in the eighteenth century led to inevitable comparisons of these brains to those of the humans and of the lower primates. The winds of scholarly opinions concerning the whales have anciently blown strongly for high intelligence but during later centuries shifted strongly against high intelligence. At the time of Aristotle (384-322 B.C.) the dolphin, for example, was held in high esteem, and many stories of the apparently great abilities of these animals were current.[3] By the time of Plinius Secundus (A.D. 23-79) the beginning of a note of skepticism was introduced. Plinius said, "I should be ashamed to tell the story were it not that it has been written about by . . . others."[4]

[1] Plinius Secundus. *Natural History.* III, Book IX.
[2] Aristotle. *Historia Animalium.* Books I-IX.
3 Ibid.
[4] Plinius Secundus, *loc. cit.*

In the middle ages the strong influence of religious philosophy on thinking placed Man in a completely separate compartment from all other living creatures, and the accurate anatomy of the whales was neglected. This point is illustrated by Konrad Gesner's drawing of a baleen whale in the 1500's in *Historia Animalium.* It has two tubes which apparently symbolize the double blowhole of the Mystacocetae. There is no modern whale known that has such tubes sticking out of the top of his head. There is a huge eye above the angle of the jaw. All whales have the eye at or near the posterior angle of the jaw. In a print published in 1598 of the anatomy of these animals the drawing of the male organ is accurate (apparently it was measured with a walking stick), but the eye is too large and is misplaced.

It was not until the anatomical work of Vesalius and others that the biological similarities and differences of man and other mammals were pointed out. It was at this time that the investigation of man's large and complex brain began.

All through these periods intelligence and the biological brain factors seemed to be completely separated in the minds of the scholars. At the times of the Greeks and the Romans there was little, if any, link made between brain and mind. Scholars attributed man's special achievements to other factors than excellence of brain structure and its use.

After the discovery of man's complicated and complex brain and the clinical correlation between brain injury and effects on man's performance, the brain and mental factors began to be related to one another. As descriptions of man's brain became more and more exact and clinical correlations increased sufficiently in numbers, new investigations on the relationships between brain size and intelligence in *Homo sa-piens* were started. The early work is summarized by Donaldson.[5]

In the late 1700's and the early 1800's the expansion of the whaling industry offered many opportunities for examination of these interesting mammals.

One of the earliest drawings of the complex brain of one of the Cetacea is that of Gottfried Reinhold Tredira-mus in 1818. An anterior view of the brain of the common porpoise *Phocaena phocaena,* it is one of the earliest pictures showing the complexity of the fissuration and the large numbers of gyri and sulci.

By the year 1843 the size of the brain of whales was being related to the total size of the body. The very large brains of the large whales were reduced in importance by considering their weight in a ratio to the weight of the total body. This type of reasoning was culminated with a long series of quantitative measures published by Eugene Dubois *(Bulletins de la Societe d'Anthropologie de Paris,* Ser. 4, VIII [1897], 337-76).

Descriptions from those of Hunter and Tyson onwards agree that, in absolute size, the brains are as large and larger than those of man. All were agreed that the smaller whales, i.e., the dolphins and porpoises, have very large brains with relation to their body size. It was argued, therefore, with respect to the dolphin, "this creature is of more than ordinary wit and capacity." (Robert Hamilton; *The Natural History of the Ordinary Cetacea or Whales,* p. 66, in Sir William Jardine, *The Naturalist's Library,* volume 7, Edinburgh, 1843.)

Tiedemann's drawings of the brain of *Delphinus delphis* and of *Delphinus phocaena* were published by H. G. L. Reichenbach in his *Anatomia Mammalium* in 1845. They show the improved awareness of the com-

[5] Donaldson, Henry H. *The Growth of the Brain.* London: Walter Scott, 1895.

plexities of these large brains in regard to cerebral cortex, the cerebellum, and the cranial nerves. Correlations between the structure of this brain and the behavior of the animal possessing it, were (and are) woefully lacking. The only behavioral accounts were those of whalers hunting these animals. Hunters concentrate on the offensive and defensive maneuvers of the animal, and can give useful information for other kinds of evaluation of the animal's behavior and presumed intelligence.

In 1787 John Hunter, writing in the *Philosophical Transactions of the Royal Society of London* (LXXVII, 423-24), said the following: "The size of the Brain differs much in different genera of this tribe, and likewise in the proportion it bears to the bulk of the animal. In the Porpoise, I believe, it [the proportion] is largest, and perhaps in that respect comes nearest to the human . . .

"The brain is composed of cortical and medullary substances, very distinctly marked; the cortical being, in colour, like the tubular substance of a kidney; the medullary, very white. These substances are nearly in the same proportion as in the human brain . . . The thalami themselves are large; the corpora striata small; the crura of the fornix are continued along the windings of the ventricles, much as in the human subject."

Flatau and Jacobsohn in 1899 wrote, "the large brain of the Porpoise is one of the smallest in the Cetacean Order in which the organ attains to a much greater absolute size than any other."[6]

In 1902 G. Elliot Smith wrote of the brain of a species of dolphin called "Delphinus tursio" (which may be the modern T*ursiops truncatus*): "This brain is larger and correspondingly richer in sulci than that of the porpoise:

[6] Smith, G. Elliot, in Royal College of Surgeons of England, Museum, *Descriptive and Illustrated Catalogue of the Physiological Series of Comparative Anatomy*. London: Taylor and Francis, 1902, pp. 349, 351, 356.

but the structure of the two organs is essentially the same." He said further, "the brains of the Beluga and all the dolphins closely resemble that of the porpoise."

Smith summarizes the discussion of the huge size of the whale's brain. "The apparently extraordinary dimensions of the whale's brain cannot therefore be considered unusual phenomena, because this enormous extent of the cerebral cortex to receive and 'store' impressions of such vast sensory surfaces becomes a condition of survival of the animal.

"The marvelous complexity of the surface of the cerebrum is the direct result of its great size. In order, apparently, that the cerebral cortex may be efficiently nourished and at the same time be spared to as great a degree as possible the risk of vascular disturbances [such as would be produced by large vessels passing into it], its thickness does not appreciably increase in large animals. [He then quotes Dubois' figures showing that the whale's cortex is the same thickness as that of the human.] Such being the case, it naturally results that the increased bulk of cortex in large animals can only be packed by becoming thrown into increasing number of folds, separated by corresponding large number of sulci."[7]

In regard to communication between individual whales, Scammon in 1874 wrote the following: "It is said that the Cachalots [Sperm Whales] are endowed with the faculty of communicating with each other in times of danger, when miles . . . distant. If this be true, the mode of communication rests instinctively within their own contracted brains."[8] Let us not forget that Scammon was talking about the mammal with the largest

7 Ibid.

8 Scammon, Charles Melville. *The Marine Mammals of the North-Western Coast of North America, Described and Illustrated: Together with an Account of the American Whale-Fishery.* San Francisco: J. H. Carmany, 1874, p. 78.

known brain on this planet. Instinct as the sole cause of communication with a brain this size seems rather improbable. This brain is not any longer considered "contracted." Both of these statements illustrate an authoritative view of that time. If one peruses the paper by Tokuzo Kojima, "On the Brain of the Sperm Whale" (in the *Scientific Reports* of the Whales Research Institute, Tokyo, VI, 1951, 49-72), one can obtain a modern clear view of this brain. The largest one that he obtained (from a 49-foot sperm whale) was 9,200 grams. The average weight of the sixteen brains presented in his paper is 7,800 grams for average body lengths of 50 feet. (The brain weight per foot of body length varied from 118 to 187 grams per foot, averaging 157; man's ratio averages about 250 grams per foot.)

In the literature of the time of Scammon, the scholars failed to give us new information about the behavior of Cetacea. There seems to have been a distinctly ambivalent attitude towards these animals which is continued today. This point of view can be summarized as follows: "the whale is a very large animal with a brain larger than that of man. This brain is the result of the huge growth of its body. All of this large brain is needed to control a large body. Because these tasks are so demanding, there is not enough brain substance left for a high degree of intelligence to develop. Thus the large brain cannot give the degree of intellectual capability that man has."

As an example of man's attitudes to cetaceans, consider the case of the U. S. Fisheries Bureau *Economic Circular* No. 38, of November 6, 1918, by Lewis Radcliffe, entitled 'Whales and Porpoises as Food." Roy Chapman Andrews is quoted as saying that hump-backed whale meat is the best of the larger cetaceans but that porpoise and dolphin meat is even better eating than that of the larger whale. The composition of the whale meat is given as 30% protein, 6% fat, and less than 2% ash. From a hump-backed whale one obtains six tons of meat, from a Sei Whale, five tons, and from a Finback, eight tons. Directions are given to remove the connective tissue between the blubber and the muscle to avoid the oily taste. For those who are interested, the paper includes twenty-two whale meat recipes and ten porpoise meat recipes.

It can well be imagined, if we ever do communicate with whales, dolphins, or porpoises, the kind of reception that this sort of literature will receive from the cetaceans.

The limited point of view of the whales as "dumb beasts" neglects the adaptations that have taken place in non-mammalian forms with very much smaller brains but with comparable bulk of body. The 6o-foot whale shark, a plankton eater, and like the rest of the sharks a water-breather, has a bulk of body comparable to that of the larger whales. It has a large brain cavity but a very small brain in a small part of this large cavity. (It is very difficult to find the weight of these brains to compare with that of the Cetacea and other mammals.) The problem of brain weight versus body weight versus intelligence is most clearly expressed by Gerhardt von Bonin in his paper in the *Journal of General Psychology* (1937).[9] He gives a very extensive table for mammals, their brain weight, their body weight, and the values of 2 parameters for their specification. He then states, "it is clear from all that has been said above that the figures given here are nothing but a description of facts, a description which, in the mathematical sense of the term, is the best' one. It does not pretend to make any enunciation about the relation of intelligence and brain weight. For that purpose we need a much broader psychological basis than we have at present

"Former attempts to analyze the relations between body

[9] von Bonin, Gerhardt. "Brain-Weight and Body-Weight in Mammals," *Journal of General Psychology,* XVI (1937), 379-89.

weight and train weight suffer from three deficits: (i) they presuppose a correlation between intelligence and brain weight, (2) they make suppositions about the intelligence of animals which are unproven, and (3) they are based on a conception of cortical function which can no longer be considered valid . . . There is a close correlation between the logarithms of brain and body weight, and this correlation is linear. Brain weight increases as the 0.655th power of body weight. The value of the cephalization co-efficient k differs from species to species. *Whether or not this is an indication of the intelligence of animals must he left to the psychologists to answer."*

One of the problems that the whales have, as compared to, say, the large shark, is breathing air while living in the sea. This requires that these animals reach the air-water interface relatively frequently—at least every one hour and a half for the bottlenose whale *(Hyperoodon),* three-quarters of an hour for the Sperm Whale *(Physeter catadon),* and every six minutes for *Tursiops truncatus.* This puts very stringent requirements on the relationship of the whales to other events within the sea. Each whale must know where the surface of the sea is at each instant and compute his future actions so that when he does run out of air he is near the surface. He is essentially a surface-to-depth and depth-to-surface oriented animal. He must travel at high speed at times in order to recapture enough air to continue whatever he is doing under the surface. This means that he must calculate his chances of obtaining a good breath of air during rain storms and similar situations. He can be violently thrown around at the surface unless he comes up in the trough rather than at the crest of the wave. Such calculations probably require an exercise of something more than just "instinct."

Water-breathing animals, on the other hand, have no need for such calculations. If the surface gets rough, they move downward and stay there. The required maneuvers are very much simpler and the amount of computation is very much less.

This requirement for the whales implies that the information coming from every one of the senses, not just the skin, needs to be correlated very rapidly and in complex patterning to allow the animals to predict their future course safely and accurately. It also requires the use of large amounts of information from memory.

The predators of the sea, other than the whales themselves, make life in the sea rather a complex business for mammals. The very large sharks can and do attack whales, dolphins, and porpoises. At times such attacks are by overwhelming numbers of sharks on a relatively small number of dolphins. All of the older animals in our experience have at least one shark bite on them—the younger animals are protected by the older ones and most of them are not so dramatically scarred.

The whales, in turn, must track their own prey in order to obtain food. With the single known exception of *Orca,* none of their predators are air-breathers. In general, the whales' diet consists of fish, squid, or other water-breathing organisms of the sea.

A scientific assessment of the position of these animals in the competitive environment of the sea is not yet fully evaluated quantitatively. Any pronouncement of the requirements in regard to new complex adaptations to new complicated situations and hence the evaluation of intelligence of these animals at this time is premature and presumptuous. The whole issue of the meaning and the use of these large brains is still very much unknown. As I say in *Man and Dolphin* earlier in this volume, I am espousing a plea for an open-minded attitude with respect to these animals. It would be presumptuous to assume that we at the present time can know how to measure their intelligence or their intellectual capacity.

The usual behavioral criteria used in evaluation of intelligence of other animals are obviously inapplicable to a mammal living in the sea. As McBride and Hebb[10] so clearly stated, they cannot place the dolphin in any sort of intellectual comparative intelligence scale; they did not know the appropriate experimental questions to ask in order to compare the dolphins with the chimpanzees, for example. Comparing a handed-mammal with a flippered-mammal, each of which lives in an entirely separate and distinctive environment, is a very difficult intellectual task even for *Homo sapiens.*

In pursuing possible measures of intellectual and intelligent capacity, what line should one pursue? The invariants that we are seeking somehow do not seem to be as concrete as "tool-making and tool-using ability" by means of the hands which has been one of the major alleged criteria for human adaptation and success. The chimpanzee and the gorilla have the hands but they do not have the brains to back up the use of the hands. Man has both the hands and the brain. Thus we can quite simply and concretely contrast the performance of the large brains of man with his hands to the smaller brains of the primates with their hands. When we consider the whales, we seem obsessed, as it were, with the necessity of our own nature to look for an analog of the hand and the manipulative ability. May it not be better to find a more general principle than just handedness and its use?

I suggest that we think more in terms of a physiologically appropriate set of more general mechanisms which may subsume several other human functions under the same principle. We must look for abilities to develop generalized dexterity of use for certain kinds of end purposes for any or all muscular outputs from the central

10 McBride, Arthur F., and Hebb, D. O. "Behavior of the Captive Bottle-Nose Dolphin, *Tursiops truncatus," Journal of Comparative and Physiological Psychology,* XLI (1948), 111-23.

nervous system. If there is a task to be done, such as lifting a stone, whether in water or air, a given animal may turn it over with his foot, with his flipper, with his hand, with his tail, or with any other body part with which he could obtain a purchase on the stone. The end task is turning over the stone, to obtain food or whatever. It makes little difference what kind of muscular equipment he uses just so he uses it appropriately.

Let me illustrate with a more complex example seen in our own laboratory. A baby dolphin was being nursed in a small tank artificially. It apparently needed the constant attention of a human attendant. Its mother had not been caught with it. After several days it discovered that if it banged on the bottom of the tank with its flipper in a rhythmic fashion it could bring the humans from the other room. (We heard a loud thumping sound transmitted from a hydrophone in its tank.) Previous to this it attempted to bring the humans from the other room by whistling the distress call of the dolphins; unlike its mother, the humans did not respond to the whistle. In a sense this distress call is in his instinctual pattern for obtaining food and aid by other dolphins. The secondary adaptation and the new effort was that of manipulating the flipper rather than the phonation mechanism in the blowhole. Thus driven by whatever the instinctual need is, it tried different outputs from its brain and finally discovered one which brought the desired results. This ability to change the output from unsuccessful ones to successful ones seems to me to be evidence of a "higher nervous system" function. Of course in fine gradation and small differences, the same kind of pattern can be shown for smaller-brained animals. It is the seeking of a new output, not necessarily instinctually tied in, and the radicalness of the change of output, plus the relating of many of the variables to one another thus generating the new output, that seems to be the hallmark of the large brain. These problems are not single variable ones with simple cause and effect, but are simultaneous multiple variable ones.

Among the manipulable outputs (muscular groups) I would include those of respiration and phonation. The dexterous and finely differentiated use of these muscles generates all the complexities of human speech. As more of the physiology and psychology of human speech are analyzed and made part of our sciences, the sharper will be our criteria for separating man from the other animals, and from those with smaller brains. Scientific descriptions of human speech are of relatively recent origin. Scientific descriptions of the physiology of the vocal tract are anything but a closed book at the present time. The neuroanatomy and neurophysiology of speech is in a relatively primitive state of development as a science. With such a lack of knowledge of the intimate and detailed mechanisms concerned, it would be rather presumptuous to evaluate at the present time their role in the measurement and testing of intelligence and intellectual capacity.

However, these factors are important in such an evaluation and become even more important in terms of evaluating a species that is not human. Thus it is necessary, in order to evaluate the intelligence of even the dolphins, much less the whales, to know something of their abilities in the areas of phonation and other kinds of bodily gestures and manipulations and hence in their abilities to communicate with one another. It is not possible to measure accurately the intelligence of any other being than that of a human being, mainly because we do not exchange ideas through any known communication mode with such beings.

The difficulties of such understanding as we can possibly gain of the real situation of the whales in the sea and their adaptation as mammals to this particular environment, can be illustrated by their use of sonic generators for the location of their prey and of the boundaries of their container by means of the perception of echoes. As is well known, the small mammals, such as the bat, use this mechanism in air.[11] The bottle-nosed dolphin also uses this same kind of mechanism under water.[12, 13, 14] Because these animals are immersed in a medium of a density and a sound velocity comparable to the density and sound velocity of their own bodies, they can presumably use their sonar also in looking, as it were, inside one another's body.[15] The sonar view of the inside of the body of a dolphin may possibly be very instructive to other dolphins and possibly even aid in diagnosis of the causes of certain problems, especially of those of the baby by the mother. For example, their buoyancy depends upon maintaining their center of gravity below their center of buoyancy; otherwise they turn over and drown. If the baby develops gas in stomach #1, he can develop problems in his buoyancy relationship which turn him over; however, the mother dolphin can probably easily find out whether or not there is a bubble of gas in the baby's stomach by her echo ranging abilities. When she discovers such a bubble, she can then burp the baby by banging on the belly with her beak. We have seen such operations take place in our tanks. Here is another instance of the animal using a given output, coupled with the proper input, to diagnose a problem and to manipulate other outputs in the solution of that

[11] Griffin, Donald R. *Echoes of Bats and. Men.* Garden City, N.Y.: Doubleday, 1959.

[12] Ibid.

[13] John C. Lilly, *Man and Dolphin,* this volume.

[14] Kellogg, Winthrop N. *Porpoises and Sonar.* Chicago: University of Chicago Press, 1961.

[15] Lilly, op. cit.

problem. How much of this is labeled "instinctual," i.e., "unlearned," is purely a matter of intellectual taste.

In the sea it is necessary to use sonic mechanisms for sightings and recognition. If one goes into the sea one realizes that one's range of vision even under the best of circumstances is rarely beyond 100 feet and most of the time is less than that even near the brilliantly lit surface of the tropical seas. With sonic means, one's range is extended up to several miles under the best of circumstances and under the worst to a few hundred feet.

Recently we have obtained evidence that shows that the dolphins communicate most of their information in the band of frequencies extending from about i kilocycle to 100 kilocycles by means of whistles and sonic clicks.[18] However, as shown by Schevill and Lawrence, they can hear sounds at least to 120 kilocycles[17] and as shown by Kellogg can produce sounds at least to 170 kilocycles.[18] We have recently been investigating the higher frequency bands in these animals and have reliable evidence that they can hear at least to 200 kilocycles and can produce sounds to at least 200 kilocycles.[19, 20] With the proper electronic equipment one can listen to the nearer portions of the upper band and quickly determine that they can transmit in these bands

18 Lilly, John C., and Miller, Alice M. "Vocal Exchanges between Dolphins; Bottlenose Dolphins 'Talk' to Each Other with Whistles, Clicks, and a Variety of Other Noises," *Science,* CXXXIV (1961), 1873-76.

17 Schevill, William E., and Lawrence, Barbara. "Auditory Response of a Bottlenosed Porpoise, *Tursiops truncatus*, to Frequencies above 100 KC," *Journal of Experimental Zoology,* CXXIV (1953), 147-65-

18 Kellogg, op. cit.

18 Lilly, op. cit.

20 Lilly, John C. "Vocal Behavior of the Bottlenose Dolphin," *Proceedings of the American Philosophical Society,* CVI (1926), 520-29.

without the necessity of transmitting in the (lower frequency) communication band. The high frequency information is broadcast in a narrow beam off the front of the beak as was first detected by Kenneth Norris.[21]

In these bands we find that they can produce musical tones or individual clickings or hissing-like noises. An emotionally upset animal threatens other animals and humans by productions of very large amounts of energy both in the sonic communication band and in the ultrasonic bands. We have worked with an old bull of 450 pounds weight who is so old his teeth have been ground down flat. In terms of his skeleton, he is the most massive animal we have ever seen. When he is irritated, his "barks" have sizable amounts of energy from about 0.5 to at least 300 kilocycles. He is also capable of transmitting in bands between 100 to 300 kilocycles without transmitting anything in the band from 1 kilocycle to 100 kilocycles in a narrow beam straight ahead of his body. When he is upset by the activities of a younger male, they face one another and blast at one another with short barks of this sort, meanwhile "threatening" by opening their mouths.

Since they live immersed in an acoustic world quite strange to us, we have great difficulty in appreciating the full life of these animals with respect to one another and their environment. From birth they are constantly bombarded with signals from the other animals of the same species and by echoes from the environment which they can apparently use very efficiently. Their ultrasonic (to us) emissions are not merely "sonar," but are interpersonal and even emotional. These animals are not inanimate, cold pieces of sonar apparatus. They use their

[21] Norris, Kenneth S., Prescott, John H., Asa-Dorian, Paul V., and Perkins, Paul. "An Experimental Demonstration of Echo-Location Behavior in the Porpoise, *Tursiops truncatus* (Montagu)," *Biological Bulletin,* CXX (1961), 163-76.

ultrasounds and their high-pitched sounds interpersonally with fervor in everything they do.[22]

We have demonstrated that the dolphins are quite capable of using vocal outputs as a demand for further rewards or for surcease from punishment. Their ability in the vocal sphere is quite sophisticated. In addition to the ultrasonic matters mentioned above, their sonic performance, when in close contact with man, is astonishing. In 1957 I discovered their ability to produce sounds similar to our speech sounds.[23] During the last two years we have had many opportunities to pursue further observations in this area. This emerging ability seems to be an adaptation to a new environment which includes Man.[24] They quickly discover that they can obtain various kinds of rewards by making what we now call "humanoid emissions." When they make a sound which sounds similar to a human syllable or word, we express our pleasure by rewarding the animals in various ways. We have been exploring what some of these rewards are in order to elicit further such behavior under better control.

We demonstrated that, like other animals, the monkey, the rat, etc., these animals can be rewarded by stimulating the proper places in their brains.[25, 26] In a series of

[22] Lilly, John C. "Interspecies Communication," *McGraw-Hill Yearbook of Science and Technology 1962.* New York: McGraw-Hill, 1962, pp. 279-81.

[23] Lilly, John C. "Some Considerations Regarding Basic Mechanisms of Positive and Negative Types of Motivations," *American Journal of Psychiatry,* CXV (1958), 498-504.

[24] Lilly, John C. "Some Aspects of the Adaptation of the Mammals to the Ocean," in John Field, ed., *Handbook of Physiology.* Washington: American Physiological Society, 1963.

[25] Lilly, "Some Considerations Regarding Basic Mechanisms of Positive and Negative Types of Motivations," op. cit.

[26] Lilly, John C., and Miller, A. M. "Operant Conditioning of the Bottlenose Dolphin with Electrical Stimulation of the Brain,"

experiments we have been establishing the controls necessary to understanding what brain rewards mean in terms of natural physiology. We have demonstrated quite formally that rubbing the skin of these animals with our hands is a rewarding experience to them; they will seek it vocally and by body gestures and give certain kinds of performance in order to obtain this reward.

We have found that "vocal transactions" are a reward to these animals.[27, 28] (See below for human analogies in the child.) This seems to be one of the basic factors in our being able to elicit humanoid emissions. The vocal transactions are started by a human shouting some words over the water of the tank in which the animal is residing. A single word may be used or many words—it makes little difference. Eventually the animal in the tank will raise his blowhole out of water and make some sort of a humanoid emission or whistle or clicks in a delphinese fashion. If the human immediately replies with some word or words, the animal may immediately respond, the human answers, and a vocal transaction is under way. We have shown that dolphins naturally do this with one another in both their whistle and clicking spheres, and sometimes do it in the barking sphere.[29] How much of this is "instinctual" and how much is not, there is no way of knowing at the present time.

A physical analysis of such vocal transactions shows them to be formally quite as complex as the vocal transactions between human beings. In other words, the dolphin may say one word or a syllable-like emission, or many, one right after the other, as may the humans. If the human says one word, the dolphin may say one, two,

Journal of Comparative and Physiological Psychology, LV (1962), **73-79-**

[27] Lilly, *Man and Dolphin,* op. cit.

[28] Lilly, "Vocal Behavior of the Bottlenose Dolphin," op. cit.

[29] Ibid.

three, or four, and if the human says one, two, three, or four, the dolphin may say one. There is no necessary master-slave kind of relationship in the delphinic emissions.

In our early reports we gave examples which were single words which sounded like the words that the human made.[30, 31] This presentation led to misunderstandings among our scientific colleagues. It looked as if the animals were doing a slavish tape-recorder rendition of what we were doing in a fashion similar to that of a parrot or a Mynah bird. All along we have known that the dolphins did not do such a slavish job and were obviously doing a much more complicated series of actions. We are just beginning to appreciate how to analyze and what to analyze in these transactions. About 10% of these emissions sound like human speech. In other words, the dolphin is "saying" far more than we have transmitted to the scientific community to date. We hesitate to say anything more about this until we begin to understand what is going on in greater detail. We are making progress slowly.

Let me then make an appeal to you—a long appeal to your logical and rational views of man and cetaceans. Here I review the above points in more general terms, and develop a plea for a new science—a new discipline combining the best of science with the best of the humanities.

Several old questions should be revived and asked again with a new attitude, with more modern techniques of investigation and with more persistence. It may take twenty years or more to develop good answers; meanwhile the intellectual life of man will profit in the under-

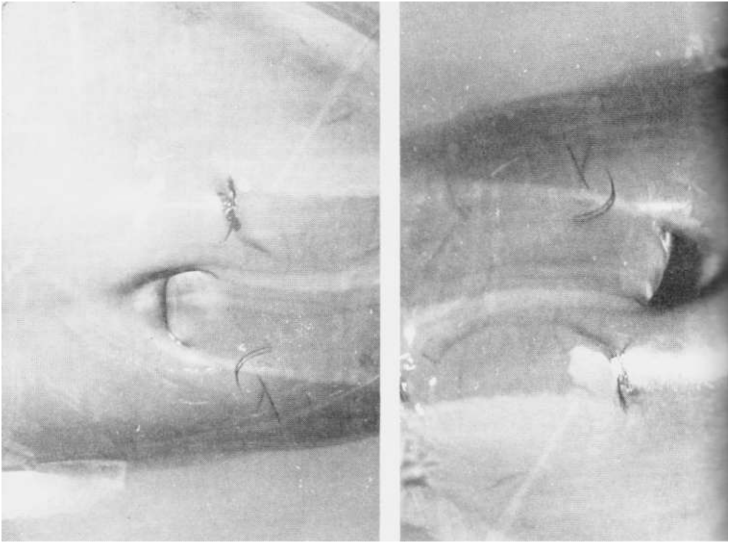
[30] Lilly, "Some Considerations Regarding Basic Mechanisms of Positive and Negative Types of Motivations," op. cit.

[31] Lilly, *Man and Dolphin*, op. cit. See *Mind of the Dolphin* and Appendix I below.

Dolphins continuing to swim in only 12" of water.

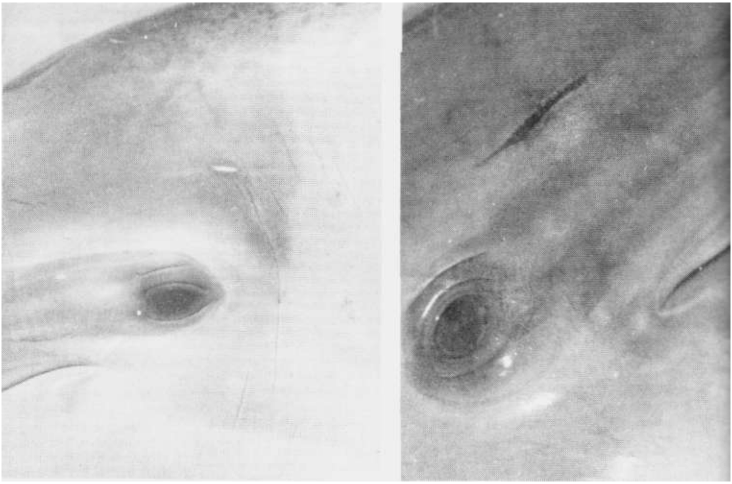
A head-on view of a dolphin in a sling showing the position of the eye in relation to the line of the mouth.

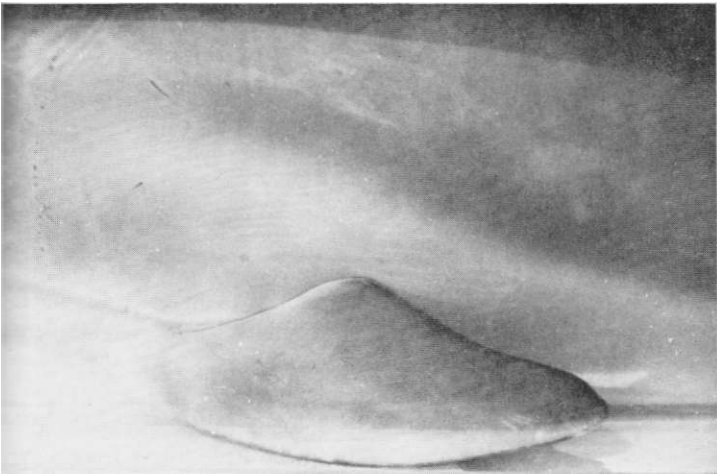
The open mouth showing the teeth, the wide "lips" and the sphincter at the back of the throat.



Left, the closed blowhole showing the crescent-shaped top of the plug. *Right,* the open blowhole during breathing.

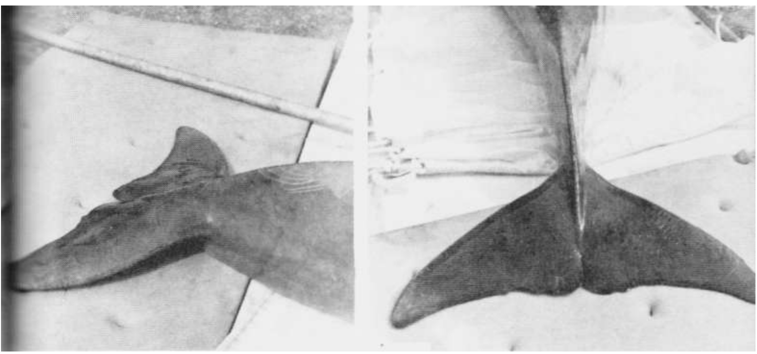
Left, Elvar's eye looking downward showing the position of the ear opening behind the eye. *Right,* Elvar's eye looking upward showing the position in relation to the back of the mouth opening.

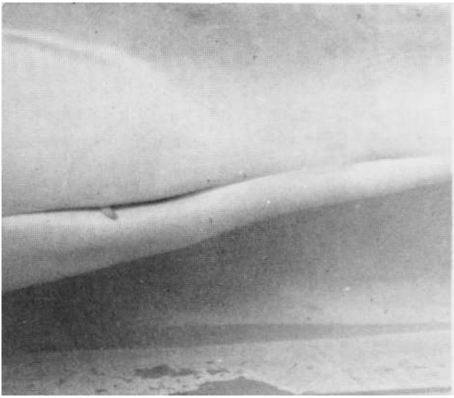


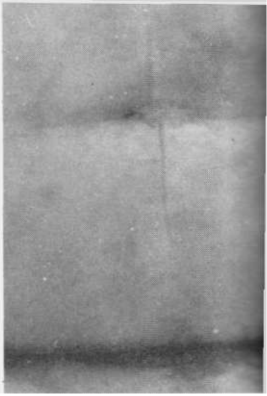


A view of the flipper used for steering and palpation.

Left, a lateral view of the flukes and peduncle, showing the keel-like structure of the peduncle. *Right,* a top view of the powerful flukes, the main propulsion mechanism of the dolphin.

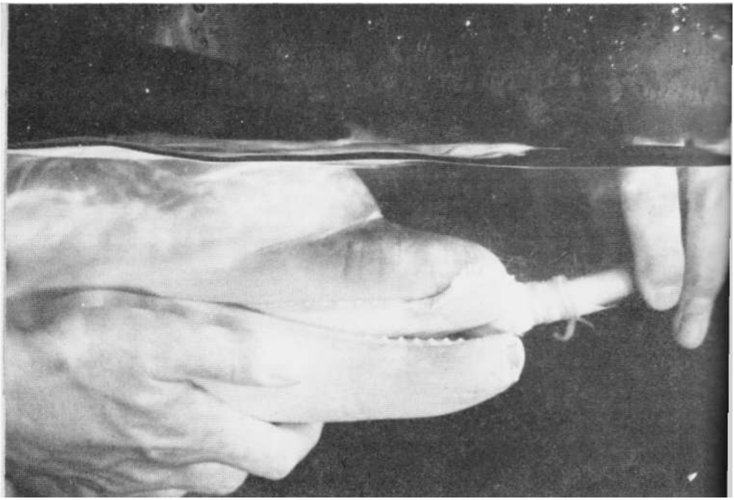






Left, the anal and genital openings in a male. In the female these two openings are combined into one long one *Right,* Elvar's umbilicus (navel).

John Lilly feeding a baby dolphin called "Baby-D." We devised a new method utilizing the little finger from a surgical glove with a hole in the tip for a nipple. The baby must be fed underwater every fifteen minutes, twenty-four hours a day. The milk contains no sugar and is a thick solution of pure fat and pure protein. This baby was caught by accident. Its mother escaped. We kept it going by the above method until it could eat fish.



taking. There is something exciting and even at times disturbing in this quest.[32] The bits and pieces may have started before historical times. In each age of man a new fragment was allowed to be recorded and passed on to subsequent generations. Each generation judged and re-judged the evidence from the older sources on the basis of its then current beliefs and on the basis of its new experiences, if any. At times good evidence was attenuated, distorted, and even destroyed in the name of the then current dogma.

Today we have similar problems; our current beliefs blind us, too. Evidence right before the eye can be distorted by the eye of the beholder quite as powerfully as it has been in previous ages of man. We can only hope that we have achieved greater insight and greater objectivity than some of our ancestors. The winds and currents of bias and prejudice blow hard and run deep in the minds of men. In one's own mind these factors are difficult to see, and when seen, difficult to attenuate and to allow for their influence. If at times I scold my own species, do not take it too personally; I am scolding myself more than you.

You can see by now that I believe that some of the answers to the quest are in our own minds. We must develop, imaginatively and humbly, numbers of alternative hypotheses to expand the testable areas of the intellect and bring to the investigation new mental instruments to test and to collect facts germane to our questions.

To ask about the intelligence of another species, we somehow first ask: how large and well-developed is its brain? Somewhat blindly we link brain size (a biological

[32] Lilly, John C. "Some Problems of Productive and Creative Scientific Research with Man and Dolphin," *Archives of General Psychiatry* (1963); also, *The Mind in the Waters,* Joan McIntire, 1974.

fact) to intelligence (a behavioral and psychological concept). We know, in the case of our own species, that if the brain fails to develop, intelligence also fails to develop.

How do we judge in our own species that intelligence develops or fails to develop? We work with the child and carefully observe its performances of common tasks and carefully measure its acquisition of speech quantitatively. We measure (among other factors) size of word vocabulary, adequacy of pronunciation, lengths of phrases and sentences, appropriateness of use, levels of abstraction achieved, and the quality of the logical processes used. We also measure speed of grasping new games with novel sets of rules and strategy; games physical and/or games verbal and vocal.

Normal mental growth patterns of human children have been measured extensively in both performance and in vocal speech acquisition. I have taken the liberty of relating these to the normal growth of brain weight of children.

Table i shows relations between age, brain weight, and speech performance, up to 23 months, 1070 grams, and the use of full sentences. By 17 years, the brain reaches and levels off at 1450 grams and the number of words, levels of abstraction, etc., are so large as to be difficult to assess.

In these processes, what are the minimum necessary but not necessarily sufficient factors?[33] On the biological side, modern theory concentrates on two factors: total numbers of neurons and the number of interconnections between them. On the psychological side, modem theory concentrates on the numbers of occurrences of reinforced contingencies experienced, the number of repetitions,

[33] Lilly, John C. "Critical Brain Size and Language," *Perspectives in Biology and Medicine* (in press).

TABLE I

THRESHOLD QUANTITIES FOR HUMAN ACQUISITION OF SPEECH: AGE AND BRAIN WEIGHT[1]

Age (months)	*Brain weight[2] (grams)*	*Speech stages[3] (first appearances')*
2	480	Responds to human voice, cooing, and vocalizes pleasure.
4	580	Vocal play. Eagerness and displeasure expressed vocally.
6	660	Imitates sounds.
9	770	First word.
11	850	Imitates syllables and words. Second word.
13	930	Vocabulary expands rapidly.
17	1,030	Names objects and pictures.
21	1,060	Combines words in speech.
23	1,070	Uses pronouns, understands prepositions, uses phrases and sentences.

[1] Lilly, John C. *Man and Dolphin: A Developing Relationship.* London: Victor Gollancz, 1962.

[2] Boston Children's Hospital data from 1,198 records, in Coppoletta, J. M., and Wolbach, S. B., "Body Length and Organ Weights of Infants and Children," *American Journal of Pathology,* IX (1933), 55-70.

[3] Summarized from McCarthy, Dorothea, "Language Develop ment in Children," in Carmichael, Leonard, ed., *Manual of Child Psychology.* New York: John Wiley, 1946, pp. 476-581.

and the number of adequate presentations from the accepted set of the consensus known as "native language," and the total numbers of sets in the stored memories at a given age. In addition, of course, is the adequate development of the transmitting and of the receiving equipment needed for speech and its ancillary behaviors.

On the biological side, modern neurology says the number of neurons in the human brain reaches maximum value before birth of about 13 billions. After this point, the increase in weight consists of increased numbers of fibers, increased connections, increased size of elements, and increased efficiency and selectivity of transmission. Thus the increase in weight of the human brain from about 400 to 1400 grams seems to be devoted to improving its internal (as well as external) communication, storage, and computation networks. It is my impression that there exist critical threshold values in the brain's growth pattern at which certain kinds of performance become possible. Complex speech acquisition seems related to brain weights of 800 to 1000 grams, but no smaller. This assumes, of course, numbers of neurons (10^{10}) and numbers of connections and opportunities for learning and time to learn commonly found with humans.

The critical psychological factors in speech acquisition are slowly being dug out and described.[34, 35] Among these the most important seem to be a continuous background of presentations to the child in rewarding circumstances of speech and its close relations to objects, actions, satisfaction of needs, and persons. Imitation of one's use of facial and vocal apparatus appears spontaneously in the happy child. The virtuosity of the child as a mimic is truly astonishing.

I am also impressed by evidence for what I call the "transactional drive." A bright child seems to seek and respond best to those persons who respond in kind, back and forth in exchanges of sounds and linked actions. For example, if one starts such a transaction with a child of

[34] Skinner, Burrhus F. *Verbal Behavior.* New York: Appleton-Century-Crofts, 1957.

[35] Lewis, Morris M. *How Children Learn to Speak.* New York: Basic Books, 1959.

22 months with a loud word, if he is ready, he may return his version of the word or a slight variant; if one replies with another variant the child replies with still a third, or even suddenly with a new word, and so on back and forth in a transactional vocal dance. Or one may reply to a child who invites such an exchange to begin. Such exchanges seem to function as rewards of themselves, and hence the name, "transactional drive." This phenomenon is more than mere mechanical slavish mimicry. It seems to aid in perfecting pronunciation, increases vocabulary, increases the bonds with other persons, serves to substitute the "consensus-dictionary" words for the private baby words, and is thus essential to learning a language of one's own species. It is thus that the child "becomes human."

As the child ages and grows, the exchanges lengthen, and the time during which each member of the dyad is quiet while the other speaks becomes longer, until finally for a half hour or so, I am lecturing and you are at least quiet, if not listening.

How does all of this relate to modern dolphins, porpoises, and whales? From the vast array of scientific facts and theories about our own species, a few of those which I feel are useful in approaching another species to evaluate its intelligence are discussed above. But before I make connections there, let us attenuate some interfering attitudes and points of view, some myths not so modem; these interfering presumptions can be stated as follows:

language.

(2) No animal is as intelligent as man.

(3) Man can adapt himself to any environment quite as well as any animal.

(4) Intelligence and intellect can be expressed only in the ways man expresses or has expressed them.

(5) All animal behavior is instinct-determined.

(6) None of man's thought and behavior is so determined.
(7) Only man thinks and plans; animals are incapable of having a mental life.
(8) Philosophy and contemplative and analytic thought are characteristic only of man, not of any animal.

All of these statements stem from ignorance and anthropocentricity. For example, who are we to say that whales, dolphins, and porpoises are to be included as "dumb beasts"? It would be far more objective and humble to tell the truth—we don't know about these animals because we haven't "been there yet." We have not lived in the sea, naked and alone, or even in mobile groups, without steel containers to keep out the sea itself. For purposes of discussion let us make the following assumptions which push counter to the current of bias running deep among us:

(1) Man has not yet been willing to investigate the possibility of another intelligent species.
(2) Whales, dolphins, and porpoises are assumed to be "dumb beasts" with little or no evidence for this presumption.
(3) We do not yet know very much about these animals—their necessities, their intelligences, their lives, the possibility of their communications.
(4) It is possible for man to investigate these matters objectively with courage and perseverance.
(5) To properly evaluate whales, dolphins, porpoises, we must use everything we have intellectually, all available knowledge, *humanistic* as well as *scientific.*

Our best knowledge of ourselves as a species, as humans, is in the humanities and in the budding, growing sciences of man. In pursuit of understanding of the whales, dolphins, and porpoises, we need, at least at the beginning, a large view which is in the human sciences and in the humanities. The sciences of animals are necessarily restrictive in their view, and hence not yet applicable to our problems.

The Dolphin in History

The history of the animal sciences shows that they have had grave difficulties with the fact that the observers are present and human. These sciences, like physics, chemistry, and biology, play the game as if the human observer were not there and the systems were isolated from man. This is fine strategy for "man-less nature" studies and quite appropriate for such studies.

However, I submit to you another view, for a science of man and animal, their relationships to one another. Modern man and modem dolphin and whale may be best investigated in the framework of a new science one might call "anthropo-zoology" or "zoo-anthropology." This science is a deep study of man, of the animal, of their mutual relations, present and potential. In this discipline scientists encourage close relations with the animal, and study the developing relation between man and so-called "beast."

Since 1960 in the Communication Research Institute[36] we have been pursuing an investigative path in this new science with the pair "man and bottle-nosed dolphin." We have encouraged and pursued studies in classical sciences such as neurophysiology, animal psychology, anatomy, biophysics, and zoology. We have also initiated and pursued this new science of the man and dolphin relation; these "homo-delphic" studies, if you will, are triply demanding: we must not only know our animal objectively but we must know man objectively, and ourselves subjectively. We cannot fight shy of involving

[36] Support for the program of the Communication Research Institute, 3430 Main Highway, Coconut Grove, Miami 33, Florida, is from the National Institute of Mental Health and the National Institute of Neurological Diseases and Blindness of the National Institutes of Health; from the Coyle Foundation; from the Office of Naval Research; from the U. S. Air Force Office of Scientific Research; and from private gifts and contributions to the Communication Research Institute.

ourselves in the investigation as objects also. In this science man, and hence one's own self, are part of the system under investigation. This is not an easy discipline. One must guard quite as rigorously (or even more so) against the pitfalls of wishful thinking and sensational fantasy as in other scientific endeavors. This field requires a self-candor, an inner honesty, and a humility quite difficult to acquire. But I maintain that good science can be done here, that the field is a proper one for properly trained and properly motivated investigators.