



Animal Intelligence

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Chapter 1

Animal Cognition

Animal cognition is the title given to the study of the mental capacities of non-human animals. It has developed out of comparative psychology, but has also been strongly influenced by the approach of ethology, behavioral ecology, and evolutionary psychology. The alternative name cognitive ethology is therefore sometimes used; and much of what used to be considered under the title of **animal intelligence** is now thought of under this heading.

In practice, animal cognition mostly concerns mammals, especially primates, cetaceans and elephants, besides canidae, felidae and rodents, but research also extends to non-mammalian vertebrates such as birds including parrots, corvids, and pigeons, as well as lizards and fish, even to non-vertebrates such as cephalopods.

Historical background

For most of the twentieth century, the dominant approach to animal psychology was to use experiments on intelligence in animals to uncover simple learning processes (such as classical conditioning and operant conditioning) that might then account for the apparently more complex intellectual abilities of humans. This approach is well summarized in the mid-century book by Hilgard (1958), but its reductionist philosophy was combined with a strongly behaviorist methodology, in which overt behavior was taken as the only valid data for the study of psychology, and in its more extreme forms (the radical behaviorism of B. F. Skinner and his experimental analysis of behavior) behavior was taken as the only topic of interest. In effect, the mental processes that humans experience in themselves were viewed as epiphenomena (see, for example, Skinner, 1969).

The success of cognitive psychology in addressing human mental processes, which began in the late 1950s and was proclaimed by Neisser (1967), led to a re-evaluation of the research paradigm, and researchers began to address animal mental processes from the

opposite direction, by taking what is known about human mental processes and looking for evidence of comparable processes in other species. In a sense this was a return to the approach of Darwin's protégé George Romanes (e.g. 1886), arguably the first comparative psychologist of the modern era. However, whereas Romanes relied heavily on anecdote and an anthropomorphic projection of human capacities onto other species, modern researchers in animal cognition are in most cases firmly behaviorist in methodology, even though they differ sharply from the behaviorist philosophy.

There are some exceptions to the rule of behaviorist methodology, such as John Lilly and, some would argue, Donald Griffin (e.g. 1992), who have been prepared to take a strong position that other animals do have minds and that humans should approach the study of their cognition accordingly. However, their claims have not found wide acceptance in the scientific community, though they have attracted an enthusiastic following among lay people.

The development of animal cognition was also strongly influenced by:

- increased use of and interest in primates (and also cetaceans) rather than the rats and pigeons that had become the classic species of the comparative psychology laboratory, and by developments within primatology;
- advancing knowledge of animals' behavior in their natural environments through studies in ethology, sociobiology and behavioral ecology; such studies often showed that animals needed certain cognitive abilities in order to adapt to their ecological niche (as for example in studies of caching birds such as Clark's Nutcracker,) or appeared to use cognitive abilities under natural conditions (for example in Jane Goodall's studies of chimpanzees);
- one or two high profile projects, in particular Allen and Beatrice Gardner's Washoe project in which a chimpanzee learned at least some elements of American Sign Language.
- advancing understanding of brain function through work in physiological psychology and cognitive neuropsychology

This account of the history of the study of animal cognition is inevitably oversimplified. From Romanes on, there have always been comparative psychologists who have been more or less cognitively inclined: obvious examples are Wolfgang Köhler, famous for his studies of insight in chimpanzees, and Edward C. Tolman, who introduced into psychology, as an explanation of the behavior of rats in mazes, two ideas that have been immensely influential in human cognitive psychology - the cognitive map and the idea of decision-making in risky choice according to expected value.

Methods

Research in animal cognition continues to use some of the established research techniques of comparative psychology and the experimental analysis of behavior, such as mazes and Skinner boxes, though it employs them in new varieties (such as the 8-arm maze and Morris water maze that have been used in many studies of spatial memory) and

in new ways. However, it complements those with observation of animals in their natural environments, or quasi-natural environments and also with field experiments.

It has also been characterized by a number of very long term projects, such as the Washoe project and other ape-language experiments (e.g. project Nim), Irene Pepperberg's extended series of studies with the African Gray Parrot Alex, Louis Herman's work with bottlenosed dolphins, and studies of long-term memory in pigeons in which birds were shown to remember pictures for periods of several years. Some cognitive research also requires the management of animal behavior, and the use of operant conditioning to facilitate animal training. In general, the conclusion of concept formation in an animal requires a generalization test where the animal responds appropriately to a novel stimulus to which associative learning cannot explain the response behavior.

Some researchers have made effective use of a Piagetian methodology, taking tasks which human children are known to master at different stages of development, and investigating which of them can be performed by particular species. Others have been inspired by concerns for animal welfare and the management of domestic species: for example Temple Grandin has harnessed her unique expertise in animal welfare and the ethical treatment of farm livestock to highlight underlying similarities between humans and other animals.

Research questions



The common Chimpanzee can use tools. This chimpanzee is using a stick in order to get food.

Given the broad program of animal cognition, of looking for the animal analogs of human cognitive processes, the areas of study in animal cognition follow more or less from those in human cognitive psychology. However, progress in the different areas has been variable. Among the fields of interest are:

Attention

Research has focused on animals' ability to distribute attention between different aspects of a stimulus, and on visual search. As in humans, it appears that sharing attention between stimulus features reduces the capacity to detect any one of them, though there are some ecologically relevant visual search tasks at which particular species show remarkable abilities (for example, pigeons have an extraordinary capacity to pick out grain from substrate).

Categorization

Following pioneering research by Richard Herrnstein, there has been a mass of research on birds' ability to discriminate between categories of stimuli, including the kinds of ill-defined category that are used in everyday human speech. Birds have been found to learn this kind of task easily, and to transfer correct responses readily to new instances of the categories.

It has also been found that rhesus monkeys understand same-different relationships, easily form categories based on prototype theory, and may even have some capacity for rule-based learning.

Memory

The categories that have been developed to analyze human memory (short term memory, long term memory, working memory) have been applied to the study of animal memory, and some of the phenomena characteristic of human short term memory (e.g. the serial position effect) have been detected in animals, particularly monkeys. However most progress has been made in the analysis of spatial memory, partly in relation to studies of the physiological basis of spatial memory and the role of the hippocampus, and partly in relation to scatter-hoarder animals such as Clark's Nutcracker, certain jays, tits and certain squirrels, whose ecological niches require them to remember the locations of thousands of caches, often following radical changes in the environment.

Spatial cognition

The ability to properly navigate and search through the environment is a critical task for many animals. Research in this area (Brown & Cook, 2006) has focused on such diffuse

topics as landmark and beacon use by ants and bees, the encoding and use of geometric properties of the environment by pigeons, and the ability of rats to represent a spatial pattern in either radial arm mazes or pole box mazes. Sometimes included under the envelope of spatial cognition is work in humans and other animals in visual search tasks, which aim to experimentally address questions about searching through one's environment for a particular object.

Tool and weapon use

Some species, such as the Woodpecker Finch of the Galapagos Islands, use particular tools as an essential part of their foraging behavior. However, these behaviors are often quite inflexible and cannot be applied effectively in new situations. Several species have now been shown to be capable of more flexible tool use. A well known example is Jane Goodall's observation of chimpanzees "fishing" for termites in their natural environment, and captive great apes are often observed to use tools effectively; several species of corvids have also been trained to use tools in controlled experiments, or use bread crumbs for bait-fishing .

Research in 2007 shows that chimpanzees in the Fongoli savannah sharpen sticks to use as spears when hunting, considered the first evidence of systematic use of weapons in a species other than humans.

Some cephalopods are known to use coconut shells for protection or camouflage.

Reasoning and problem solving

Closely related to tool use is the study of reasoning and problem solving. It has been observed that the manner in which chimpanzees solve problems, such as that of retrieving bananas positioned out of reach, is not through trial-and-error. Instead, they were observed to proceed in a manner that was "unwaveringly purposeful."

It is clear that animals of quite a range of species are capable of solving a range of problems that are argued to involve abstract reasoning; modern research has tended to show that the performances of Wolfgang Köhler's chimpanzees, who could achieve spontaneous solutions to problems without training, were by no means unique to that species, and that apparently similar behavior can be found in animals usually thought of as much less intelligent, if appropriate training is given. Causal reasoning has also been observed in rooks and New Caledonian crows.

Language

The modeling of human language in animals is known as animal language research. In addition to the ape-language experiments mentioned above, there have also been more or less successful attempts to teach language or language-like behavior to some non-primate species, including parrots and Great Spotted Woodpeckers. Louis Herman published research on artificial language comprehension in the bottlenosed dolphin using cognitive

research methods at the height of the skepticism produced by Herbert Terrace's criticism of chimpanzee language experiments through his own results with the animal Nim Chimpsky. In particular, the focus on the *comprehension* mode only allowed cognitive methods of utilizing blinded observers to grade the animals' gross physical behavior, rather than trying to interpret putative language *production*. Herman's results (Herman, Richards, & Wolz, 1984) were published in the journal *Cognition*, regarding work on the dolphins Akeakamai and Phoenix. All such research has been controversial among cognitive linguists.

Consciousness

The sense in which animals can be said to have consciousness or a self-concept has been hotly debated; it is often referred to as the debate over animal minds. The best known research technique in this area is the mirror test devised by Gordon G. Gallup, in which an animal's skin is marked in some way while it is asleep or sedated, and it is then allowed to see its reflection in a mirror; if the animal spontaneously directs grooming behavior towards the mark, that is taken as an indication that it is aware of itself. Self-awareness, by this criterion, has been reported for chimpanzees and also for other great apes, the European Magpie, some cetaceans and a solitary elephant, but not for monkeys. The mirror test has attracted controversy among some researchers because it is entirely focused on vision, the primary sense in humans, while other species rely more heavily on other senses such as the olfactory sense in dogs.

It has been suggested that metacognition in some animals provides some evidence for cognitive self-awareness. A dolphin, the great apes, and rhesus monkeys have demonstrated the ability to monitor their own mental states and use an "I don't know" response to avoid answering difficult questions. These species might also be aware of the strength of their memories. Unlike the mirror test, which relies primarily on body images and bodily self-awareness, uncertainty monitoring paradigms are focused on the kinds of mental states that might be linked to mental self-awareness.

A different approach to determine whether a non-human animal is conscious derives from passive speech research with a macaw. Some researchers propose that by passively listening to an animal's voluntary speech, it is possible to learn about the thoughts of another creature and to determine that the speaker is conscious. This type of research was originally used to investigate a child's crib speech by Weir (1962) and in investigations of early speech in children by Greenfield and others (1976). With speech-capable birds, the methods of passive-speech research open a new avenue for investigation.

Mathematics

Some animals are capable of distinguishing between different amounts and rudimentary counting. Elephants have been known to perform simple arithmetic and rhesus monkeys can count. Ants are able to use quantitative values and transmit this information. For instance, ants of several species are able to estimate quite precisely numbers of encounters with members of other colonies on their feeding territories. Young

chimpanzees have outperformed human college students in tasks requiring remembering numbers. Pigeons have been shown to outperform humans on the Monty Hall problem, a probability puzzle.

Cognitive faculty by species

Some animals such as great apes, crows, dolphins, dogs, elephants, cats, pigs, rats, and parrots are still typically thought by laymen as intelligent in ways that some other species of animal are not. For example, crows are attributed with human-like intelligence in the folklore of many cultures. A number of recent survey studies have demonstrated the consistency of these rankings between people in a given culture and indeed to a considerable extent across cultures.

A common image is the *scala naturae*, the ladder of nature on which animals of different species occupy successively higher rungs, with humans typically at the top.

A more fruitful approach has been to recognize that different animals may have different kinds of cognitive processes, which are better understood in terms of the ways in which they are cognitively adapted to their different ecological niches, than by positing any kind of hierarchy.

One question that can be asked coherently is how far different species are intelligent in the same ways as humans are, i.e., are their cognitive processes similar to ours. Not surprisingly, our closest biological relatives, the great apes, tend to do best on such an assessment. Among the birds, corvids and parrots have typically been found to perform well. Despite ambitious claims, evidence of unusually high human-like intelligence among cetaceans is patchy, partly because the cost and difficulty of carrying out research with marine mammals mean that experiments frequently suffer from small sample sizes and inadequate controls and replication. Octopuses have also been shown to exhibit a number of higher-level skills such as tool use, but the amount of research on cephalopod intelligence is still limited.

Chapter 2

Tool use by Animals



Tool use by a Gorilla



An adult gorilla, possibly using a stick to gauge the depth of water



A chimpanzee gathering food with a stick

Tools are used by some animals, particularly primates, to perform simple tasks such as getting food or grooming. Originally thought to be a skill only possessed by humans, tool use requires some level of intelligence. Primates have been observed exploiting sticks and stones to accomplish tasks. Numerous bird species have also been noted as capable of using tools. The behaviour has also been observed in dolphins, elephants, otters, birds and octopi.

Opposable thumbs are a benefit in tool use, though creatures without hands have managed to use other body parts to their advantage, notably the mouth.

Types of tools

Key to identifying tool use is defining what constitutes a tool. Researchers of animal behavior have arrived at different formulations.

An object that has been modified to fit a purpose' or 'An inanimate object that one uses or modifies in some way to cause a change in the environment, thereby facilitating ones achievement of a target goal'.

—Hauser, 2000

the use of physical objects other than the animal's own body or appendages as a means to extend the physical influence realized by the animal

—Jones and Kamil, 1973

an object carried or maintained for future use

—Finn, Tregenza, and Norman, 2009.

The lack of a unique and sharp definition makes it difficult to identify many animal behaviours.

Uses

Tool use implies an animal has knowledge of the relationship between objects and their effects.

If an object is placed out of reach on a towel that itself is in reach, dogs, cats, and children will pull the towel to bring the object closer to them. But does this show knowledge about the nature of the world (declarative memory) or recall of rules already learnt (procedural)?

- Sticks can be used to break into termite nests for food or even to fight rivals. They are sometimes used for grooming.
- Stones can be used, again, to fight rivals. However, they may also be used to carve bits of wood by more intelligent animals.

Some species, such as the Woodpecker Finch of the Galapagos Islands, use particular tools as an essential part of their foraging behavior. However, these behaviors are often quite inflexible and cannot be applied effectively in new situations. Several species have now been shown to be capable of more flexible tool use. A well known example is Jane Goodall's observation of chimpanzees "fishing" for termites in their natural environment, and captive great apes are often observed to use tools effectively; several species of corvids have also been trained to use tools in controlled experiments, or use bread crumbs for bait-fishing.

Tool use by specific groups of animals

Primates

The animals that make the widest use of tools are humans, who have developed mechanical, electric and electronic tools for multiple purposes, far in advance of even the most advanced non-human animals.

Research in 2007 shows that chimpanzees in the Fongoli savanna sharpen sticks to use as spears when hunting, considered the first evidence of systematic use of weapons in a species other than humans. It has also been observed in the 1970s that some chimpanzees/bonobos use sticks as probes to collect ants and termites. Also they have been observed cutting down the stick with their fingers and teeth so that it can fit into a

hole in the ants' nest. They have even been observed using two tools, a stick to dig into the ant nest and a 'brush' made from grass stems with their teeth to collect the ants.

In West Africa chimpanzees have been observed banging nuts with a stone in order to crack them. Some troops use another stone whilst others use wooden clubs (heavy sticks). In one troop of chimpanzees it was observed that a female was using a stick to break into a bee hive to acquire honey. In an experiment a group of chimpanzees were presented with a model leopard with a moving head. There was soon commotion as leopards are one of the chimpanzees' predators. They were then observed clubbing the model with heavy quarterstaffs (fallen trees and/or branches). They continued doing this until the moving head had fallen off. Both bonobos and chimpanzees have also been observed making "sponges" out of leaves and moss that suck up water and are used as grooming tools.

Gorillas have been observed to use sticks to measure the depth of water and as "walking sticks" to support their posture when crossing deeper water (shown above).

Orangutans have also been observed to use sticks to measure the depth of water. It has also been observed that Orangutans in Sumatra use sticks to acquire seeds from a certain fruit. This is because the lining of the inside of the fruit has hairs that sting. On the island of Kaja a male Orangutan was observed using a pole to acquire fish from a net after observing local humans spear fishing.

Tool use has been observed in capuchin monkeys both in captivity and in their natural environments. In a captive environment, capuchins readily insert a stick into a tube containing viscous food that clings to the stick, which they then extract and lick. Capuchins also use a stick to push food from the center of a tube retrieving the food when it reaches the far end and as a rake to sweep objects or food toward themselves .

Wild capuchin monkeys in many areas use stone hammers and anvils to crack nuts and encased seeds. They transport stones and nuts to an anvil for this purpose. Capuchins also use stones to excavate tubers and sticks to flush prey from inside rock crevices.



A Bonobo using a stick to 'fish' for termites in San Diego Zoo



Stage 2



Stage 3



Extracting the insects

Birds



An Egyptian vulture in flight

Many birds have been shown as capable of using tools. By Jones and Kamil's definition above, an Egyptian vulture dropping a bone on a rock would not be using a tool since the rock cannot be seen as an extension of the body. However the use of a rock manipulated using the beak to crack an ostrich egg would qualify the Egyptian vulture as a tool user. Many other species, including parrots, corvids and a range of passerines, have been noted as tool users.

New Caledonian Crows have been observed in the wild to use stick tools with their beaks to extract insects from logs. While young birds in the wild normally learn this technique from elders, a laboratory crow named "Betty" improvised a hooked tool from a wire with no prior experience. The Woodpecker Finch from the Galapagos Islands also uses simple stick tools to assist it in obtaining food. In captivity, a young Cactus Finch learned to imitate this behaviour by watching a Woodpecker Finch in an adjacent cage. Crows in urban Japan have innovated a technique to crack hard-shelled nuts by dropping them onto cross walks and letting them be run over and cracked by cars. They then retrieve the cracked nuts when the cars are stopped at the red light. In some towns in America, the crows would drop the walnuts onto busy streets and hope the cars would crack the nuts. Striated Herons (*Butorides striatus*) and Hooded Crows (*Corvus cornix*) use bait to catch fish.



A sea otter can be seen here using a rock to break open a shell.

Seagulls have been known to drop live oyster shells on paved and hard surfaces so that cars can drive over them and break the shell. So many get dropped that it is hard to drive down pavements safely near waterways. Certain species (e.g. the Herring Gull) have exhibited tool use behavior, using pieces of bread as bait with which to catch goldfish, for example.

Common ravens are one of only a few species who make their own toys. They have been observed breaking off twigs to play with socially.

Cetaceans

As of 2005, scientists have observed limited groups of Bottlenose Dolphins around the Australian Pacific using a basic tool. When searching for food on the sea floor, many of these dolphins were seen tearing off pieces of sponge and wrapping them around their "bottle nose" to prevent abrasions.

Dolphins are often seen engaging in playful behavior and create tools to use for entertainment. They have been observed to blow bubbles which they form into rings to play with. After creating the bubble ring, a dolphin will use its nose and body to maintain the shape of the bubble and keep it from floating to the surface.

Elephants



Elephants in a reserve

Elephants show a remarkable ability to use tools, despite having no hands. Instead, they use their trunk much like one would an arm. Elephants have been observed digging holes to drink water and then ripping bark from a tree, chewing it into the shape of a ball, filling in the hole and covering over it with sand to avoid evaporation. The elephant later went back to this spot for a drink. They also often use branches to swat flies or scratch themselves. Elephants have also been known to drop very large rocks onto an electric fence to either ruin the fence or cut off the electricity.

Mustelids

Sea otters have been observed using stones to hammer abalone shells off the rocks. They hammer at a rate of 45 hits in 15 seconds or 180 rpm, and do it in two-three dives.

Veined octopus



A small (4-5 cm diameter) individual using a nut shell and clam shell as shelter.

As of 2009, the octopus is the only invertebrate animal which has been conclusively shown to use tools. At least four specimens of the Veined Octopus (*Amphioctopus marginatus*) have been witnessed retrieving discarded coconut shells, manipulating them, transporting them some distance, stacking them and then reassembling them to use as a shelter. This discovery was documented in the journal *Current Biology* and has been filmed on video.

Most hermit crabs use discarded shells of other species for habitation and other crabs choose sea anemones to cultivate on their carapaces as camouflage; numerous insects use rocks, sand, leaves and so on as building materials, however none of this is classified as tool use.

Chapter 3

Talking Animal

A **talking animal** or **speaking animal** refers to any form of non-human animal which can produce sounds (or gestures) resembling those of a human language. Many species or groups of animals have developed forms of Animal Communication Systems which, to some, can look like a non-verbal language although it is not due to a lack of grammar, syntax, recursion, and displacement. Studies in animal cognition have been arguably successful in teaching some animals speech or sign, similar to but not actually sign language with Koko the gorilla. Koko was unable, however, to break-away from the here-and-now (displacement) which is just one of the many hallmarks of language Koko was unable to achieve.

A very similar perspective of study is talking animals in fiction.

On imitation and understanding



Clever Hans performs

The term may have a nearly literal meaning, by referring to animals which can imitate human speech, though not necessarily possessing an understanding of what they may be mimicking. The most common example of this would be parrots, many of which repeat many things nonsensically through exposure. It is an anthropomorphism to call this human speech, as it has no semantic grounding.

Clever Hans was a horse that was claimed to have been able to perform arithmetic and other intellectual tasks. After formal investigation in 1907, psychologist Oskar Pfungst demonstrated that the horse was not actually performing these mental tasks, but was watching the reaction of his human observers. The horse was responding directly to involuntary cues in the body language of the human trainer, who had the faculties to solve each problem, with the trainer unaware that he was providing such cues.

On formality of animal language

A "formal language" requires a communication with a syntax as well as semantics. It is not simply sufficient for one to communicate information, or even use symbology to communicate ideas. It has yet to be demonstrated that any animal species has developed a formal language, or been able to learn a formal language.

Researchers have attempted to teach great apes (Gorillas, Chimpanzees, and Bonobos) spoken language with poor results, and sign language with significantly better results. However, even the best communicating great ape has shown an inability to grasp the idea of syntax and grammar, instead communicating at best at the same level as a pidgin language in Humans. They are expressive and communicative, but lack the formality that remains such a rarity in human speech.

Reported cases by species

Birds

Research done by Dr. Irene Pepperberg strongly suggests that parrots are capable of speaking in context and with intentional meaning. Pepperberg's star pupil, Alex the African Grey Parrot, had demonstrated the ability to assemble words out of letters—in other words, to read and spell.

Dogs

- Odie, the talking pug that will say a convincing "I love you" on demand has made appearances on Letterman and on The Montel Show and on AOL's "T.V. top 5".
- Paranormal researcher Charles Fort wrote in his book *Wild Talents* (1932) of several alleged cases of dogs that could speak English. Fort took the stories from contemporary newspaper counts, but they are unverifiable at this late date.
- Internet phenomenon, Mishka the talking Husky, has been trained to say certain phrases, most notably "I love you", and has videos of her saying phrases like "Hello", "NOOOOO", and also has learned to sing through the help of an iPad.

Cats

- A talking cat called Cingene (Gypsy) made Turkish television news on March 20, 1993. The two year old black cat managed to say at least seven words on television.
- A more recent Internet phenomenon is the case of a cat who was videotaped speaking recognizable human words and phrases such as "Oh my dog," "Oh Don piano", and "All the live long day." Footage of this cat, nicknamed "Oh Long Johnson" from one of the phrases spoken, was featured on *America's Funniest Home Videos* in 1998, and a longer version of the clip (which revealed the animal was speaking to another cat) was later aired in the UK. Clips from this video are prevalent on YouTube.



Tiggy the talking cat at home

- Another recent Internet phenomenon is the cat named Tiggy. Tiggy the Talking Cat (1990 - June 23rd 2010) was a unique cat who made a unique talking like noise. Tiggy is from Grimsby, England and was born in 1990; she died on Wednesday 23rd June 2010 at the age of 20.

Tiggy started making this strange noise at around the age of 8 and would only make it when she was alone and out of sight. After years of hearing the noise and never seeing it being made, in May 2007 out of curiosity as to what Tiggy looked like when making this noise (and also to show it to friends who didn't believe the cat could talk) her owners set up a video camera and left it on record in a spot where Tiggy regularly "spoke", eventually footage was captured of Tiggy sitting in the hallway making the noise which sounded like "Hello" four times. This video was uploaded to youtube and was the first ever Tiggy video. In the first Tiggy video she was quite a distance from the camera so the owners tried again, the second attempt was a great success with Tiggy walking up to the camera and talking for around 20 seconds. The video captured the second time was also uploaded to YouTube along with the first video and it became a huge hit acquiring millions of views on YouTube turning Tiggy into an internet celebrity. A further video was then filmed in the same house and uploaded to Youtube in June, no more videos of tiggy appeared on YouTube until August 2009 when videos of Tiggy playing and talking were uploaded. Footage of Tiggy has made its way on to several TV Shows in Both the USA and the U.K. Tiggy's first T.V appearance was in the U.K. on channel 4's Richard and Judy show during the "funny five" segment of the show which consisted of 5 funny

videos from the internet being nominated by a different celebrity guest each week, viewers then voted for their favorite online. Tiggys won the Funny Five competition for the 2007 series of the show and the crew visited Tiggys in her home and presented her with a plaque signed by presenters Richard and Judy, it was Tiggys appearance on this show which helped to make her popularity on YouTube so large with her being featured on the main YouTube page due to the huge amount of views the TV appearances caused. Tiggys has then gone on to appear on a number of shows all over the world including: CBBC's Chute, BBC's Lenny Henry.tv, America's County Fried Home Videos, The Ellen DeGeneres and various shows on Animal Planet.

- Miles v. City Council of Augusta, Georgia

Other

- Hoover, a harbor seal that would vocally repeat common phrases he heard around his exhibit at the New England Aquarium, including his name. He appeared in publications like *Reader's Digest* and *The New Yorker* and television programs like *Good Morning America*.
- Gef the talking mongoose was an alleged talking animal who inhabited a small house on the Isle of Man, off the coast of Great Britain. Opinion is divided on whether Gef was a poltergeist, a strange animal or cryptid, a hoax, or something else. Most doubt the case happened at all as told.
- Batyr (1969–1993), an elephant from Kazakhstan, was widely published as having a vocabulary of more than 20 phrases. Recordings of Batyr saying "Batyr is good", "Batyr is hungry" and using words such as "drink" and "give" was played on Kazakh state radio in 1980.
- Kosik (1990—), an elephant able to imitate some Korean words

Chapter 4

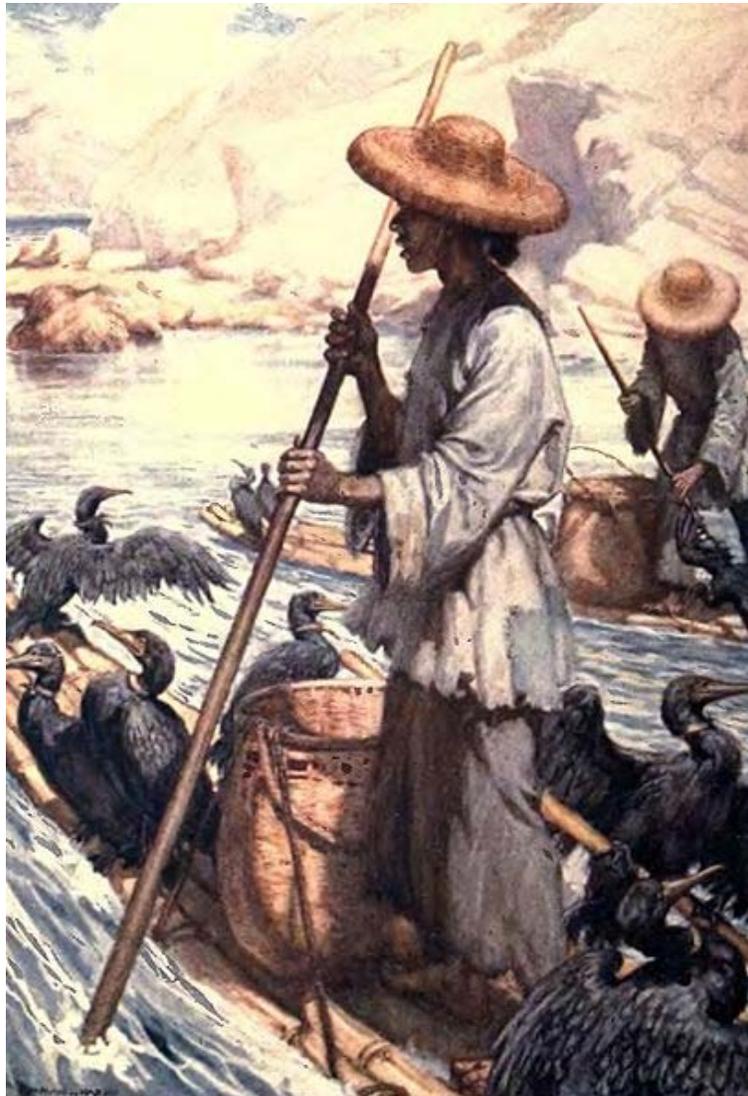
Bird Intelligence



Kea are known for their intelligence and curiosity, both vital to their survival in a harsh mountain environment. Kea can solve logical puzzles, such as pushing and pulling things in a certain order to get to food, and will work together to achieve a certain objective, and some have the intelligence of an average six-year-old.

Bird intelligence deals with the definition of intelligence and its measurement as it applies to birds. Traditionally, birds have been considered inferior in intelligence to mammals, and derogatory terms such as *bird brains* have been used colloquially in some cultures. Such perceptions are no longer considered scientifically valid. The difficulty of defining or measuring intelligence in non-human animals makes the subject difficult for scientific study. Anatomically, a bird has a relatively large brain compared to head size. The visual and auditory senses are well developed in most species, while tactile and olfactory senses are well developed only in a few groups. Locomotion is achieved through flight and use of the legs in most species. The beak and feet are used to manipulate food and other objects. Birds can communicate using visual signals as well as through the use of calls and song. The testing of intelligence is therefore based on studying the responses to sensory stimuli.

Studies



Cormorants used by fishermen in Southeast Asia may be able to count

Bird intelligence has been studied through several attributes and abilities. Many of these studies have been on birds such as quail, domestic fowl and pigeons kept under captive conditions. It has, however, been noted that field studies have been limited, unlike those of the apes. Birds such as the corvids and psittacines have been shown to live social lives, have long developmental periods and large forebrains, and these may be expected to have greater cognitive abilities.

Counting

Counting has been considered an ability that shows intelligence. Early anecdotal evidence has suggested that crows may count up to 3. Researchers however need to be cautious and ensure that birds are not merely demonstrating the ability to subitize. Some studies have suggested that crows may indeed have a true numerical ability. Parrots have been shown to count up to 6.

Cormorants used by Chinese fishermen that were given every eighth fish as a reward were found to be able to keep count up to eight.

In the 1970s, on the Li River, Pamela Egremont observed fishermen who allowed the birds to eat every eighth fish they caught. Writing in the *Biological Journal of the Linnean Society*, she reported that, once their quota of seven fish was filled, the birds "stubbornly refuse to move again until their neck ring is loosened. They ignore an order to dive and even resist a rough push or a knock, sitting glum and motionless on their perches." Meanwhile, other birds that had not filled their quotas continued to catch fish as usual. "One is forced to conclude that these highly intelligent birds can count up to seven," she wrote.

—Hoh, E. H.

Many birds are also able to detect changes in the number of eggs in their nest and brood. Parasitic cuckoos are often known to remove one of the host eggs before laying their own.

Associative learning

Visual or auditory signals and their association with food and other rewards have been well studied and birds have been trained to recognize and distinguish complex shapes. This is probably an important ability that aids their survival.

Spatial and temporal abilities

A common test of intelligence is the detour test. Here a glass barrier between the bird and an item such as food is used in the setup. Most mammals discover that the objective is reached by first going away from the target. Domestic fowl fail on this test. Many corvids were found to readily solve the problem.

Large fruit-eating birds in tropical forests depend on trees which fruit at different times of the year. Many species, such as pigeons and hornbills, have been shown to be able to decide upon foraging areas according to the time of the year. Birds that show food caching behaviour have also shown the ability to recollect the locations of food caches. Nectarivorous birds such as hummingbirds also optimize their foraging by keeping track of the locations of good and bad flowers. Studies of Western Scrub Jays (*Aphelocoma californica*) also suggests that birds may be able to plan for the future. They cache food according to future needs and risk of not being able to find the food on subsequent days.

Many birds follow strict time schedules in their activities. These are often dependent upon environmental cues. Birds also are sensitive to daylight length, and this awareness is especially important as a cue for migratory species. The ability to orient themselves during migrations is attributed to birds' superior sensory abilities, rather than to intelligence.

Self awareness

To check if an animal possesss or lacks the ability to recognize itself in its own reflection shows if they are conscious of themselves and able to distinguish themselves and from other animals, this is done by using the mirror test. The European Magpie is the only animal, besides a mammal that is shown to be able to pass this test by trying to remove a coloured sticker from underneath their beaks when shown in a mirror. However in 1981, Epstein, Lanza and Skinner published a paper in the journal Science in which they argued that the pigeon also passes the mirror test. A pigeon was trained to look in a mirror to find a response key behind it which the pigeon then turned to peck - food was the consequence of a correct choice (i.e., the pigeon learned to use a mirror to find critical elements of its environment). Next, the pigeon was trained to peck at dots placed on its feathers; food was, again, the consequence of touching the dot. The latter training was accomplished in the absence of the mirror. The final test was placing a small bib on the pigeon - enough to cover a dot placed on its lower belly. A control period without the mirror present yielded no pecking at the dot. When the mirror was revealed, the pigeon became active, looked in the mirror and then tried to peck on the dot under the bib. It is true that untrained pigeons have never been able to pass the mirror test. However, pigeons do not normally have access to mirrors and do not have the necessary experiences to use them. Giving the pigeons this experience in no way guaranteed it would pass the mirror test - remember, the pigeon never pecked dots on its own body in the presence of the mirror (until the final test). Despite that they are not classified as being able to recognize their reflection, because the pigeons that did were trained to do so and the animal has to be able to do this without the assistance of a person. Therefore it must also be shown to be able to do this in the wild as well with no experience, but just intelligence to see if it is able to comprehend that it is looking at its own reflection on its own. However even when an animal is trained to do this it's still unknown if they are aware that they are looking at themselves, or are just repeating the same movements and commands that they were taught so that they may receive a treat as a reward after they have correctly completed their task.

Tool use



The Woodpecker finch using a stick to impale a grub, and the next image showing it had successfully captured it.

Many birds have been shown capable of using tools. The definition of a tool has been debated with no consensus being reached. One proposed definition of tool use has been defined as

the use of physical objects other than the animal's own body or appendages as a means to extend the physical influence realized by the animal

—Jones and Kamil, 1973

By this definition, a Lammergeier dropping a bone on a rock would not be using a tool since the rock cannot be seen as an extension of the body. However the use of a rock manipulated using the beak to crack an ostrich egg would qualify the Egyptian vulture as a tool user. Many other species, including parrots, corvids and a range of passerines, have been noted as tool users.

New Caledonian Crows have been observed in the wild to use stick tools with their beaks to extract insects from logs. While young birds in the wild normally learn this technique from elders, a laboratory crow named "Betty" improvised a hooked tool from a wire with no prior experience. The Woodpecker Finch from the Galapagos Islands also uses simple stick tools to assist it in obtaining food. In captivity, a young Cactus Finch learned to imitate this behaviour by watching a woodpecker finch in an adjacent cage. Crows in urban Japan have innovated a technique to crack hard-shelled nuts by dropping them onto crosswalks and letting them be run over and cracked by cars. They then retrieve the

cracked nuts when the cars are stopped at the red light. Striated Herons (*Butorides striatus*) use bait to catch fish.

Observational learning

Learning using rewards to reinforce responses is often used in laboratories to test intelligence. However, the ability of animals to learn by observation and imitation is considered more significant. Crows have been noted for their ability to learn from each other.

Brain anatomy

At the beginning of the 20th century, scientists argued that the birds had hyper-developed basal ganglia, with tiny mammalian-like telencephalon structures. Modern studies have refuted this view. The basal ganglia only occupy a small part of the avian brain. Instead, it seems that birds use a different part of their brain, the medio-rostral neostriatum/hyperstriatum ventrale as the seat of their intelligence, and the brain-to-body size ratio of psittacines and corvines is actually comparable to that of higher primates.

Studies with captive birds have given insight into which birds are the most intelligent. While parrots have the distinction of being able to mimic human speech, studies with the African Grey Parrot have shown that some are able to associate words with their meanings and form simple sentences. Along with parrots, the crows, ravens, and jays (family Corvidae) are perhaps the most intelligent of birds. Not surprisingly, research has shown that these species tend to have the largest HVCs. Dr. Harvey J. Karten, a neuroscientist at UCSD who has studied the physiology of birds, has discovered that the lower parts of avian brains are similar to those of humans.

Social behaviour

Social life has been considered to be a driving force for the evolution of intelligence. Many birds have social organizations, and loose aggregations are common. Many corvid species separate into small family groups (or "clans") for activities such as nesting and territorial defense. The birds then congregate in massive flocks made up of several different species for migratory purposes. Some birds use teamwork while hunting. Predatory birds hunting in pairs have been observed using a "bait and switch" technique, whereby one bird will distract the prey while the other swoops in for the kill.

Social behaviour requires individual identification, and most birds appear to be capable of recognizing mates, siblings and young. Other behaviours such as play and cooperative breeding are also considered indicators of intelligence.

When crows are caching food, they appear to be sensitive to note who is watching them hide the food. They also steal food caught by others.

In some fairy-wrens such as the Superb and Red-backed, males pick flower petals in colors contrasting with their bright nuptial plumage and present them to others of their species that will acknowledge, inspect and sometimes manipulate the petals. This function seems not linked to sexual or aggressive activity in the short and medium term thereafter, though its function is apparently not aggressive and quite possibly sexual.

Language

Birds communicate with their flockmates through song, calls, and body language. Studies have shown that the intricate territorial songs of some birds must be learned at an early age, and that the memory of the song will serve the bird for the rest of its life. Some bird species are able to communicate in a variety of dialects. For example, the New Zealand saddleback will learn the different song "dialects" of clans of its own species, much as human beings might learn diverse regional dialects. When a territory-owning male of the species dies, a young male will immediately take his place, singing to prospective mates in the dialect appropriate to the territory he is in.

Recent studies indicate that some birds may have an ability to understand grammatical structures.

Conceptual abilities

Evidence that birds can form abstract concepts such as *same-different* has been proven by *Alex*, the African grey parrot. Alex was trained to vocally label more than 100 objects of different colours and shapes and which are made from different materials. Alex could also request or refuse these objects ('I want X') and quantify numbers of them.

It has been noted that bird brainwaves are very similar to that of humans, there are many similarities between the lobes of the brain and most notable the cerebral cortex. For this reason it is believed they can understand human language.

Theory of mind

A study on the Little Green Bee-eater suggests that these birds may be able to see from the point of view of a predator. The Western Scrub Jay hides caches of food and will later re-hide food if it was watched by another bird the first time, but only if the bird hiding the food has itself stolen food before from a cache. This might suggest a theory of mind, but other "lower level" explanations are possible. Such an ability to see from the point of view of another individual had previously been attributed only to the great apes. Such abilities form the basis for empathy. Research conducted with an Eleonora Cockatoo named Snowball has shown that birds can learn to dance to human-made music.

Chapter 5

Cat Intelligence

Cat intelligence is the considered capacity of learning, thinking, problem solving, reasoning, and adaptability possessed by the domestic cat. Intelligence in cats is demonstrated by the capacity to develop and use tools, learn new behavior techniques, apply previously acquired knowledge to new situations, communicate needs and desires within social groups, and respond to training cues. Mammalian neuroscientists have attempted to simulate the feline brain in order to understand the origins and operation of cat intelligence, but results to date are inconclusive and additional study is needed.

Brain size and surface area



The brain of a cat

The brain size of the average cat is 5 centimeters in length and 30 grams. Since the average cat is 60 cm long and 3.3 kg, the brain makes up 1/12 of its length and 1/110 of its mass. Thus, the average cat's brain accounts for 0.9 percent of its total body mass, compared to 2 percent of total body mass in the average human. The surface area of a cat's cerebral cortex is approximately 83 cm². The modern human cerebral cortex is about 2500 cm². According to researchers at Tufts University School of Veterinary Medicine, the physical structure of human brains and that of cats are very similar; they have the same lobes in the cerebral cortex (the "seat" of intelligence) as humans do. Human brains also function the same way, conveying data via many identical neurotransmitters.

The learning cat

It is proven that cats learn by trial and error, observation and imitation. They retain certain information (such as the ability to investigate new environments) much longer than dogs. In one study, it was found that cats possess visual memory ability comparable to that of monkeys.

Intelligence by breed

Ranking the intelligence of cats by breed is popular among pet owners, veterinarians and others, but the practice tends to run into difficulties. In general, the subject of cat intelligence rankings tends to be subjective. Cat breeder Norman Auspitz states the following: "As a rule, people seem to think the more active breeds have higher intelligence than the less active breeds. I will tell you that in feline agility, all breeds have done very well or very poorly as the case may be.. Having said that, there is no certified measure of cat intelligence and this general rule may be very anthropomorphic... until there is a credible definition of what might be meant by cat intelligence and a way to measure it, any comment anyone will make about the subject is, at best, speculation. Although, Siamese seem to be one of the more intelligible breeds, in terms of problem solving and communication skills. "

Observed abilities of cats

Inventing and using a tool

At least one cat was documented by a scientist to have adapted an object for use as a tool to add water to dry cat food, this tool-use being invented by the cat without any prior training by humans.

Opening doors and windows

Cats that are accustomed to being let outside, or that want to get into their home, may learn to open windows and doors. They are capable of learning different routes for entry and exit; for instance a cat might find the window in its owner's kitchen easier to open to exit the house, but to get in, they might have to use the screen door in the backyard. Also, they may learn to open cupboard doors to get to food. Cats' paws are not as effective at manipulation as human hands, owing to lack of an opposable thumb, but they can for instance learn to operate door lever handles by pulling them down, even though gripping the handle is difficult for cat paws.

Retrieving items from hard to reach places

A cat playing with a ball may suddenly find that the ball is under the couch. The cat will try different ways, changing paws, position, and other elements, the way a human would. This trial and error approach to puzzle solving can be demonstrated in the laboratory using Thorndike's puzzle boxes. In these boxes, cats must manipulate a series of levers in

order to escape. They initially achieve this by trial and error, before committing the sequence to memory. They also use memory to reduce the amount of trial and error when encountering comparable novel situations e.g. new puzzle boxes. The cat may also be taught to get treats from high and hard to reach places, like on top of a refrigerator, or in a cupboard. Using the same logic as it did with the toy, the cat will get to each treat. A cat that has figured out where the cat food is kept may find that the food is inside a large bag. It might try to get in the bag or open it by means of removing the clip.

Using the toilet



Toilet trained cat

Because of their sensitive sense of smell, some cats prefer going outside to urinate and defecate, and rarely go in the same spot twice. Kittens are typically trained by their

mothers to use a litter box and cover up their waste, so litter training rarely requires human intervention; once they understand where the litter box is, they will seek it out from then on. Cats can also be trained to make use of a toilet; some cats learn on their own after watching their owners, but for most cats, it is necessary to be taught by owners. In general, however, a toilet-trained cat is a rare animal, and successful toilet training depends both on the willingness of the animal to learn as well as on the patience of the owner to teach.

Playing fetch

Some cats can be trained to play fetch with a varied degree of success (which is dependent on the cat and its mood). Siamese, Bengals and Burmese cats are well-regarded as breeds that naturally carry objects in their mouths. They are easy to train to fetch and carry, again it may come naturally. Other breeds such as the Egyptian Mau, Maine Coon, Turkish Van, Savannah, Short Hair and Turkish Angora, and Bombay are also well known for an almost dog-like affinity for playing fetch; at least one Bombay started the game with its owner and trained the owner. It is possible to get a cat to remain seated until an object is thrown. At that point, their sense of sight kicks in. As long as there is at least a remote chance of locating the thrown item, the cat will run off to find it. Once retrieved, waiting or a simple call is enough for the cat to return with the item (if it does not chose to do it themselves) and deposit it (usually) within arm's reach (or just outside as a possible form of dominance, making the owner change position). Chasing an object in the air is a natural cat hunting behavior, and many cats will chase down a thrown toy for the sheer enjoyment of running and catching. Of course, any distraction and the cat may completely forget the game. This might suggest that a dog, which will do almost anything to please its owner due to pack instinct, will tend to focus on its game for both the owner and its pleasure, while a cat clearly plays the game for its own self-interest in chasing and pouncing. For a dog, the reward for a retrieved toy may be a vigorous petting or vocalization of praise and also a second toss, for a cat, the only reward is typically the second throw.

Communication

Cats, like many animals, communicate in a social environment in various ways. Some aspects of this behaviour are simple, such as purring to express the desire for and enjoyment of attention, meowing near the food bowl to get fed, some remember what time they get fed and attempt to gain their owner's attention at that time every day, etc., and some are more complex. Domestic cats organize themselves in complex social units when food is plentiful and conditions are otherwise conducive to it. It is actually quite important to cats' welfare to understand that they are not 'solitary by nature.' Although they do not socialize in the same way that dogs do (they do not hunt in packs, for example, and are not responsive to praise and blame in the same way) they still associate themselves strongly with specific other animals (including humans) and are probably even more attached to place and routine than dogs or their human owners. Cats may tend to communicate more indirectly, that is if they want their owner to open a door or pick up a favorite toy, they will often stare at the object intently with only occasional looks to the

owner, until the owner, noting the focus of the cat, will look to where the cat is looking. Cats will often place themselves in favorite positions where some behavior of the owner is expected. These positions are not always related to conditioning, but possibly from the cat remembering that the last time it was in this particular position something it wanted to happen, happened. Unlike true conditioning, however, the cat can easily adjust to new positions to get to the same object of its desire. Whether this is a sign of intelligence or a lack of intelligence is perhaps unfathomable as cats show so much individualized behavior.

Training and tricks

Cats are traditionally hard to train as circus animals, mainly because cats appear to only assume such behaviors in exchange for a direct benefit, unlike dogs which respond well to emotional reassurance. While this is usually true, a human with a good relationship to a cat, where there is trust and good communication, can find a cat to be almost as trainable as a dog. A good example of this is The Yuri Kuklachev Cat Theatre based in Moscow, the owner of which has been training cats for many years to do a full range of circus style tricks. Also there is the belief that cats are harder to train than dogs owing to impatience and boredom with the training exercise. Like dogs and people, many cats have active minds that thrive on stimulation, exploration and learning. Many of the same basic methods of training a dog—shaping behavior, and giving reinforcement in the form of treats, lavish praise or attention for correct responses—work extremely well when training a cat. A cat can be taught to "sit" for treats or meals; this or other such repeatable behaviour responses can act as a foundation for further training.

Computer simulation of the cat brain

Scientists have simulated a cat's cerebral cortex, the thinking part of the brain, using a massive supercomputer. However, the reports have raised controversy, because the computer does not actually think like a cat. The computer simulation is *cat-scale*, meaning that the simulation is powerful enough to simulate a cat brain, but it is not a proper, realistic simulation of a cat brain. Conflicting views comment on the fact that the simulation uses a faithful reproduction of the neurons in the brain, and also argue that the simulation does not use biologically realistic simulations of the neurons in a cat brain. Other arguments point out the motives for reverse-engineering a cat brain, as there are tensions between the goals of the simulation. Neuroscientists want to understand how the brain's architecture, using biological neurons, leads to consciousness and neurological disorders, whereas computer scientists want to understand brain architecture in order to create new kinds of electronics.

There are a number of reasons the cat brain is a goal of computer simulations. Cats are a familiar and easily-kept animal, so the physiology of cats has been particularly well studied. The physical structure of human brains and cat brains are very similar. Cats, like humans, have binocular vision that gives them depth perception.

Building artificial mammal brains requires ever more powerful computers as the brain gets more complex, from the mouse brain, to the rat brain (in 2007), to the cat brain, and ultimately to the human brain. Building artificial mammal brains advances the research of both neuroscience and artificial intelligence, but also leads to questions of the definition of sentient and conscious life forms, and to the ethics of artificial consciousness.

Chapter 6

Cephalopod Intelligence



An octopus in a zoo

Cephalopod intelligence has an important comparative aspect in the understanding of intelligence, because it relies on a nervous system fundamentally different from that of vertebrates. The cephalopod class of molluscs, particularly the Coleoidea subclass (cuttlefish, squid and octopuses), are considered the most intelligent invertebrates and an important example of advanced cognitive evolution in animals.

The scope of cephalopod intelligence is controversial, complicated by the challenges of studying these elusive and fundamentally different creatures. Classical conditioning of cephalopods has been reported, and one study (Fiorito and Scotto, 1992) even concluded that octopuses practise observational learning. However, the latter idea is strongly disputed, and doubt has been shed on some other reported capabilities as well. In any case, impressive spatial learning capacity, navigational abilities, and predatory techniques remain beyond question.

Examples of intelligence

Predation techniques

Unlike most other molluscs, all cephalopods are active predators (with the possible exception of the bigfin squid). Their requirement to locate and capture their prey has been a probable driving force behind the development of their intelligence, uniquely advanced in their phylum.

The Humboldt squid hunts schools of fish, showing extraordinary cooperation and communication in its hunting techniques. This is the first observation of such behaviour in invertebrates.

Crabs, the staple food source of most octopus species, present significant challenges with their powerful pincers and their potential to exhaust the cephalopod's respiration system from a prolonged pursuit. In the face of these challenges, octopuses will instead seek out lobster traps and steal the prize inside. They are also known to climb aboard fishing boats and hide in the containers that hold dead or dying crabs.

Dexterity

Dexterity, an ability essential for tool use and manipulation is also found in cephalopods. The highly sensitive suction cups and prehensile arms of octopuses, squid, and cuttlefish are as effective at holding and manipulating objects as the human hand. However, unlike vertebrates, the motor skills of octopuses do not seem to depend upon mapping their body within their brains, as the ability to organize complex movements is not thought to be linked to particular arms.

One particularly clever octopus called Otto has been known to juggle his fellow tankmates around out of boredom, as well as throwing rocks and smashing the aquarium glass. On more than one occasion he even caused short circuits by crawling out of his tank and shooting a jet of water at the overhead lamp.

Octopus opening a container with a screw cap









Communication

Another example of cephalopod intelligence is the communication that takes place between the more social species of squid. Some cephalopods are capable of rapid changes in skin color and pattern through nervous control of chromatophores. This ability almost certainly evolved primarily for camouflage, but squids use color, patterns, and flashing to communicate with one another in various courtship rituals. Caribbean Reef Squid can send one message via color patterns to a squid on their right, while they send another message to a squid on their left.

Tool use

As of 2009, the octopus is the only invertebrate animal which has been conclusively shown to use tools. At least four specimens of the Veined Octopus (*Amphioctopus marginatus*) have been witnessed retrieving discarded coconut shells, manipulating them, transporting them some distance, and then reassembling them to use as a shelter. This discovery was documented in the journal *Current Biology* and has been filmed on video. Most hermit crabs use discarded shells of other species for habitation and other crabs choose sea anemones to cultivate on their carapaces as camouflage; numerous insects use rocks, sand, leaves and so on as building materials, however none of this behavior compares to the complexity of the octopus's fortress behavior, which involves picking up and carrying a tool to use later on.

Chapter 7

Cetacean Intelligence

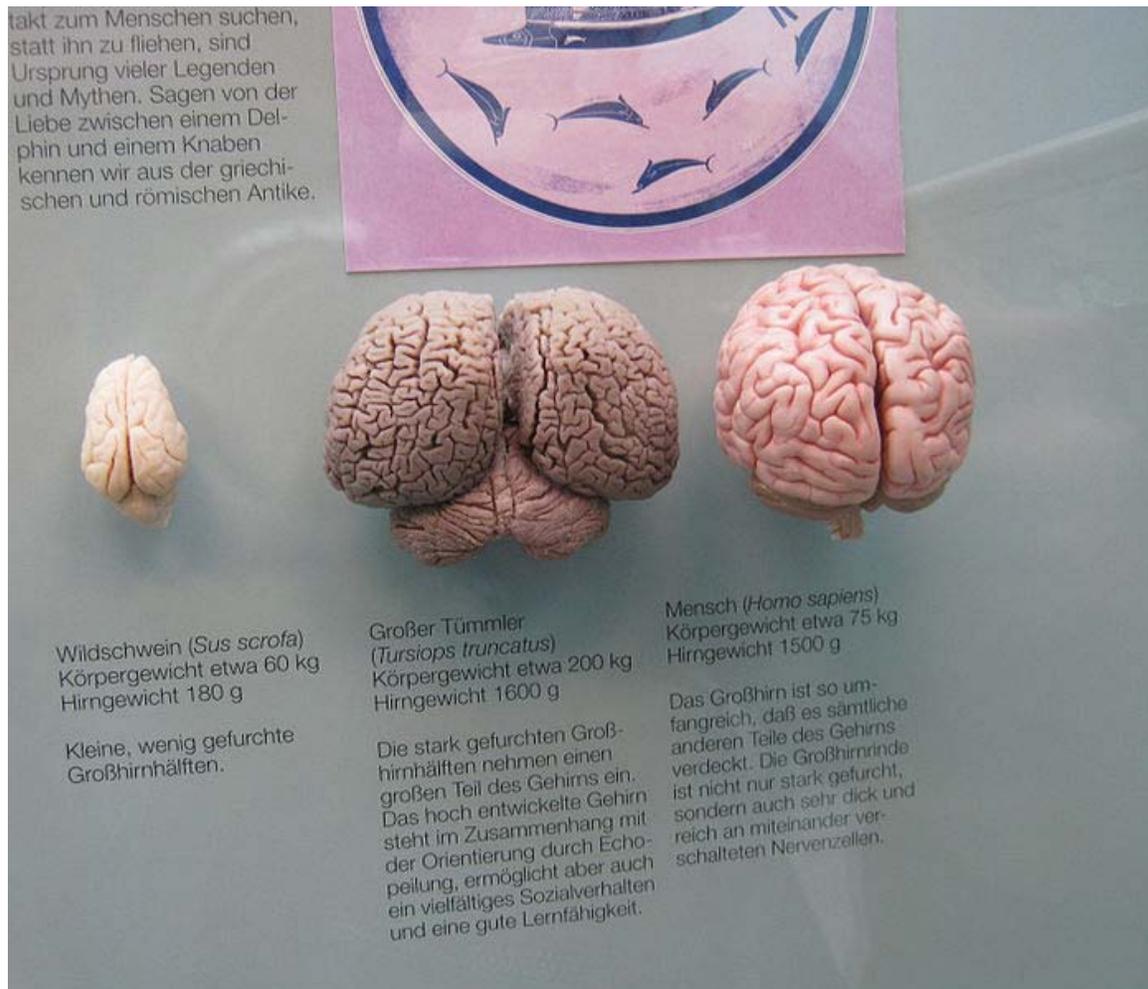


Akeakamai, a bottlenose dolphin, was a subject in an animal language study at the Kewalo Basin Marine Mammal Laboratory in Oahu, Hawaii.

Cetacean intelligence denotes the cognitive capabilities of the Cetacea order of mammals, which includes whales, porpoises, and dolphins.

Brain size

Brain size used to be considered an indicator of the intelligence of an animal. However, many other factors also affect intelligence and recent discoveries concerning bird intelligence decrease confidence with the usefulness of brain size as an indicator. Since most of the brain is used for maintaining bodily functions, greater ratios of brain to body mass may increase the amount of brain mass available for more complex cognitive tasks. Allometric analysis indicates that mammalian brain size scales at approximately the $2/3$ or $3/4$ power of the body mass. Comparison of a particular animal's brain size with the expected brain size based on such allometric analysis provides an encephalization quotient (EQ) that can be used as another indication of the animal's intelligence.



Scale model of bottlenose dolphin (*Tursiops truncatus*) brain (middle), compared with brains of wild pig (*Sus scrofa*) (left), and human (*Homo sapiens*) (right).

- Sperm whales (*Physeter macrocephalus*) have the largest brain mass of any extant animal, averaging 7.8 kg in mature males.

- Bottlenose dolphins (*Tursiops truncatus*) have an absolute brain mass of 1500-1700 grams. This is slightly greater than that of humans (1300-1400 grams) and about four times that of chimpanzees (400 grams).
- The brain to body mass ratio (encephalization quotient, or EQ) in some members of the odontocete superfamily Delphinoidea (dolphins, porpoises, belugas, and narwhals) is second only to modern humans, and greater than all other mammals (there is debate whether that of the treeshrew might be second) In some dolphins, it is less than half that of humans: 0.9% versus 2.1%. This comparison seems more favorable if the large amount of blubber (15-20% of mass) that dolphins require for insulation is omitted.
- The encephalization quotient varies widely between species. The Orca/Killer whale has an EQ of 2.57, the franciscana dolphin of 1.67, the Ganges River dolphin of 1.55, the bottlenose dolphin of 4.14, and the tucuxi dolphin of 4.56. These are less than the human EQ of 7.44, but some are greater than that of chimpanzees at 2.49, dogs at 1.17, cats at 1.00, and mice at 0.50.
- One comparative way to try to gauge intelligence is to compare a species' brain size at birth to the completely developed adult brain. This indicates how much learning a species accumulates while young. The majority of mammals are born with a brain close to 90% of the adult weight. Humans are born with 28% of the adult weight, chimpanzees with 54%, bottlenose dolphins with 42.5%, and elephants with 35%. By eighteen months, the brain mass of a bottlenose dolphin is about 80% of that of an adult. Human beings generally do not achieve this percentage until the age of three or four years.

The discovery of spindle cells (neurons without extensive branching, known also as "von Economo neurons", or VENs) in the brains of the humpback whale, fin whale, sperm whale, killer whale, bottlenose dolphins, Risso's dolphins, and beluga whales is another unique discovery. Humans, the great apes, and elephants are the only other species known to have spindle cells, species all well known for their great intelligence. Spindle neurons seem important for development of intelligent behavior. Such a discovery may suggest a convergent evolution of these species. Harkeem *et al's* research of spindle neurons proposes the following theory:

“There are a few mammals apart from hominids, cetaceans, and elephants that have brains somewhat larger than the apes. It would be interesting to determine whether or not these mammals, such as the giraffes and hippopotamuses, have VENs in parts of the brain corresponding to [frontoinsular] and [anterior cingulate cortex]. If they are present, it would suggest that the VEN morphology may be primarily related to absolute brain size. If not, it would suggest that the VENs may be related to behavioral specializations common to hominids, whales, and elephants.

Brain structure

Elephant brains also show a similar complexity to dolphin brains, and are also more convoluted than that of humans, and with a cortex "thicker than that of cetaceans.

However, in dolphins, "no patterns of cellular distribution, nuclear subdivision, or cellular morphology indicate specialization of the LC (coeruleus complex)" despite the large absolute brain size and unihemispheric sleep phenomenology of cetaceans. Moreover, it is generally agreed that the growth of the neocortex, both absolutely and relative to the rest of the brain, during human evolution, has been responsible for the evolution of intelligence, however defined. While a complex neocortex usually indicates great intelligence, there are exceptions to this. For example, the spiny egg laying anteater (echidna) has a very developed brain, yet is not widely considered to be very intelligent.

Some scientists argue that the greater the number of cortical neurons a species has, the greater their intelligence. Although many cetaceans have a great number of cortical neurons, after *Homo sapiens*, the species with the greatest number of cortical neurons and synapses is the elephant. All sleeping mammals, including dolphins, have a stage known as REM sleep. Unlike terrestrial mammals, dolphin brains contain a paralimbic lobe, which may possibly be used for sensory processing. The dolphin is a voluntary breather, even during sleep, with the result that veterinary anaesthesia of dolphins is impossible, as it would result in asphyxiation. Ridgway reports that EEGs show alternating hemispheric asymmetry in slow waves during sleep, with occasional sleep-like waves from both hemispheres. This result has been interpreted to mean that dolphins sleep only one hemisphere of their brain at a time, possibly to control their voluntary respiration system or to be vigilant for predators. This is also given as explanation for the large size of their brains.

Dolphin brain stem transmission time is faster than that normally found in humans, and is approximately equivalent to the speed found in rats. As echo-location is the dolphin's primary means of sensing its environment – analogous to eyes in primates – and since sound travels four and a half times faster in water than in air, scientists speculate that the faster brain stem transmission time, and perhaps the paralimbic lobe as well, assist speedy processing of sound. The dolphin's dependence on speedy sound processing is evident in the structure of its brain: its neural area devoted to visual imaging is only about one-tenth that of the human brain, while the area devoted to acoustical imaging is about 10 times that of the human brain. (This is unsurprising: primate brains devote much more volume to visual processing than those of almost any other animal, and human brains more than other primates.) Sensory experiments suggest a great degree of cross-modal integration in the processing of shapes between echolocative and visual areas of the brain. Unlike the case of the human brain, the cetacean optic chiasm is completely crossed, and there is behavioral evidence for hemispheric dominance for vision.

Problem-solving ability

Some research shows that dolphins among other animals understand concepts such as more or less in term of numerical continuity (but not necessarily counting). A recent research found that dolphins may be able to discriminate between numbers. However, the same researcher suggested that "It may involve mimicry," he said, "as dolphins are unsurpassed in imitative abilities among nonhuman animals."

A commonly used definition of intelligence is "the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly, and learn from experience." This definition is separate from social/communicative traits or the ability to learn tricks (which can be done through conditioning), and because of this many people believe that dolphins are not as intelligent as humans.

Several researchers observing animals' ability to learn set formation tend to rank dolphins about the level of elephants in "intelligence" and show that dolphins do not have any unusual talent with problem solving compared with the other animals classed with very great intelligence. Macphail in his "Brain and intelligence in vertebrates" compared data from studies regarding learning "set formation" of animals. The result show that dolphins are skilled at performing this sort of standardized testing but not as adept as other animals of the study. The true extent of dolphin's intelligence is really unknown to humans in the sense that we, ourselves, have evolved over time to maintain sustenance on the land whereas they have evolved to live in the water.

Behavior

Pod characteristics

Dolphin group sizes vary quite dramatically. River dolphins usually congregate in fairly small groups from 6 to 12 in number or, in some species, singly or in pairs. The individuals in these small groups know and recognise one another. Other species such as the oceanic Pantropical Spotted Dolphin, Heaviside's Dolphin and Spinner Dolphin travel in large groups of hundreds of individuals. It is unknown whether every member of the group is acquainted with every other. However, there is no doubt that such large packs can act as a single cohesive unit - observations show that if an unexpected disturbance, such as a shark approach, occurs from the flank or from beneath the group, the group moves in near-unison to avoid the threat. This means that the dolphins must be aware not only of their near neighbors but also of other individuals nearby - in a similar manner to which humans perform "Audience waves". This is achieved by sight, and possibly also echolocation. One speculative hypothesis proposed by Jerison (1986) is that members of a pack of dolphins are able to share echolocation results with each other to create a better understanding of their surroundings.

Resident orcas living in British Columbia, Canada, and Washington, United States live in extremely stable family groups. The basis of this social structure is the matriline, consisting of a mother and her offspring, who travel with her for life. Male orcas never leave their mothers' pods, while female offspring may branch off to form their own matriline if they have many offspring of their own. Males have a particularly strong bond with their mother, and travel with them their entire lives, which can exceed 50 years. It is interesting behavior, as it may seem that there would not be any benefit from this except perhaps in hunting techniques, although they could join other groups to hunt. There are two interesting examples of this familial bond in males. Two male sons, identified as A38 and A39, constantly accompany their mother A30, despite the fact that she does not need protection and they can all hunt by themselves, and rarely leave her side. Researchers

have noted that if one son wanders away, one always remains with the mother. Another example are the brothers A32, A37 and A46, whose mother (A36) died. Instead of the family disbanding, the three brothers remain constantly together.

Relationships in the orca population can be discovered through their vocalizations. Matrilineal groups who share a common ancestor from only a few generations back share mostly the same dialect, comprising a pod. Pods who share some calls indicate a common ancestor from many generations back, and make up a clan. Interestingly, the orcas use these dialects to avoid in-breeding. They mate outside the clan, which is determined by the different vocalizations. On one occasion, an orca's mother and father were determined to be of the same clan, although in different pods. There is evidence that other species of dolphins may also have dialects.

In bottlenose dolphin studies by Wells in Sarasota, Florida, and Smolker in Shark Bay, Australia, females of a community are all linked either directly or through a mutual association in an overall social structure known as *fission-fusion*. Groups of the strongest association are known as "bands", and their composition can remain stable over years. There is some genetic evidence that band members may be related, but these bands are not necessarily limited to a single matrilineal line. There is no evidence that bands compete with each other. In the same research areas, as well as in Moray Firth, Scotland, males form strong associations of two to three individuals, with a coefficient of association between 70 and 100. These groups of males are known as "alliances", and members often display synchronous behaviors such as respiration, jumping, and breaching. Alliance composition is stable on the order of tens of years, and may provide a benefit for the acquisition of females for mating. The complex social strategies of marine mammals such as bottlenose dolphins, "provide interesting parallels" with the social strategies of elephants and chimpanzees.

Complex play

Dolphins are known to engage in complex play behavior, which includes such things as producing stable underwater toroidal air-core vortex rings or "bubble rings". There are two main methods of bubble ring production: rapid puffing of a burst of air into the water and allowing it to rise to the surface, forming a ring; or swimming repeatedly in a circle and then stopping to inject air into the helical vortex currents thus formed. The dolphin will often then examine its creation visually and with sonar. They also appear to enjoy biting the vortex-rings they've created, so that they burst into many separate normal bubbles and then rise quickly to the surface. Certain whales are also known to produce bubble rings, or even bubble-nets for the purpose of foraging. Many dolphin species are also known for playing by riding in waves, whether natural waves near the shoreline in a method akin to human "body-surfing", or within the waves induced by the bow of a moving boat in a behavior known as *bow-riding*.

Cross-species cooperation

There have been instances in captivity of various species of dolphin and porpoise helping and interacting across species, including helping beached whales. Also they have been known to live alongside Resident (fish eating) Orca Whales for limited times.

Creative behavior

Aside from having exhibited the ability to learn complex tricks, dolphins have also demonstrated the ability to produce creative responses. This was studied by Karen Pryor during the mid-1960s at Sea Life Park in Hawaii, and was published as "*The Creative Porpoise: Training for Novel Behavior*" during 1969. The two test subjects were two rough-toothed dolphins (*Steno bredanensis*), named Malia (a regular show performer at Sea Life Park) and Hou (a research subject at adjacent Oceanic Institute). The experiment tested when and whether the dolphins would identify that they were being rewarded (by fish) for originality in behavior and was very successful. However, since only two dolphins were involved in the experiment, the study is difficult to generalize.

Starting with the dolphin named Malia, the method of the experiment was to choose a particular behavior exhibited by her each day and reward each display of that behavior throughout the day's session. At the start of each new day Malia would present the prior day's behavior, but only when a new behavior was exhibited was a reward given. All behaviors exhibited were, at least for a time, known behaviors of dolphins. After approximately two weeks Malia apparently exhausted "normal" behaviors and began to repeat performances. This was not rewarded.

According to Pryor the dolphin became almost despondent. However, at the sixteenth session without novel behavior, the researchers were presented with a flip they had never seen before. This was reinforced. As related by Pryor, after the new display: "instead of offering that again she offered a tail swipe we'd never seen; we reinforced that. She began offering us all kinds of behavior that we hadn't seen in such a mad flurry that finally we could hardly choose what to throw fish at..."

The second test subject, Hou, took thirty-three sessions to reach the same stage. On each occasion the experiment was stopped when the variability of dolphin behavior became too complex to make further positive reinforcement meaningful.

The same experiment was repeated with humans, and it took the volunteers about the same length of time to figure out what was being asked of them. After an initial period of frustration or anger, the humans realised they were being rewarded for novel behavior. In dolphins this realisation produced excitement and more and more novel behaviors - in humans it mostly just produced relief.

Captive orcas have often displayed interesting responses when they get 'bored' with activities. For instance, when Dr. Paul Spong worked with the orca Skana, he researched her visual skills. However, after performing favorably in the 72 trials per day, Skana

suddenly began consistently getting every answer wrong. Dr Spong concluded that a few fish were not enough motivation. He began playing music, which seemed to provide Skana with much more motivation.

At the Institute for Marine Mammal Studies in Mississippi, it has also been observed that the resident dolphins seem to show an awareness of the future. The dolphins are trained to keep their own tank clean by retrieving rubbish and bringing it to a keeper, to be rewarded with a fish. However, one dolphin, named Kelly, has apparently learned a way to get more fish, by hoarding the trash under a rock at the bottom of the pool and bringing it up one small piece at a time.

Use of tools

As of 2005, scientists have observed limited groups of bottlenose dolphins around the Australian Pacific using a basic tool. When searching for food on the sea floor, many of these dolphins were seen tearing off pieces of sponge and wrapping them around their "bottle nose" to prevent abrasions.

Communication

Whale song is the sounds made by whales and which is used for different kinds of communication.

Dolphins emit two distinct kinds of acoustic signals, which are named *whistles* and *clicks*.

- Clicks - quick broadband burst pulses - are used for echolocation, although some lower-frequency broadband vocalizations may serve a non-echolocative purpose such as communication; for example, the pulsed calls of Orcas. Pulses in a click train are emitted at intervals of ~35-50 milliseconds, and in general these inter-click intervals are slightly greater than the round-trip time of sound to the target.
- Whistles - narrow-band frequency modulated (FM) signals - are used for communicative purposes, such as contact calls, the pod-specific dialects of resident Orcas, or the signature whistle of bottlenose dolphins.

There is strong evidence that some specific whistles, named *signature whistles*, are used by dolphins to identify and/or call each other; dolphins have been observed emitting both other specimens' signature whistles, and their own. A unique signature whistle develops quite early during a dolphin's life, and it appears to be created in an imitation of the signature whistle of the dolphin's mother.

Xitco reported the ability of dolphins to eavesdrop passively on the active echolocative inspection of an object by another dolphin. Herman terms this effect the "acoustic flashlight" hypothesis, and may be related to findings by both Herman and Xitco on the comprehension of variations on the pointing gesture, including human pointing, dolphin postural pointing, and human gaze, in the sense of a redirection of another individual's attention, an ability which may require theory of mind.

The environment where dolphins live makes experiments much more expensive and complicated than for many other species; additionally, the fact that cetaceans can emit and hear sounds (which are believed to be their main means of communication) in a range of frequencies much wider than that of humans means that sophisticated equipment, which was scarcely available in the past, is needed to record and analyse them. For example, clicks can contain significant energy in frequencies greater than 110 kHz (for comparison, it is unusual for a human to be able to hear sounds above 20 kHz), requiring that equipment have a sampling rates of at least 220 kHz; MHz-capable hardware is often used.

In addition to the acoustic communication channel, the visual modality is also significant. The contrasting pigmentation of the body may be used, for example with "flashes" of the hypopigmented ventral area of some species, as can the production of bubble streams during signature whistling. Also, much of the synchronous and cooperative behaviors, as described in the Behavior section of this entry, as well as cooperative foraging methods, likely are managed at least partly by visual means.

While there is little evidence for dolphin language, experiments have shown that they can learn human sign language. Akeakamai, a bottlenose dolphin, was able to understand both individual words and basic sentences like "touch the frisbee with your tail and then jump over it" (Herman, Richards, & Wolz 1984). Dolphins have also exhibited the ability to understand the significance of the ordering of each set of tasks in one sentence.

Self-awareness

Self-awareness is seen, by some, to be a sign of very-developed, abstract thinking. Self-awareness, though not well-defined scientifically, is believed to be the precursor to more advanced processes like meta-cognitive reasoning (thinking about thinking) that are typical of humans. Scientific research of this topic has suggested that bottlenose dolphins, along side elephants and great apes possess self-awareness.

The most widely used test for self-awareness in animals is the mirror test, developed by Gordon Gallup during the 1970s, in which a temporary dye is placed on an animal's body, and the animal is then presented with a mirror. Some scientists still disagree with these findings, arguing that the results of these tests are open to human interpretation and susceptible to the Clever Hans effect. This test is much less definitive than when used for primates, because primates can touch the mark or the mirror, while dolphins cannot, making their alleged self-recognition behavior less certain. Critics argue that behaviors that are said to identify self-awareness resemble existing social behaviors, and so researchers could be misinterpreting social responses to another dolphin. The researchers counter-argue that the behaviors shown to evidence self-awareness are very different from normal responses to another dolphin, including paying significantly more attention to another dolphin than towards their mirror image. Dr. Gallup termed the results "*the most suggestive evidence to date*" of mirror self-recognition in dolphins, but "*not definitive*" because he was not certain that the dolphins were not interpreting the image in the mirror as another animal. Whereas apes can merely touch the mark on themselves

with their fingers, dolphins show less definitive behavior of self-awareness, twisting and turning themselves to observe the mark.

As a further response to these criticisms, during 1995, Marten and Psarakos used television to test dolphin self-awareness. They showed dolphins real-time footage of themselves, recorded footage, and another dolphin. They concluded that their evidence suggested self-awareness rather than social behavior. However, this study has not been repeated since then, the results remain thus uncorroborated. However, dolphins have since passed the mirror test. (Reiss,Marino)

Comparative cognition

Research of the comparative cognition of the dolphin is one of the primary methods of the investigation of cetacean intelligence.

Examples of cognitive abilities investigated in the dolphin include concept formation, sensory skills, and the use of mental representation of dolphins. Such research has been ongoing since the late 1970s, and includes the specific topics of: acoustic mimicry, behavioral mimicry (inter- and intra-specific), comprehension of novel sequences in an artificial language (including non-finite state grammars as well as novel anomalous sequences), memory, monitoring of self-behaviors (including reporting on these, as well as avoiding or repeating them), reporting on the presence and absence of objects, object categorization, discrimination and matching (identity matching to sample, delayed matching to sample, arbitrary matching to sample, matching across echolocation and vision, reporting that no identity match exists, etc.), synchronous creative behaviors between two animals, comprehension of symbols for various body parts, comprehension of the pointing gesture and gaze (as made by dolphins or humans), problem solving, echolocative eavesdropping, and more. Some researchers include Louis Herman, Mark Xitco, John Gory, Stan Kuczaj, Adam Pack, and many others.

While these are largely laboratory studies, field studies relating to dolphin and cetacean cognition are also relevant to the issue of intelligence, including those proposing tool use, culture, fission-fusion social structure (including tracking alliances and other cooperative behavior), acoustic behavior (bottlenose dolphin signature whistles, sperm whale clicks, orca pod vocalizations), foraging methods (partial beaching, cooperation with human fishermen, herding fish into a ball, etc.). See: Richard Connor, Hal Whitehead, Peter Tyack, Janet Mann, Randall Wells, Kenneth Norris, B. Wursig, John Ford, Louis Herman, Diana Reiss, Lori Marino, Sam Ridgway, Paul Nachtigall, Eduardo Mercado, Denise Herzing, Whitlow Au.

In contrast to the primates, cetaceans are particularly far-removed from humans in evolutionary time. Therefore, cognitive abilities generally cannot be claimed to derive from a common ancestor, whereas such claims are sometimes made by researchers studying primate cognition. Though cetaceans and humans (in common with all mammals) had a common ancestor in the distant past, it was almost certainly of distinctly inferior cognitive abilities compared to its modern descendants. The early divergence of

the human—dolphin ancestry line creates a problem in what cognitive tasks to test for because human/dolphin brains have been naturally selected so differently, with completely different cognitive abilities favoring their very different environments. Therefore, an anthropomorphic problem exists with exactly what cognitive abilities to test, how to test them, as well as the validity of the experimental results because of the completely different evolutionary lineage and environment human and cetaceans have.

Chapter 8

Dog Intelligence



Many dogs can easily be trained to retrieve objects like this stick.

Dog intelligence is the ability of a dog to learn, think, and solve problems. Dog trainers, owners, and researchers have as much difficulty agreeing on a method for testing canine intelligence as they do for human intelligence. One specific difficulty is confusing a breed's genetic characteristics and a dog's obedience training with intelligence.

Certain breeds, like Doberman Pinschers, Border Collies, Poodles, German Shepherds, Shetland Sheepdogs, Rottweilers, Labrador Retrievers, Papillons, Australian Cattle Dogs and Golden Retrievers, are claimed by some to be "smarter" breeds of dogs because of

their obedience. However, the ability and willingness to learn and obey commands is not the only possible measurement of intelligence. Other breeds, such as sled dogs and sight hounds demonstrate intelligence in other ways.

Inherited abilities

Dogs are pack animals. They understand social structure and obligations, and are capable of interacting with other members of the pack. Adult canines train their young by "correcting" them when they behave in an unacceptable manner (such as biting too hard or eating out of turn) and reward them for acceptable behavior, by playing with them, feeding them, or cleaning them.

They are also den animals. This means that they can easily learn behavior related to keeping the den clean (such as housebreaking) and relaxing in an enclosed area (such as a crate during travel or for training).

Some breeds have been selectively bred for hundreds or thousands of years for the quality of learning quickly. That quality has been downplayed for other breeds in favor of other characteristics like the ability to track or hunt game, or to fight other animals. The capacity to learn basic obedience and complicated behavior, however, is inherent in all dogs. Owners must simply be more patient with some breeds than with others.

Nonetheless, inherited behavior is not necessarily an indicator of intelligence. For example, a sheep herding breed, like a Border Collie, would be expected to learn how to herd sheep very quickly and might even perform the job with little training. The same breed, however, would be a challenge to train how to point and retrieve game. A Pointer often points to game instinctively and naturally retrieves game without damaging it, but training it to herd sheep would be difficult if not impossible.

Evaluation of intelligence

The meaning of "intelligence" in general, not only in reference to dogs, is hard to define. Some tests measure problem-solving abilities and others test the ability to learn in comparison to others of the same age. Defining it for dogs is just as difficult. It is likely that dogs do not have the ability to premeditate an action to solve a problem. Some dogs may, however, have more drive to keep trying various things until they accidentally reach a solution and still others might have more ability to make the association between the "accident" and the result.

For example, the ability to learn quickly could be a sign of intelligence. It could be interpreted as a sign of blind subservience and a desire to please. In contrast, some dogs who do not learn very quickly may have other talents. An example is breeds that are not particularly interested in pleasing their owners, such as Siberian Huskies. Huskies are often fascinated with the myriad possibilities for escaping from yards and catching small animals, figuring out on their own numerous and often ingenious ways of doing both.

Assistance dogs are also required to be obedient at all times. This means they must learn a tremendous number of commands, understand how to act in a large variety of situations, and recognize threats to their human companions, some of which they might never before have encountered.

Many owners of livestock guardian breeds believe that breeds such as Great Pyrenees or the Kuvasz are not easily trained because their independent nature prevents them from seeing the point of such commands as "sit" or "down". The Molosser breeds are said to be particularly sensitive to physical or vocal aggression and, as such, are generally thought to respond to positive reinforcement-based methods of training. Hounds, (such as Beagles, Bloodhounds, and Basset Hounds), rank in the bottom tier of "The Intelligence of Dogs" list, but probably suffer from a certain approach to intelligence assessment. These dogs are bred to have a tenacious tracking mentality, taking advantage of their acute sense of smell, and less ability in "problem solving," which is the central task of Working and Herding dogs. In addition, many dog "authorities" are unaware of the Scenthound's extraordinary ability to perceive and evaluate things other than odors. They can detect pheromones, among other things, and may have the ability to evaluate a human's or another dog's personality or disposition from as far away as 300 feet. This can be described as "conditional intelligence" where the animal is quick to learn some things, while appearing reluctant to learn others.

Testing and research

Certain intelligence tests involve the dog's ability to recognize and respond to a large vocabulary of commands. Other tests involve their desire or ability to respond to different situations. Just as with humans, there is a wide variety of interpretations as to what makes a dog "intelligent".

Various studies have attempted to rigorously classify intelligence of dogs. A recent example is animal psychologist Juliane Kaminski's paper in *Science* that demonstrated that Rico, a Border Collie, could learn over 200 words. Rico could remember the names of several items for up to four weeks after its last exposure (Kaminski eliminated the Clever Hans effect using strict protocols). Rico was also able to interpret phrases such as "fetch the sock" in terms of its component words (rather than considering its utterance to be a single word). Rico could also give the sock to a specified person. In 2008, Betsy, also a Border Collie, was featured on the cover of National Geographic Magazine. Betsy's intelligence rivaled that of Rico's in that she knew over 340 words and was able to correlate an object with a photographic image of the object, despite having seen neither before.

In his 1996 book *Good Natured*, ethologist Frans de Waal discusses an experiment on guilt and reprimands conducted on a female Siberian husky. The dog had the habit of shredding newspapers, and when her owner returned home to find the shredded papers and scold her she would act guilty. However, when the owner himself shredded the papers without the dog's knowledge, the dog "acted just as 'guilty' as when she herself

had created the mess." De Waal concludes that the "guilt" displayed by dogs is not true guilt but rather the anticipation of the behavior of an angry superior in a given situation.

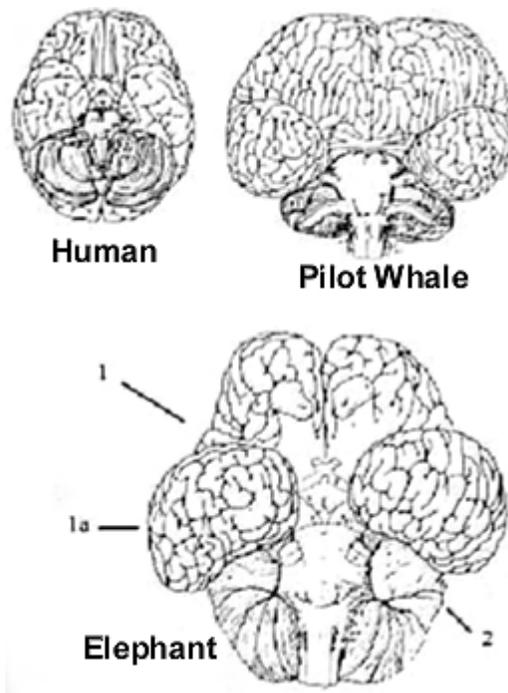
A recent study in the journal PNAS concluded that dogs can feel complex emotions, like jealousy.

Psychology research has shown that human faces are asymmetrical with the gaze instinctively moving to the right side of a face upon encountering other humans to obtain information about their emotions and state. Research at the University of Lincoln (2008) shows that dogs share this instinct when meeting a human being, and only when meeting a human being (i.e., not other animals or other dogs). As such they are the only non-primate species known to do so.

School psychologist Kathy Coon developed the first intelligence test for dogs in 1976 , with the work continuously revised through 2003. Assessments were developed to test short term memory, agility, ability to adapt, problem solving, unique detour problems, and to see how the dog reacts to conditions which he or she finds unacceptable. The performance of individual dogs was compared to over 100 dogs on which the test was standardized. Additional breed norms were developed in her book, *The Dog Intelligence Test*.

Chapter 9

Elephant Intelligence



Human, pilot whale and elephant brains up to scale. (1)-cerebrum (1a)-temporal lobe and (2)-cerebellum

Elephants are amongst the world's most intelligent species. With a mass of just over 5 kg (11 lb), elephant brains are larger than those of any other land animal, and although the largest whales have body masses twenty-fold those of a typical elephant, whale brains are barely twice the mass of an elephant's brain. The elephant's brain is similar to that of humans in terms of structure and complexity - such as the elephant's cortex having as many neurons as a human brain, suggesting convergent evolution.

Elephants exhibit a wide variety of behaviors, including those associated with grief, learning, allomothering, mimicry, art, play, a sense of humor, altruism, use of tools,

compassion, cooperation, self-awareness, memory and possibly language. All point to a highly intelligent species that are thought to be equal with cetaceans and primates. Due to the high intelligence and strong family ties of elephants, some researchers argue it is morally wrong for humans to cull them.

Aristotle once said that elephants were "The beast which passeth all others in wit and mind."

Brain structure

Cerebral cortex

The elephant (both Asian and African) has a very large and highly convoluted neocortex, a trait also shared by humans, apes and certain dolphin species. Scientists see this as a sign of complex intelligence. While this is the widely held belief, there is at least one exception: the echidna has a highly developed brain, yet is not considered to be intelligent. Asian elephants have the greatest volume of cerebral cortex available for cognitive processing of all existing land animals. Elephants have a volume of cerebral cortex available for cognitive processing that exceeds that of any primate species, and extensive studies place elephants in the category of great apes in terms of cognitive abilities for tool use and tool making.

The elephant brain exhibits a gyral pattern more complex and with more numerous convolutes, or brain folds, than that of humans, primates or carnivores, but less complex than cetaceans. However, the cortex of the elephant brain is "thicker than that of cetaceans" and is believed to have as many cortical neurons (nerve cells) and cortical synapses as that of humans, which exceeds that of cetaceans. Elephants are believed to rank equal with dolphins in terms of problem-solving abilities, and many scientists tend to rank elephant intelligence at the same level as cetaceans; in fact, a 2011 article published by ABC Science states that, "elephants [are as] smart as chimps, [and] dolphins".

Other features of the brain

Elephants also have a very large and highly convoluted hippocampus, a brain structure in the limbic system that is much bigger than that of any human, primate or cetacean. The hippocampus of an elephant takes up about 0.7% of the central structures of the brain, comparable to 0.5% for humans and with 0.1% in Risso's dolphins and 0.05% in bottlenose dolphins. The hippocampus is linked to emotion through the processing of certain types of memory, especially spacial. This is thought possibly to be why elephants suffer from psychological flashbacks and the equivalent of post-traumatic stress disorder (PTSD).

The encephalization quotient (EQ) of elephants "ranges from 1.13 to 2.36. The total EQ average is 1.88, with an average of 2.14 for Asian elephants, and 1.67 for African, There is considerable debate about whether the EQ, or size of the brain relative to body size, is

an accurate gauge for intelligence, especially since the animal with the highest EQ is a treeshrew yet they are not considered to be highly intelligent.

Brain size at birth relative to adult brain size

Like humans, elephants must learn behavior as they grow up. They are not born with the instincts of how to survive. Elephants have a very long period in their lives for learning, lasting for around ten years. One comparative way to try to gauge intelligence is to compare brain size at birth to the fully developed adult brain. This indicates how much learning a species accumulates while young. The majority of mammals are born with a brain close to 90% of the adult weight.

Humans are born with 28% of the adult weight, bottlenose dolphins with 42.5%, chimpanzees with 54%, and elephants with 35%. This indicates that elephants have the highest amount of learning to undergo next to humans, and behavior is not mere instinct but must be taught throughout life. It should be noted that instinct is quite different from learned intelligence. Parents will teach their young how to feed, use tools and learn their place in the highly complex elephant society. The cerebrum temporal lobes, which function as storage of memory, are much larger than those of a human.

Spindle neurons

Spindle cells appear to play a central role in the development of intelligent behavior. Initially, it was thought that the presence of spindle neurons was unique to humans and the great apes. However, studies have shown that spindle neurons are also found in the brains of both Asian and African elephants, as well as humpback whales, fin whales, killer whales, sperm whales, bottlenose dolphins, Risso's dolphins, and beluga whales. The remarkable similarity between the elephant brain and the human brain supports the thesis of convergent evolution.

Elephant society

The elephant has one of the most closely knit societies of any living species. Elephant families can only be separated by death or capture. Cynthia Moss, an ethologist specialising in elephants, recalls an event involving a family of African elephants. Two members of the family were shot by poachers, who were subsequently chased off by the remaining elephants. Although one of the elephants died, the other, named Tina, remained standing, but with knees beginning to give way. Two family members, Trista and Teresia (Tina's mother), walked to both sides of Tina and leaned in to hold her up. Eventually, Tina grew so weak, she fell to the ground and died. However, Trista and Teresia did not give up but continually tried to lift her. They managed to get Tina into a sitting position, but her body was lifeless and fell to the ground again. As the other elephant family members became more intensely involved in the aid, they tried to put grass into Tina's mouth. Teresia then put her tusks beneath Tina's head and front quarters and proceeded to lift her. As she did so, her right tusk broke completely off, right up to the lip and nerve cavity. The elephants gave up trying to lift Tina but did not leave her;

instead, they began to bury her in a shallow grave and throw leaves over her body. They stood over Tina for the night and then began to leave in the morning. The last to leave was Teresia.

Because elephants are so closely knit and highly matriarchal, a family can be devastated by the death of another (especially a matriarch), and some groups never recover their organization. Cynthia Moss has observed a mother, after the death of her calf, walk sluggishly at the back of a family for many days.

Edward Topsell stated in his publication *The History of Four-Footed Beasts* in 1658, "There is no creature among all the Beasts of the world which hath so great and ample demonstration of the power and wisdom of almighty God as the elephant." Of note, he stated in the same publication that elephants worship the sun and the moon and become pregnant by chewing on mandrake, neither of which are true. Elephants are believed to be on par with chimpanzees with regards to their cooperative skills.

Elephant altruism

Elephants are thought to be highly altruistic animals that will even aid other species, including humans, in distress. In India, an elephant was helping locals lift logs by following a truck and placing the logs in pre-dug holes upon instruction from the mahout (elephant trainer). At a certain hole, the elephant refused to lower the log. The mahout came to investigate the hold-up and noticed a dog sleeping in the hole. The elephant only lowered the log when the dog was gone.

Cynthia Moss has often seen elephants going out of their way to avoid hurting or killing a human, even when it was difficult for them (such as having to walk backwards to avoid a person).

Joyce Poole documented an encounter told to her by Colin Francombe on Kuki Gallman's Laikipia Ranch. A ranch herder was out on his own with camels when he came across a family of elephants. The matriarch charged at him and knocked him over with her trunk, breaking one of his legs. In the evening, when he did not return, a search party was sent in a truck to find him. When the party discovered him, he was being guarded by an elephant. The animal charged the truck, so they shot over her and scared her away. The herdsman later told them that when he could not stand up, the elephant used her trunk to lift him under the shade of a tree. She guarded him for the day and would gently touch him with her trunk.

Self-medication

Elephants in Africa will self-medicate by chewing on the leaves of a tree from the Boraginaceae family, which induces labor. Kenyans also use this tree for the same purpose.

Death ritual

Elephants are the only species on Earth other than *Homo sapiens sapiens* and Neanderthals known to have or have had any recognizable ritual around death. They show a keen interest in the bones of their own kind (even unrelated elephants that have died long ago). They are often seen gently investigating the bones with their trunks and feet and remaining very quiet. Sometimes elephants that are completely unrelated to the deceased will still visit their graves. When an elephant is hurt, other elephants (even if they are unrelated) will aid them.

Elephant researcher Martin Meredith recalls an occurrence in his book about a typical elephant death ritual that was witnessed by Anthony Michael Hall, a South African biologist who had studied elephants in Addo, South Africa, for over eight years. The entire family of a dead matriarch, including her young calf, were all gently touching her body with their trunks, trying to lift her. The elephant herd were all rumbling loudly. The calf was observed to be weeping and made sounds that sounded like a scream, but then the entire herd fell incredibly silent. They then began to throw leaves and dirt over the body and broke off tree branches to cover her. They spent the next two days quietly standing over her body. They sometimes had to leave to get water or food, but they would always return.

Occurrences of elephants behaving this way around human beings are common throughout Africa. On many occasions, they have buried dead or sleeping humans or aided them when they were hurt. Meredith also recalls an event told to him by George Adamson, a Kenyan Game Warden, regarding an old Turkana woman who fell asleep under a tree after losing her way home. When she woke up, there was an elephant standing over her, gently touching her. She kept very still, because she was very frightened. As other elephants arrived, they began to scream loudly and buried her under branches. She was found the next morning by the local herdsmen, unharmed.

George Adamson also recalls when he shot a bull elephant from a herd that kept breaking into the government gardens of Northern Kenya. George gave the elephant's meat to local Turkana tribesmen and then dragged the rest of the carcass half a mile away. That night, the other elephants found the body and took the shoulder blade and leg bone and returned the bones to the exact spot the elephant was killed. Scientists often debate the extent that elephants feel emotion.

Play

Joyce Poole on many occasions has observed wild African elephants at play. They apparently do things for their own and others' entertainment. Elephants have been seen sucking up water, holding their trunk high in the air, and then spraying the water like a fountain.

Mimicry

Recent studies have shown that elephants can also mimic sounds they hear. The discovery was found when Mlaika, an orphaned elephant, would copy the sound of trucks passing by. So far, the only other animals that are thought to mimic sounds are whales, dolphins, bats, primates and birds. Calimero, an African elephant who was 23 years old, also exhibited a unique form of mimicry. He was in a Swiss zoo with some Asian elephants. Asian elephants use chirps that are different from African elephants' deep rumbling noises. Calimero also began to chirp and not make the deep calls that his species normally would.

Kosik, an Indian elephant at Everland Amusement Park, South Korea, surprised trainers when they thought there was a person in his enclosure that was actually Kosik imitating Jong Gap Kim, his trainer. Kosik can make sounds imitating up to eight Korean words, including *sit*, *no*, *yes* and *lie down*. His mimicry is remarkably human-sounding. Kosik produces human-like sounds by putting his trunk in his mouth and then shaking it while breathing out, similar to how people whistle with their fingers. Elephants use contact calls to stay in touch with one another when they are out of one another's sight. Female elephants are able to remember and distinguish the contact calls of female family and bond group members from those of females outside of their extended family network. They can also distinguish between the calls of family units depending upon how frequently they came across them.

Tool use

Elephants show a remarkable ability to use tools, using their trunks like arms. Elephants have been observed digging holes to drink water and then ripping bark from a tree, chewing it into the shape of a ball, filling in the hole and covering over it with sand to avoid evaporation, then later going back to the spot for a drink. They also often use branches to swat flies or scratch themselves. Elephants have also been known to drop very large rocks onto an electric fence either to ruin the fence or to cut off the electricity.

Art



A painting elephant

Like several other species, elephants are able to produce abstract art using their trunks to hold brushes. An example of this was shown in the TV program *Extraordinary Animals*, in which elephants at a camp in Thailand were able to draw self-portraits with flowers. Although the images were drawn by the elephants, there was always a person assisting and guiding the movement. From those presentations, it cannot be definitely evaluated whether the elephants are conscious about the shape of their drawings or not.

This extraordinary video documentation of an elephant painting a picture of an elephant - possibly indicating self-awareness - has become widespread on internet news and video

websites. The quality of the painting is extremely high, leading many astonished viewers to doubt the video's authenticity.

Problem-solving ability

Elephants are able to spend a lot of time working on problems. They are able to change their behavior radically to face new challenges, a hallmark of complex intelligence. A 2010 experiment revealed that in order to reach food, "elephants can learn to coordinate with a partner in a task requiring two individuals to simultaneously pull two ends of the same rope to obtain a reward", putting them on an equal footing with chimpanzees in terms of their level of cooperative skills.

In the 1970s, at Marine World Africa, USA, there lived an Asian elephant named Bandula. Bandula worked out how to break open or unlock several of the pieces of equipment used to keep the shackles on her feet secure. The most complex device was a brommel hook, a device that closes when two opposite points are slid together. Bandula used to fiddle with the hook until it slid apart when it was aligned. Once she had freed herself, she would help the other elephants escape. In Bandula's case and certainly with other captive elephants, there was an element of deception involved during the escapes, such as the animals looking around making sure no one was watching.

In another case, a female elephant worked out how she could unscrew iron rods with an eye hole that were an inch thick. She used her trunk to create leverage and then untwist the bolt.

Ruby, an Asian elephant at Phoenix Zoo would often eavesdrop on conversations keepers would have talking about her. When she heard the word *paint*, she became very excitable. The colours she favoured were green, yellow, blue and red. On one particular day, there was a fire truck that came and parked outside her enclosure where a man had just had a heart attack. The lights on the truck were flashing red, white and yellow. When Ruby painted later on in the day, she chose those colours. She also showed a preference for particular colours that the keepers wore.

Harry Peachey, an elephant trainer, developed a cooperative relationship with an elephant named Koko. Koko would help out the keepers, "prompting" the keepers to encourage him with various commands and words that Koko would learn. Peachey stated that elephants are almost predisposed to cooperate and work with humans as long as they are treated with respect and sensitivity. Koko worked out when his keepers needed a bit of "elephant help" when they were transferring the females of the group to another zoo. When the keepers wanted to transfer a female, they would usually say her name, followed by the word *transfer* (e.g., "Connie transfer"). Koko soon figured out what this meant. If the keepers asked an elephant to transfer and they did not budge, they would say, "Koko, give me a hand." When he heard this, Koko would help. Peachey firmly believes that after 27 years of working with elephants, they can understand the semantics and syntax of some of the words they hear. This is something thought to be very rare in the animal kingdom.

A study by Dr. Naoko Irie of Tokyo University has shown that elephants demonstrate skills at arithmetic. The experiment "consist[ed] of dropping varying numbers of apples into two buckets in front of the [Ueno Zoo] elephants and then recording how often they could correctly choose the bucket holding the most fruit." When more than one apple was being dropped into the bucket, this meant that the elephants had to "keep running totals in their heads to keep track of the count." The results showed that "Seventy-four percent of the time, the animals correctly picked the fullest bucket. An African elephant named Ashya scored the highest with an amazing eighty-seven percent.... Humans in this same contest managed a success rate of just sixty-seven percent." The study was also filmed to ensure its accuracy.

Self-awareness

Asian Elephants have joined a small group of animals, including great apes, bottlenose dolphins and magpies, that exhibit self-awareness. The study was conducted with the Wildlife Conservation Society (WCS) using elephants at the Bronx Zoo in New York. Although many animals will respond to a mirror, very few show any evidence that they recognize it is in fact themselves in the mirror reflection.

The Asian elephants in the study also displayed this type of behavior when standing in front of a 2.5 m-by-2.5 m mirror - they inspected the rear and brought food close to the mirror for consumption.

Evidence of elephant self awareness was shown when the elephant Happy repeatedly touched a painted *X* on her head with her trunk, a mark which could only be seen in the mirror. Happy ignored another mark made with colourless paint that was also on her forehead to ensure she was not merely reacting to a smell or feeling.

Frans De Waal, who ran the study, stated, "These parallels between humans and elephants suggest a convergent cognitive evolution possibly related to complex society and cooperation."

Joyce Poole, of the Amboseli Elephant Research Project, Kenya, has demonstrated vocal learning and imitation in elephants of sounds made by each other and in the environment. She is beginning to research whether sounds made by elephants have dialects, a trait that is rare in the animal kingdom.

Self-awareness and culling

There has been considerable debate over the issue of culling African elephants in South Africa's Kruger National Park as a means of controlling the population. Some scientists and environmentalists argue that it is "unnecessary and inhumane" to cull them since "elephants resemble humans in a number of ways, not least by having massive brains, social bonds that appear to be empathetic, long gestations, high intelligence, offspring that require an extended period of dependent care, and long life spans. A South African Animal Rights group asked in a statement anticipating the announcement, 'How much

like us do elephants have to be before killing them becomes murder? ". Others argue that culling is necessary when biodiversity is threatened.

Chapter 10

Great Ape Language

Research into non-human **great ape language** has involved teaching chimpanzees, gorillas and orangutans to communicate with human beings and with each other using sign language, physical tokens, and lexigrams. Some primatologists argue that the primates' use of these tools indicates their ability to use "language", although this is not consistent with some definitions of that term.

Questions in animal language research

Animal language research attempts to answer the following questions:

- What problems can animals solve without language, and can they solve them better after they have received language training?
- Can the lessons learned in teaching animals be applied to human children?
- How, and how much, do animals' abilities to learn language differ from those of humans?
- Are the abilities that underlie language general or highly specialized?
- Where is the line between language and other forms of communication?

Apes that demonstrate understanding

Non-human animals have been recorded to have produced behaviors that are consistent with meanings accorded to human sentence productions. (A *production* is a stream of *lexemes* with semantic content. A language is grammar and a set of lexemes. A *sentence*, or statement, is a stream of lexemes that obeys a grammar, with a beginning and an end.) Some animals in the following species can be said to "understand" (*receive*), and some can "apply" (*produce*) consistent, appropriate, grammatical streams of communication. David Premack and Jacques Vauclair have cited language research for the following animals:

- Common Chimpanzees and Bonobos
- Gorillas

- Orangutans

Primate use of sign language

Sign language and computer keyboards are used in primate language research because non-human primates lack vocal cords and other human speech organs. However, primates do possess the manual dexterity required for keyboard operation.

Many researchers into animal language have presented the results of the studies described below as evidence of linguistic abilities in animals. Many of their conclusions have been disputed.

It is now generally accepted that Apes can learn to sign and are able to communicate with humans. However, it is disputed as to whether they can form syntax to manipulate such signs.

Washoe

Washoe, a Common Chimpanzee, was caught in the wild in 1966. When she was about ten months old, she was received by the husband-and-wife research team of Beatrix T. Gardner and R. Allen Gardner. Chimpanzees are completely dependent until two years of age and semi-dependent until the age of four. Full adult growth is reached between 12 and 16 years of age. So the Gardners received her at a good age for research into language development. The Gardners tried to make Washoe's environment as similar as possible to what a human infant with deaf parents would experience. There was always a researcher or assistant in attendance during Washoe's waking hours. Every researcher communicated with Washoe by using American Sign Language (ASL), minimizing the use of the spoken voice. The researchers acted as friends and companions to Washoe, using various games to make the learning as exciting as possible.

The Gardners used many different training methods:

- *Imitation*: After Washoe had learned a couple of words, she started, like chimpanzees usually do, to imitate naturally. For example, when she entered the Gardners' bathroom, she spontaneously made the sign for "toothbrush", simply because she saw one.
- *Babbling*: In this case, "babbling" does not mean vocal babbling. Instead, Washoe used untaught signs to express a desire. She used a begging gesture, which was not much different from the ASL signs "give me" and "come." (Human infants who are learning sign language often babble with their hands.)
- *Instrumental Conditioning*: The researchers used instrumental conditioning strategies with Washoe. For example, they taught the word "more" by using tickling as a reward. This technique was later applied to a variety of relevant situations.

The results of the Gardners' efforts were as follows:

- *Vocabulary*: When a sign was reported by three independent observers, it was added to a checklist. The sign had to occur in an appropriate context and without prompting. The checklist was used to record the frequency of a sign. A sign had to be used at least once a day for 15 consecutive days before it was deemed to have been acquired. Alternatively, a sign had to be used at least 15 days out of 30 consecutive days. By the end of the 22nd month of the project, thirty-four signs had been learned.
- *Differentiation*: Washoe used the sign "more" in many different situations until a more specific sign had been learned. At one point, she used the sign for "flower" to express the idea of "smell." After additional training, Washoe was eventually able to differentiate between "smell" and "flower."
- *Transfer*: Although the same object was presented for each learning trial (a specific hat, for example), Washoe was able to use the sign for other similar objects (e.g. other hats).
- *Combinations*: Washoe was able to combine two or three signs in an original way. For example, "open food drink" meant "open the fridge" and "please open hurry" meant "please open it quickly."

Nim Chimpsky

Linguistic critics challenged the animal trainers to demonstrate that Washoe was actually using language and not symbols. The *null hypothesis* was that the Gardners were using conditioning to teach the chimpanzee to use hand formations in certain contexts to create desirable outcomes, and that they had not learned the same linguistic rules that humans innately learn.

In response to this challenge, the chimpanzee Nim Chimpsky was taught to communicate using sign language in studies led by Herbert S. Terrace. In 44 months Nim Chimpsky learned 125 signs. However, linguistic analysis of Nim's communications demonstrated that Nim's use was symbolic, and lacked grammar, or rules, of the kind that humans use in communicating via language. This constitutes a chimpanzee vocabulary learning rate of roughly 0.1 words per day. This rate is not comparable to the average college-educated English-speaking human who learns roughly 14 words per day between ages 2 and 22.

Plastic tokens

Sarah and two other chimpanzees, Elizabeth and Peony, in the research programs of David Premack, demonstrated the ability to produce grammatical streams of token selections. The selections came from a vocabulary of several dozen plastic tokens; it took each of the chimpanzees hundreds of trials to reliably associate a token with a referent, such as an apple or banana. The tokens were chosen to be completely different in appearance from the referents. After learning these protocols, Sarah was then able to associate other tokens with consistent behaviors, such as negation, name-of, and if-then. The plastic tokens were placed on a magnetic slate, within a rectangular frame in a line. The tokens had to be selected and placed in a consistent order (a grammar) in order for the trainers to reward the chimpanzees.

One other chimpanzee, Gussie, was trained along with Sarah but failed to learn a single word. Other chimpanzees in the projects were not trained in the use of the tokens. All nine of the chimpanzees could understand gestures, such as supplication when asking for food; similarly, all nine could point to indicate some object, a gesture which is not seen in the wild. The supplication is seen in the wild, as a form of communication with other chimpanzees.

A juvenile Sumatran orangutan Aazk (named after the American Association of Zookeepers) who lived at the Roeding Park Zoo (Fresno, California) was taught by Gary L. Shapiro from 1973 to 1975 how to "read & write" with plastic children's letters, following the training techniques of David Premack. The technique of conditional discrimination was used such that the orangutan could eventually distinguish plastic letter (symbols) as representations of referents (e.g., object, actions) and "read" an increasingly longer series of symbols to obtain a referent (e.g., fruit) or "write" an increasingly longer series of symbols to request or describe a referent. While no claim of linguistic competence was made, Aazk's performance demonstrated design features of language, many similar to those demonstrated by Premack's chimpanzee, Sarah.

Kanzi

Kanzi, a Bonobo, is believed to understand more human language than any other nonhuman animal in the world. Kanzi apparently learned by eavesdropping on the keyboard lessons researcher Sue Savage-Rumbaugh was giving to his adoptive mother. Kanzi learned to communicate with a Lexigram board, pushing symbols that stand for words. The board is wired to a computer, so the word is then vocalized out loud by the computer. This helps Kanzi develop his vocabulary and enables him to communicate with researchers.

One day, Rumbaugh used the computer to say to Kanzi, "Can you make the dog bite the snake?" It is believed Kanzi had never heard this sentence before. In answering the question, Kanzi searched among the objects present until he found a toy dog and a toy snake, put the snake in the dog's mouth, and used his thumb and finger to close the dog's mouth over the snake. In 2001, Alexander Fiske-Harrison, writing in the *Financial Times*, observed that "asked by an invisible interrogator through head-phones (to avoid cueing) to identify 35 different items in 180 trials. His success rate was 93 per cent." In further testing beginning when he was 7 ½ years old, Kanzi was asked 416 complex questions, responding correctly over 74% of the time. Kanzi has been observed verbalizing a meaningful noun to his sister.

Criticisms of primate language research

Some scientists, including MIT linguist Noam Chomsky and cognitive scientist Steven Pinker, are skeptical about claims made for great ape language research. Among the reasons for skepticism are the differences in ease with which human beings and apes can learn language, questions as to the whether there is a clear beginning and end to the

signed gestures, and whether the apes actually understand language or are simply doing a clever trick for a reward.

While vocabulary words from American Sign Language are used to train the apes, native users of ASL note that mere knowledge of ASL's vocabulary does not equate to ASL, but more closely reflects Pidgin Signed English which is not a full-fledged language. In the research involving Washoe, all researchers returned lists of signs Washoe used, with the exception of the one deaf native ASL user who reported no signs but many gestures. Native users of ASL make clear distinctions about what handshapes, palm orientations and places of articulation signs must have to constitute linguistic activity. Signs must also be used combinatorially and in the correct grammatical sequence. Thus apes are seen as attempting to approximate these complex rules but are considered to be failing because of such malformations in the production of ASL signs. (However, proponents argue that such limitations might indicate instead that great ape ASL use more closely approximates a rudimentary stage of a young child's language development, or an early stage of an adult second language learner.)

Chapter 11

Human-Animal Communication

Human-animal communication is easily observed in everyday life. The interactions between pets and their owners, for example, reflect a form of spoken, while not necessarily verbal, dialogue. A dog being scolded does not need to understand every word of its admonishment, but is able to grasp the message by interpreting cues such as the owner's stance, tone of voice, and body language. This communication is two-way, as owners can learn to discern the subtle differences between barks and meows ... one hardly has to be a professional animal trainer to tell the difference between the bark of an angry dog defending its home and the happy bark of the same animal while playing. Communication (often nonverbal) is also significant in equestrian activities such as dressage.

Word repetition in birds

Although the word repetition skills observed in some birds (most famously parrots) should not be mistaken for lingual communication, this tendency has nonetheless influenced fictional portrayals of animal communication, as sentient talking parrots and similar birds are common in children's fiction, such as the talking, loud-mouth parrot Iago of Disney's *Aladdin*. Bruce Thomas Boehner's book *Parrot Culture: Our 2,500-Year-Long Fascination with the World's Most Talkative Bird* explores this issue thoroughly.

The next level: language

Achieving a deeper level of communication between animals and humans has long been a goal of science. Perhaps the most famous example of recent decades has been Koko, a gorilla who is supposedly able to communicate with humans using a system based on American Sign Language with a "vocabulary" of over 1000 words.

John Lilly and Cetacean Communication

In the 1960s, John Lilly, M.D., prolific writer and explorer of consciousness via the isolation tank (his invention) and LSD, and contemporary and associate of Timothy

Leary, began experiments in the Virgin Islands aiming to establish meaningful communication between humans and the bottlenose dolphin (*Tursiops truncatus*). Lilly financed, mostly personally, a human-dolphin cohabitat, a house on the ocean's shore that contained an area that was partially flooded and allowed a human and dolphin to live together in the same space, sharing meals, play, language lessons, and even sleep.

Two experiments of this sort are explained in detail in Lilly's popular books. The first experiment was more of a test run to check psychological and other strains on the human and cetacean participants, determining the extent of the need for other human contact, dry clothing, time alone, and so on. Despite tensions after several weeks, the experimenter, Margaret C. Howe, agreed to a two-and-a-half month experiment, living isolated with 'Peter' dolphin.

A basic outline of Peter dolphin's linguistic progress is as follows: early lessons involved mostly noise and interruptions from Peter during English lessons, and a food reward of fish was necessary for him to 'attend class.' After several weeks, a concerted effort by Peter to imitate the instructor's speech was evident, and human-like sounds were apparent, and recorded. More interesting was the dolphin's immediate grasp of basic semantics, such as the different aural indicators for 'ball' and 'doll' and other toys present in the aquarium. Peter was able to perform tasks such as retrieval on the (aurally) indicated object without fail. Later in the project the dolphin's ability to process linguistic syntax was made apparent, in that Peter could distinguish between the commands (e.g., only) "Bring the ball to the doll," and "Bring the doll to the ball." This ability not only demonstrates the bottlenose dolphin's grasp of basic grammar, but also implies the dolphins' own language must include some such syntactical rules. The correlation between length and 'syllables' (bursts of the dolphin's sound) with the instructor's speech also went from essentially zero at the beginning of the session to almost a perfect correlation by its completion. I.e., a sentence spoken by the instructor involving 35 syllables and lasting 8 seconds would be met with an 8-second burst of sound from Peter dolphin involving 35 easily-discernible 'syllables' or bursts of sound.

Much later, experiments by Louis Herman, a former collaborator and student of Lilly's, demonstrated the crossmodal perceptual ability of dolphins. Dolphins typically perceive their environment through sound waves generated in the melon of their skulls, through a process known as echolocation (similar to that seen in bats, though the mechanism of production is different). The dolphin's eyesight however is also fairly good, even by human standards, and Herman's research found that any object, even of complex and arbitrary shape, identified either by sight or sound by the dolphin, could later be correctly identified by the dolphin with the alternate sense modality with almost 100 per cent accuracy, in what is classically known in psychology and behaviorism as a match-to-sample test. The only errors noted were presumed to have been a misunderstanding of the task during the first few trials, and not an inability of the dolphin's perceptual apparatus. This capacity is strong evidence for abstract and conceptual thought in the dolphin's brain, wherein an idea of the object is stored and understood not merely by its sensory properties; such abstraction may be argued to be of the same kind as complex language, mathematics, and art, and implies a potentially very great intelligence and conceptual

understanding within the brains of tursiops and possibly many other cetaceans. Accordingly, Lilly's interest later shifted to whale song and the possibility of high intelligence in the brains of large whales, and Louis Herman's research at the now misnomered Dolphin Institute in Honolulu, Hawaii, focuses exclusively on the Humpback whale.

Animal communication as entertainment

Though animal communication has always been a topic of public comment and attention, for a period in history it surpassed this and became sensational popular entertainment. From the late 18th century through the mid 19th century, a succession of "learned pigs" and various other animals were displayed to the public in for-profit performances, boasting the ability to communicate with their owners (often in more than one language), write, solve math problems, and the like. One poster dated 1817 shows a group of "Java sparrows" who are advertised as knowing *seven languages*, including Chinese and Russian. One pig of the era was so famous that it performed for royalty, and an obituary upon its death claimed that it made more money than any actor or actress of the same time; a fact that, whether strictly true, was at least believable to contemporary readers. By the late 1840s the fad had died down considerably. While the occasional appearance by a "learned" animal continued into the radio and television eras, it was by then generally understood that feats such as using cards to spell words, barking or tapping a hoof to solve equations, and the like were the products of training rather than actual *communication*. Though the tradition continues to this day on the "Stupid Pet Tricks" segment of Late Night with David Letterman, it seems likely that the era of trained pigs entertaining the crowned heads of Europe are over.

BowLingual

One real-world example of a technological means of one-way human-animal communication is BowLingual, a Japanese device which claims to translate barks from dozens of different breeds of dogs, including mixed-breeds. Based largely on Dr. Matsumi Suzuki's Animal Emotion Analysis System developed at Japan Acoustic Laboratory, the device outputs one of 200 phrases (grouped into six different moods), supposedly reflecting "meaning" of the dog's bark. The device was apparently successful enough in Japan to be brought to the American market, and was even named one of 2002's best inventions by Time Magazine. However, reports of the BowLingual's accuracy have been mixed at best, with popular product-review website Epinions giving it a low 1.5 stars average.

Human-animal communication in culture

The concept of human-animal communication has existed in culture for longer than recorded history, being an element of many myths and folk tales of numerous cultures, and continues in modern popular entertainment. Here we lists some examples of this, divided by the method of communication (magical/supernatural, innate natural ability, technological, and unspecified/misc).

Magic and supernatural

- In many fantasy role playing games, Druid characters are able to speak with animals through the use of a spell. The Dungeons & Dragons version of this spell is called "Speak with Animals".
- Eliza Thornberry of Nickelodeon's animated TV series *The Wild Thornberrys* can speak with animals after a spell is placed on her by an African tribal shaman.
- In the Harry Potter series of books, Harry is a parselmouth (able to speak with snakes in their own language, parseltongue, which sounds like hissing and spitting to the ears of those without this (apparently hereditary) skill).
- In *The Immortals* series of books, Veralidaine Sarrasri (Daine) has "wild magic" which enables her to communicate with animals. After being trained in the use of her wild magic, she learns to enter the minds of animals and shapeshift.

Innate ability

- Cypher, real name Douglas Ramsey, of Marvel Comics' *The New Mutants*, has a "mutant" ability to instantly translate any language he hears or sees, including animal languages.
- Doctor Dolittle, subject of a series of children's books by Hugh Lofting as well as various film and stage adaptations, is a doctor whose ability to speak with animals makes him successful in dealing with animals but closes him off from most humans.

Technological

- In *Star Trek*, the communicator badges worn by Starfleet crew members allow direct translation between humans and various sentient and semi-sentient aliens and creatures, though it is undetermined whether they work with "dumb" animals. It is presumed that this is not possible, as the relatively few domesticated animals seen on the show do not appear to converse with their owners (Data's cat, and Archer's beagle, for example). The council-chamber of the Xindi accommodates her Aquatic members in a water-tank.
- In issue 285 of DC's *Detective Comics*, Martian Manhunter fights a brigade of "Martian mandrills" which were being manipulated by villains through the use of a communicator device stolen from the mandrills' rocket.
- On the television cartoon *Krypto the Superdog*, Krypto has an "intergalactic communicator" device in his dog tag, which allows Kevin Whitney to communicate with him. The device is technology from Krypton, Superman's homeworld.

Unspecified and miscellaneous

- In Hergé's *Tintin* comics, Tintin's dog Snowy is sentient and able to "think". Although his thoughts are written in word bubbles rather than thought bubbles, it is generally assumed that the human characters cannot understand him. Once, in

the early volume *Tintin in America*, Tintin was able to directly understand Snowy. Hergé did not elaborate on why this was so; presumably it was used simply to advance the plot and not to bog down the story with a "talking dog" element.

- The American television show Mr. Ed centers around a horse's ability to communicate with his owner, Wilbur. The plot of this television series was inspired by the movie character Francis the Talking Mule.

Chapter 12

Primate Cognition

Primate cognition is the cognitive abilities of non-human primates. Humans are primates too but, traditionally, humans are thought to be different from other animals. Darwin may have been the first to think otherwise when he jotted in his notebook:

Origin of man now proved. Metaphysic must flourish. He who understands baboon would do more for metaphysics than Locke.

—Charles Darwin, 1838

Primates are capable of high levels of cognition; some make tools and use them to acquire foods and for social displays; some have sophisticated hunting strategies requiring cooperation, influence and rank; they are status conscious, manipulative and capable of deception; they can recognise kin and conspecifics; they can learn to use symbols and understand aspects of human language including some relational syntax, concepts of number and numerical sequence.

Studies in primate cognition

Theory of mind

Premack and Woodruff's 1978 article "Does the chimpanzee have a theory of mind?" was a contentious issue because of the problem of inferring from animal behavior the existence of thinking, of the existence of a concept of self or self-awareness, or of particular thoughts.

Non-human research still has a major place in this field, however, and is especially useful in illuminating which nonverbal behaviors signify components of theory of mind, and in pointing to possible stepping points in the evolution of what many claim to be a uniquely human aspect of social cognition. While it is difficult to study human-like theory of mind and mental states in species which we do not yet describe as "minded" at all, and about whose potential mental states we have an incomplete understanding, researchers can focus on simpler components of more complex capabilities.

For example, many researchers focus on animals' understanding of intention, gaze, perspective, or knowledge (or rather, what another being has seen). Part of the difficulty in this line of research is that observed phenomena can often be explained as simple stimulus-response learning, as it is in the nature of any theorizers of mind to have to extrapolate internal mental states from observable behavior. Recently, most non-human theory of mind research has focused on monkeys and great apes, who are of most interest in the study of the evolution of human social cognition.

There has been some controversy over the interpretation of evidence purporting to show theory of mind ability—or inability—in animals. Two examples serve as demonstration: first, Povinelli et al. (1990) presented chimpanzees with the choice of two experimenters from which to request food: one who had seen where food was hidden, and one who, by virtue of one of a variety of mechanisms (having a bucket or bag over his head; a blindfold over his eyes; or being turned away from the baiting) does not know, and can only guess. They found that the animals failed in most cases to differentially request food from the "knower." By contrast, Hare, Call, and Tomasello (2001) found that subordinate chimpanzees were able to use the knowledge state of dominant rival chimpanzees to determine which container of hidden food they approached.

Tomasello and like-minded colleagues who originally argued that great apes did not have theory of mind have since reversed their position. Povinelli and his colleagues, however, maintain that Tomasello's group has misinterpreted the results of their experiments. They point out that most evidence in support of great ape theory of mind involves naturalistic settings to which the apes may have already adapted through past learning. Their "reinterpretation hypothesis" explains away all current evidence supporting attribution of mental states to others in chimpanzees as merely evidence of risk-based learning; that is, the chimpanzees learn through experience that certain behaviors in other chimpanzees have a probability of leading to certain responses, without necessarily attributing knowledge or other intentional states to those other chimpanzees. They therefore propose testing theory of mind abilities in great apes in novel, and not naturalistic settings. Kristin Andrews takes the reinterpretation hypothesis one step further, arguing that it implies that even the well-known false-belief test used to test children's theory of mind is susceptible to being interpreted as a result of learning.

Language

The modeling of human language in animals is known as animal language research. Nim Chimpsky, a chimpanzee, was successfully taught 125 signs during his life, though some disagree that this really constituted language. There have been other, more successful animal language projects.

Tool use

Research in 2007 shows that chimpanzees in the Fongoli savannah sharpen sticks to use as spears when hunting, considered the first evidence of systematic use of weapons in a species other than humans.

Problem solving

In 1913, Wolfgang Köhler started writing a book on problem solving titled *The Mentality of Apes* (1917). In this research, Köhler observed the manner in which chimpanzees solve problems, such as that of retrieving bananas when positioned out of reach. He found that they stacked wooden crates to use as makeshift ladders, in order to retrieve the food. If the bananas were placed on the ground outside of the cage, they used sticks to lengthen the reach of their arms.

Köhler concluded that the chimps had not arrived at these methods through trial-and-error (which American psychologist Edward Thorndike had claimed to be the basis of all animal learning, through his law of effect), but rather that they had experienced an insight (also sometimes known as an “aha experience”), in which, having realized the answer, they then proceeded to carry it out in a way that was, in Köhler’s words, “unwaveringly purposeful.”

Asking questions and giving negative answers

In the 1970s and the 1980s there had been suggestions that apes are unable to ask questions and to give negative answers. According to the numerous published studies apes are able to answer human questions, and the vocabulary of the acculturated apes contains question words. Despite these abilities, according to the published research literature, apes are not able to ask questions themselves, and in human-primate conversations questions are asked by the humans only. Ann and David Premacks designed a potentially promising methodology to teach apes to ask questions in the 1970s: “In principal interrogations can be taught either by removing an element from a familiar situation in the animal’s world or by removing the element from a language that maps the animal’s world. It is probable that one can induce questions by purposefully removing key elements from a familiar situation. Suppose a chimpanzee received its daily ration of food at a specific time and place, and then one day the food was not there. A chimpanzee trained in the interrogatives might inquire ‘Where is my food?’ or, in Sarah’s case ‘My food is ?’ Sarah was never put in a situation that might induce such interrogation because for our purposes it was easier to teach Sarah to answer questions”.

A decade later Premacks wrote: "Though she [Sarah] understood the question, she did not herself ask any questions -- unlike the child who asks interminable questions, such as What that? Who making noise? When Daddy come home? Me go Granny's house? Where puppy? Sarah never delayed the departure of her trainer after her lessons by asking where the trainer was going, when she was returning, or anything else".

Despite all their achievements, Kanzi and Panbanisha also have not demonstrated the ability to ask questions so far. Joseph Jordania suggested that the ability to ask questions could be the crucial **cognitive threshold** between human and ape mental abilities. Jordania suggested that asking questions is not a matter of the ability of using syntactic structures, it is primarily a matter of cognitive ability. Questions can be (and are) asked

without the use of syntactic structures, with the help of the questions intonation only (like this is the case in children's early pre-linguistic development).

Chapter 13

Whale Sounds



Humpback whales are well known for their songs

Whale sounds are the sounds made by whales and which are used for different kinds of communication.

The word "song" is used to describe the pattern of regular and predictable sounds made by some species of whales, notably the Humpback Whale. This is included with or in comparison with music, and male humpback whales have been described as "inveterate composers" of songs that are "strikingly similar" to human musical traditions". Male Humpback whales sing only on calving grounds and only in the mating period and humpback songs are similar, almost identical, within a single population. It has been suggested that humpback songs communicate male fitness to female whales. The click sounds made by Sperm whales and dolphins are not strictly song, but the clicking sequences have been suggested to be individualized rhythmic sequences that

communicate the identity of a single whale to other whales in its group and allows the groups to coordinate foraging activities.

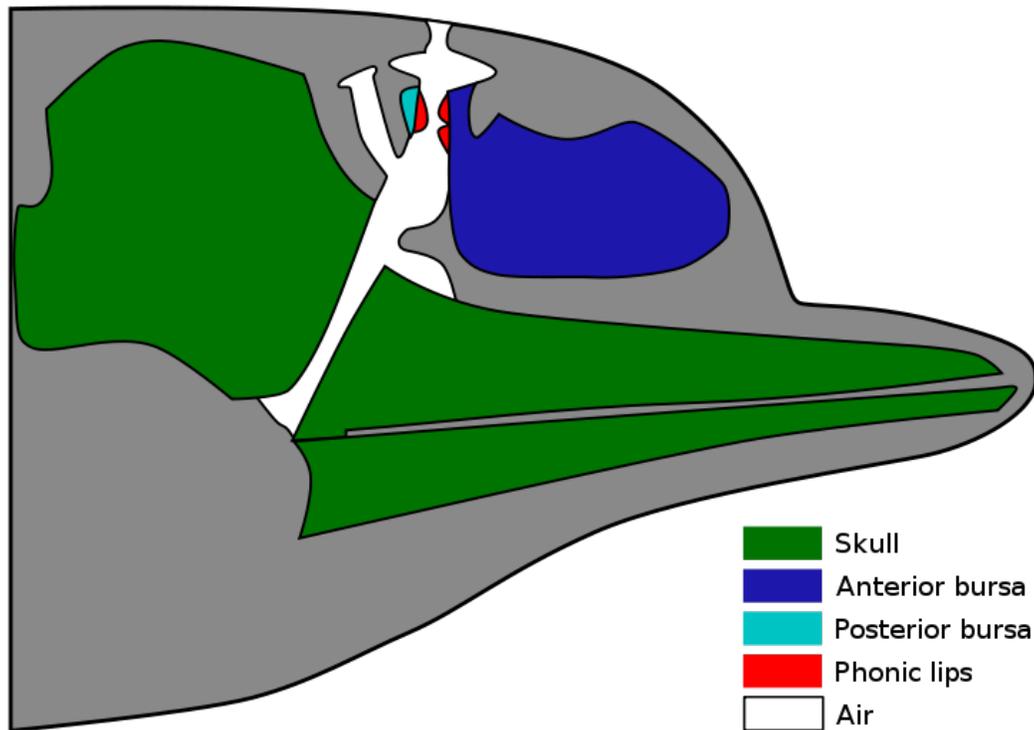
The mechanisms used to produce sound vary from one family of cetaceans to another. Marine mammals, such as whales, dolphins, and porpoises, are much more dependent on sound for communication and sensation than are land mammals, because other senses are of limited effectiveness in water. Sight is less effective for marine mammals because of the way water absorbs light. Smell also is limited, as molecules diffuse more slowly in water than in air, which makes smelling less effective. However, the speed of sound is roughly four times greater in water than in the atmosphere at sea level. Because sea mammals are so dependent on hearing to communicate and feed, environmentalists and cetologists are concerned that they are being harmed by the increased ambient noise in the world's oceans caused by ships, sonar and marine seismic surveys.

Production of sound

Humans produce sound by expelling air through the larynx. The vocal cords within the larynx open and close as necessary to separate the stream of air into discrete pockets of air. These pockets are shaped by the throat, tongue, and lips into the desired sound, allowing humans to speak.

Cetacean sound production differs markedly from this mechanism. The precise mechanism differs in the two major suborders of cetaceans: the *Odontoceti* (toothed whales—including dolphins) and the *Mysticeti* (baleen whales—including the largest whales, such as the Blue Whale).

Odontocete whale sound production



Idealized dolphin head showing the regions involved in sound production. This image was redrawn from Cranford (2000).

Toothed whales do not make the long, low-frequency sounds known as the whale song. Instead, they produce rapid bursts of high-frequency clicks and whistles. Single clicks are generally used for echolocation whereas collections of clicks and whistles are used for communication. Though a large pod of dolphins will produce a wide range of different noises, very little is known about the meaning of the sound. Frankel quotes one researcher who says listening to a school of odontocetes is like listening to a group of children at a school playground.

The multiple sounds odontocetes make are produced by passing air through a structure in the head called the **phonic lips**. This structure functions like the human nasal cavity. As the air passes through this narrow passage, the phonic lip membranes are sucked together, causing the surrounding tissue to vibrate. These vibrations can, as with the vibrations in the human larynx, be consciously controlled with great sensitivity. The vibrations pass through the tissue of the head to the melon, which shapes and directs the sound into a beam of sound useful in echolocation. Every toothed whale except the sperm whale has two sets of phonic lips and is thus capable of making two sounds independently. Once the air has passed the phonic lips it enters the vestibular sac. From there, the air may be

recycled back into the lower part of the nasal complex, ready to be used for sound creation again, or passed out through the blowhole.

The French name for phonic lips, *museau de singe*, translates literally as "monkey's muzzle," which the phonic lip structure is supposed to resemble. New cranial analysis using computed axial and single photon emission computed tomography scans in 2004 showed, at least in the case of bottlenose dolphins, that air might be supplied to the nasal complex from the lungs by the palatopharyngeal sphincter, enabling the sound creation process to continue for as long as the dolphin is able to hold its breath.

Mysticete whale sound production

Baleen whales (formally called mysticetes) do not have phonic lip structure. Instead, they have a larynx that appears to play a role in sound production, but it lacks vocal cords and scientists remain uncertain as to the exact mechanism. The process, however, cannot be completely analogous to humans, because whales do not have to exhale in order to produce sound. It is likely that they recycle air around the body for this purpose. Cranial sinuses may also be used to create the sounds, but again researchers are currently unclear how.

Mysticete whale sound levels

The frequency of baleen whale sounds ranges from 10 Hz to 31 kHz. A list of typical levels is shown in the table below.

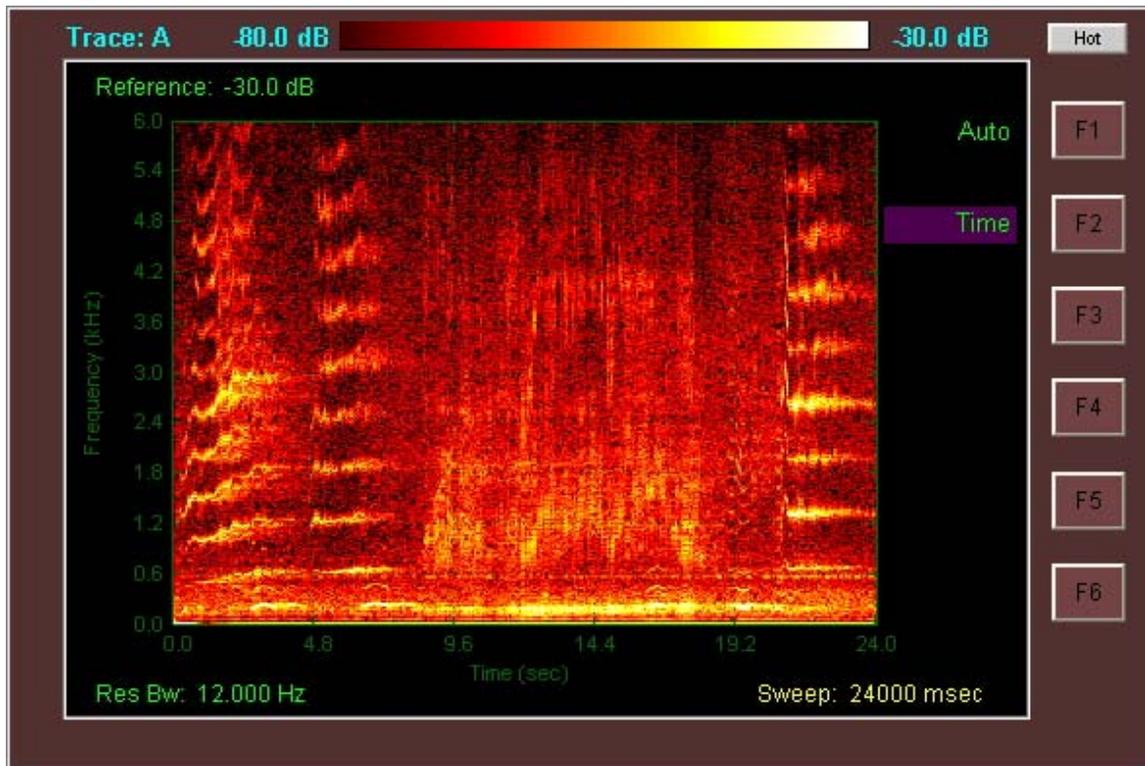
Source	Broadband source level (dB re 1 μPa at 1m)
Fin whale moans	155–186
Blue whale moans	155–188
Gray whale moans	142–185
Bowhead whale tonals, moans and song	128–189

Purpose of whale-created sounds

While the complex sounds of the Humpback whale (and some blue whales) are believed to be primarily used in sexual selection, the simpler sounds of other whales have a year-round use. While toothed whales are capable of using echolocation to detect the size and nature of objects, this capability has never been demonstrated in baleen whales. Further, unlike some fish such as sharks, a whale's sense of smell is not highly developed. Thus, given the poor visibility of aquatic environments and that sound travels so well in water, sounds audible to humans may play a role in navigation. For instance, the depth of water or the existence of a large obstruction ahead may be detected by loud noises made by baleen whales.

The singing of whale songs for aesthetic enjoyment, personal satisfaction, or 'for art's sake', is "an untestable question in scientific terms."

Song of the Humpback Whale



Spectrogram of Humpback Whale vocalizations. Detail is shown for the first 24 seconds of the 37 second recording Humpback Whale "Song".

Two groups of whales, the Humpback Whale and the subspecies of Blue Whale found in the Indian Ocean, are known to produce a series of repetitious sounds at varying frequencies. This is known as whale song. Marine biologist Philip Clapham describes the song as "probably the most complex in the animal kingdom".

Male humpback whales perform these vocalizations only during the mating season, and so it is believed the purpose of songs is to aid sexual selection. Whether the songs are a competitive behavior between males seeking the same mate, a means of defining territory or a "flirting" behavior from a male to a female is not known and the subject of ongoing research. Males have been observed singing while simultaneously acting as an "escort" whale in the immediate vicinity of a female. Singing has also been recorded in competitive groups of whales that are composed of one female and multiple males.

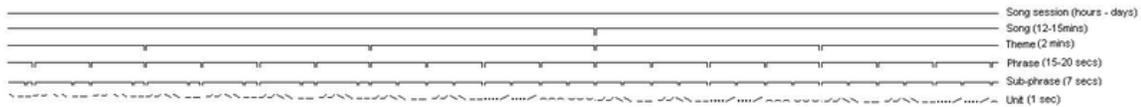
Interest in whale song was aroused by researchers Roger Payne and Scott McVay after the songs were brought to their attention by a Bermudian named Frank Watlington who was working for the US government at the SOFAR station listening for Russian submarines with underwater hydrophones off the coast of the island.

The songs follow a distinct hierarchical structure. The base units of the song (sometimes loosely called the "notes") are single uninterrupted emissions of sound that last up to a

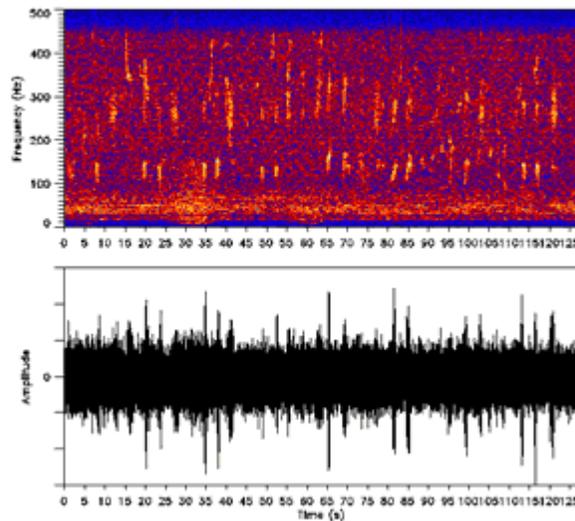
few seconds. These sounds vary in frequency from 20 Hz to 10 kHz (the typical human range of hearing is 20 Hz to 20 kHz). The units may be frequency modulated (i. e., the pitch of the sound may go up, down, or stay the same during the note) or amplitude modulated (get louder or quieter). However the adjustment of bandwidth on a spectrogram representation of the song reveals the essentially pulsed nature of the FM sounds.

A collection of four or six units is known as a sub-phrase, lasting perhaps ten seconds. A collection of two sub-phrases is a phrase. A whale will typically repeat the same phrase over and over for two to four minutes. This is known as a theme. A collection of themes is known as a song. The whale will repeat the same song, which last up to 30 or so minutes, over and over again over the course of hours or even days. This "Russian doll" hierarchy of sounds has captured the imagination of scientists.

All the whales in an area sing virtually the same song at any point in time and the song is constantly and slowly evolving over time. For example, over the course of a month a particular unit that started as an "upsweep" (increasing in frequency) might slowly flatten to become a constant note. Another unit may get steadily louder. The pace of evolution of a whale's song also changes—some years the song may change quite rapidly, whereas in other years little variation may be recorded.



Idealized schematic of the song of a humpback whale.
Redrawn from Payne, et al. (1983)



Humpback whale, sound spectrum and time plots

Whales occupying the same geographical areas (which can be as large as entire ocean basins) tend to sing similar songs, with only slight variations. Whales from non-overlapping regions sing entirely different songs.

As the song evolves, it appears that old patterns are not revisited. An analysis of 19 years of whale songs found that while general patterns in song could be spotted, the same combination never recurred.

Humpback whales may also make stand-alone sounds that do not form part of a song, particularly during courtship rituals. Finally, humpbacks make a third class of sound called the feeding call. This is a long sound (5 to 10 s duration) of near constant frequency. Humpbacks generally feed cooperatively by gathering in groups, swimming underneath shoals of fish and all lunging up vertically through the fish and out of the water together. Prior to these lunges, whales make their feeding call. The exact purpose of the call is not known, but research suggests that fish know what it means. When the sound was played back to them, a group of herring responded to the sound by moving away from the call, even though no whale was present.

Some scientists have proposed that Humpback Whale songs may serve an echolocative purpose, but this has been subject to disagreement.

Other whale sounds

Humpback whales have also been found to make a range of other social sounds to communicate such as "grunts", "groans", "thwops", "snorts" and "barks".

Most baleen whales make sounds at about 15–20 hertz. However, marine biologists, led by Mary Ann Daher, at the Woods Hole Oceanographic Institution reported in *New Scientist* in December 2004 that she had been tracking a whale in the North Pacific for 12 years that was "singing" at 52 Hz. The scientists are unable to explain this dramatic difference from the norm; however, they believe the whale is baleen and unlikely to be a new species, suggesting that currently known species may have a wider vocal range than previously thought.

In 2009, researchers found that blue whale song has been deepening in its tonal frequency since the 1960s. While noise pollution has increased ambient ocean noise by over 12 decibels since the mid-20th century, researcher Mark McDonald indicated that higher pitches would be expected if the whales were straining to be heard.

Most other whales and dolphins produce sounds of varying degrees of complexity. Of particular interest is the Beluga (the "sea canary") which produces an immense variety of whistles, clicks and pulses.

Human interaction



Voyager Golden Records carried whale songs into outer space with other sounds representing planet Earth.

Though some observers suggest that undue fascination has been placed on the whales' songs simply because the animals are under the sea, most marine mammal scientists believe that sound plays a particularly vital role in the development and well-being of cetaceans.

Researchers use hydrophones (often adapted from their original military use in tracking submarines) to ascertain the exact location of the origin of whale noises. Their methods allow them also to detect how far through an ocean a sound travels. Research by Dr.

Christopher Clark of Cornell University conducted using military data showed that whale noises travel for thousands of kilometres. As well as providing information about song production, the data allows researchers to follow the migratory path of whales throughout the "singing" (mating) season. One important finding is that whales in a process called the Lombard effect adjust their song to compensate for background noise pollution.

Prior to the introduction of human noise production, Clark says the noises may have travelled right from one side of an ocean to the other, agreeing with a thirty-year-old concept blaming large-scale shipping. His research indicates that ambient noise from boats is doubling with each decade. This has the effect of reducing the range at which whale noises can be heard. Clark admitted to being particularly concerned by this increase in ambient noise. Environmentalists fear that such boat activity is putting undue stress on the animals as well as making it difficult to find a mate.

Chapter 14

African Grey Parrot

African Grey Parrot



Congo African Grey Parrot



Timneh African Grey Parrot

Conservation status



Near Threatened (IUCN 3.1)

Scientific classification [e]

Kingdom: Animalia

Phylum: Chordata

Class: Aves

Order: Psittaciformes
Family: Psittacidae
Genus: *Psittacus*
Linnaeus, 1758
Species: *P. erithacus*

Binomial name

Psittacus erithacus
Linnaeus, 1758

Subspecies

- *Psittacus erithacus erithacus*
Linnaeus, 1758
- *Psittacus erithacus timneh*
Fraser, 1844



Ranges shown by the red areas

The **African Grey Parrot** (*Psittacus erithacus*), also known as the **Grey Parrot**, is a medium-sized parrot found in the primary and secondary rainforest of West and Central Africa. Experts regard it as one of the most intelligent birds. They feed primarily on palm nuts, seeds, fruits, leafy matter, but have been observed eating snails. Their overall gentle nature and their inclination and ability to mimic speech have made them popular pets. This has led many to be captured from the wild and sold into the pet trade. The African Grey Parrot is listed on CITES appendix II, which restricts trade of wild caught species, because wild populations can not sustain trapping for the pet trade. As a pet, they must be entertained, or they start to pluck their feathers. With good care and diet, the African Grey parrot can live up to 70 years of age in captivity.

Taxonomy and systematics

There are two subspecies universally accepted:

- **Congo African Grey Parrot** (*Psittacus erithacus erithacus*):
This is the nominate subspecies, larger than the Timneh at about 33 cm (13 in) long, with light grey feathers, cherry red tails, and an all black beak. Immature birds of this subspecies have tails with a darker, duller red towards the tip (Juniper and Parr 1999) until their first moult which occurs within 18 months of age. These birds also initially have grey irises which change to a pale yellow colour by the

time the bird is a year old. The Congo grey parrot is found on the islands of Príncipe and Bioko and is distributed from south-eastern Ivory Coast to Western Kenya, Northwest Tanzania, Southern Democratic Republic of the Congo (DRC) and Northern Angola. In aviculture, it is often called a "CAG".

- **Timneh African Grey Parrot** (*Psittacus erithacus timneh*):
These are smaller in size, have a darker charcoal grey colouring, a darker maroon tail, and a light, horn-coloured area to part of the upper mandible. The timneh grey parrot is endemic to the western parts of the moist Upper Guinea forests and bordering savannas of West Africa from Guinea-Bissau, Sierra Leone and Southern Mali east to at least 70 km (43 mi) east of the Bandama River in Ivory Coast. It is often called a "TAG". As pets Timnehs begin learning to speak earlier than Congos, and are often said to be less nervous around strangers and novel situations.

Some aviculturalists recognize a third and even a fourth subspecies, but these are not distinguishable in scientific studies.

Status and conservation



Timneh African Grey Parrot (wings clipped)

Rarer than previously believed, it is uplisted from a species of Least Concern to Near Threatened in the 2007 IUCN Red List. A recent analysis suggests that up to 21% of the global population may be taken from the wild annually, primarily for the pet trade.

The species is endemic to primary and secondary rainforest of West and Central Africa. Grey parrots depend on large old trees for the natural hollows they use for nesting. Studies in Guinea and Guinea-Bissau have found that the preferred species of nesting trees are also preferred timber species. There is a positive relationship between the status of the species and the status of primary forest: where the forests are declining, so too are populations of Grey parrots.



Congo African Grey Parrot in a bird park

The African Grey Parrot is listed on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). This requires both that exports be accompanied by a permit issued by a national authority and that a finding has been made that the export is non-detrimental to the species in the wild. With exports totaling more than 350,000 specimens from 1994–2003, the grey parrot is one of the most heavily-traded CITES-listed bird species. In response to continuing population declines, exceeded quotas and unsustainable and illegal trade, including among range states, CITES included the grey parrot in Phase VI of the CITES Review of Significant Trade in

2004. This review has resulted in recommended zero export quotas for several range states and a CITES Decision to develop regional management plans for the species.

In the United States, importation of wild-caught Grey parrots is prohibited under the U.S. Wild Bird Conservation Act of 1992. In the European Union, an EU Directive of 2007 prevents importation of this and any other "wild-caught" bird for the pet trade.

Mimicry and intelligence

Unlike other parrots, wild African Greys have been documented imitating the calls of several other species. African Grey parrots have been tested using rigorous scientific standards. They are classed alongside the most intelligent animal species.

Dr. Irene Pepperberg's research with captive African greys, most notably with a bird named Alex, has scientifically demonstrated that they possess the ability to associate human words with meanings, and to intelligently apply the abstract concepts of shape, colour, number, zero-sense, etc. According to Pepperberg and others, they perform many cognitive tasks at the level of dolphins, chimpanzees, and even a human toddler

Many pet Congo African Greys learn to speak slowly until their second or third year. Timnehs are generally observed to start speaking earlier. Both subspecies seem to have same ability and tendency to produce human speech, but vocal ability and proclivity may range widely among individual birds.

One notable African Grey is N'kisi, who in 2004 already was said to have a vocabulary of over 950 words and was noted for creative use of language, as had been Alex. For example, when Jane Goodall visited N'kisi in his New York home, he greeted her with "Got a chimp?" as he'd seen pictures of her with chimpanzees in Africa.

Noises

Wild African Grey Parrots frequently whistle, shriek, squeak, click, etc. The African Grey owner should expect to hear regular renditions of the microwave, telephone, alarm clocks, dripping water, wild birds, video games, and any other electronic sound that is often heard by the parrot, thus, they have also been noted for profanity even after changing owners. African birds also have the capability of mimicking and distinguishing between different voices presented to the bird.

Aviculture



A pet Congo African Grey Parrot

Their sociability and intelligence can make African Grey Parrots excellent pets with a strongly devoted following among parrot owners. These same qualities mean that African Greys require special commitment by their owners including frequent one-on-one interaction and supervised time out of their cage. They also require large cages, a varied diet that includes fresh foods, and plenty of safe and destructible toys. When not provided with these things African Greys quickly develop unpleasant behaviors and can eventually develop health problems that are difficult to remedy (such as feather-plucking). Even the healthiest, happiest pet African Grey will generate a fair amount of mess and noise. Like most parrots, they are non-domesticated, and even a well-socialized, hand-raised and

aviary bred bird is only one or two generations from a wild predecessor. Despite this, there is a long recorded history of African Greys kept by the ancient Greeks, wealthy Roman families, King Henry VIII, Portuguese sailors, and others.

Captive breeding



A one day old Congo African Grey Parrot chick that was hatched in an incubator

Mutations



African Grey Parrot red-factor mutations, including the all-red individual discussed here.

Several mutations occur naturally in the wild, like the F2 Pied Mutation, which results in a broad red band across the abdomen. 1998 saw the first created Grey mutation when South African bird breeder Von van Antwerpen and New Zealand partner Jaco Bosman selected F2 Pieds and created the first red African Grey.

Other mutations include:

- Albino (no pigment)
- Lutino (yellow pigment)
- Incomplete Ino (mostly white, but with small percentage of melanin)
- Grizzles (soft pinkish scalloping found in its feathers)
- Blues (white pigment in the tail)
- Parino (very light scalloping found in its feathers)

Foods toxic to parrots

- Chocolate
- Avocado
- Caffeine
- Alcohol
- Apple seeds (as they contain cyanide)
- Peach pit (contains cyanide)
- Cherry pit (contains cyanide)
- store-bought vegetables, possible chemicals from produce spritzers, farm pesticides/fertilizers, artificial dyes on many store-bought vegetables not listed in ingredients section

Chapter 15

Learned Pig

The **learned pig** was a pig taught to respond to commands in such a way that it appeared to be able to answer questions by picking up cards in its mouth. By choosing cards it answered arithmetical problems and spelled out words. The "learned pig" caused a sensation in London during the 1780s. It became a common object of satire, illustrated in caricatures and referred to in literature.

The original "learned pig" was followed by other trained pigs, which subsequently became a feature of fairs and other public attractions in Europe and America during the 19th century. In the words of G.E. Bentley, "They served as subjects for cartoons by Rowlandson and moral essays in children's books and savage doggerel by Blake, and they illustrated the manners of the English in works by Joseph Strutt and Robert Southey and Thomas Hood. These freaks of learning clearly exercised a fascination among the literary geniuses of the age as they did among the swinish multitude."

The original pig

The original Learned Pig was trained by a Scotsman Samuel Bisset, who ran a travelling novelty show. The idea of an "intellectual" animal was not new. A similar attraction known as "Marocco the thinking horse" (c.1586–c.1606) had been exhibited over a century earlier; there were also contemporary examples of the "horse of knowledge", exhibited for example at Astley's Amphitheatre. But performing horses were nothing unusual. No performing pigs are known to have been trained before.

The pig was shown with great success in Dublin. After Bisset's death the pig was taken over by a Mr Nicholson, who toured it in Britain. It was exhibited in Nottingham in 1784, coming to London in the following year." According to publicity at the time,

This entertaining and sagacious animal casts accounts by means of Typographical cards, in the same manner as a Printer composes, and by the same method sets down any capital or Surname, reckons the number of People present, tells by evoking on a Gentleman's Watch in company what is the Hour and Minutes; he likewise tells any Lady's Thoughts in company, and distinguishes all sorts of colours.

The show was a great success, and the pig later toured the provincial towns, returning to London later in the year and then moving on to the continent of Europe. After a career of four years a report stated that the pig died in 1788. However, a later report claimed that it had just returned from France following the revolution of 1789, and was ready to "discourse on the Feudal System, the Rights of Kings and the Destruction of the Bastille".

The phenomenon caused much comment. James Boswell recalls conversations with Samuel Johnson in which he joked about the pig's scholarship. Johnson never saw the pig. He died just before it came to London, but he commented on a report of its show in Nottingham. He suggested that "the pigs are a race unjustly calumniated. *Pig* has, it seems, not been wanting to *man*, but *man* to *pig*. We do not allow *time* for his education, we kill him at a year old." Another man present joked that Alexander Pope would not have used the pig as a symbol of "the lowest degree of grovelling instinct" in his works if this creature had been known to him, but added that the pig had probably been subject to some form of torture to force it to respond to commands. Johnson replied that at least it had escaped slaughter "the pig has no cause to complain; he would have been killed the first year if he had not been *educated*, and protracted existence is a good recompence for very considerable degrees of torture."

The discussion about how the pig had been trained also led to disputes about the cognitive abilities of pigs; whether the animal actually recognised letters or even words, or whether it was simply responding to direct prompting. The phenomenon was also discussed in instructional literature aimed at children, to describe the essential difference between human and animal capacities and to warn against cruelty to animals, on the assumption that the pigs were badly beaten by their trainers to force them to behave.

Later pigs

In 1798 a learned pig appeared in the United States. William Frederick Pinchbeck displayed a "Pig of Knowledge" in New England. He claimed to have toured all the major towns of the Union and introduced the pig to President John Adams, to "universal applause". Pinchbeck later explained his methods of training the pig in a pamphlet. He denied that any form of torture was involved, insisting that it was better to "coax" the pig to follow instructions. The animal would soon learn to respond to the slightest hints of movement from the trainer. He stated that credulous spectators accused him of using witchcraft, one stating that "his performances were the effects of the Black Art; that the Pig ought to be burnt, and the Man banished, as he had no doubt but...[his trainer] familiarly corresponded with the devil." Others suggested that the pig was evidence of reincarnation, "the spirit of the grunting philosopher might once have animated a man."

In the early 19th century, Nicholas Hoare, an illusionist, exhibited "Toby the sapient pig" in London. Toby could "discover a person's thoughts", a skill "never heard of before to be exhibited by an animal of the swine race". Around 1817 Toby also published an autobiography, *The life and adventures of Toby, the sapient pig: with his opinions on men and manners. Written by himself.*

A pig owned by Pinchbeck was shown in London between 1818 and 1823. According to his publicity, the pig had acquired his wisdom from "Souchanguyee, the Chinese Philosopher." He answered questions by "pointing to cards, letters, and persons in the audience."

"Toby" became a standard name for a learned pig. The writer Harrison Weir depicts a learned pig called Toby, which he saw "year ago at Camberwell Fair" for a penny. According to Harrison, the pig carried a correctly numbered card to a person who had called out a number; it spelled "vittels," and then it left to have some, "with a joyful grunt, and the show was over."

Caricature

The original learned pig inspired a large number of satirical comments and comic prints. Thomas Rowlandson published a caricature of "The Wonderful Pig" in 1785, in which the pig is shown displaying his erudition to a crowd of amazed ladies and gentlemen. A placard states "The Surprising PIG well versed in all Languages, perfect Arethmatician Mathematician & Composer of Musick."

Other caricatures used the appeal of the pig to poke fun at theatrical fads of the day. *The Theatrical War* satirises the actor-impresario John Palmer, dressed in Shakespearean costume, being threatened by other attractions including the pig.

The 1784 print *The Downfall of Taste and Genius, or, The World As it Goes* by Samuel Collings ridicules "the taste that prefers the Dancing Dogs, the Learned Pig, and Harlequin to Shakespeare". This was a "recurrent theme" of prints at the time. The print depicts the pig leading a procession of performing animals who knock over figures representing the fine arts while copies of Shakespeare's and Pope's works are trampled underfoot by the animals.

An anonymous print entitled "The Wonderful Pig of Knowledge" shows a pig performing in a parlour apparently engaged in spelling the word "PORC[INE]"

Politicians were also satirised by being compared to the pig. William Pitt was referred to as "the Wonderful Pig" on several occasions. One satirical print showed Pitt with the body of a pig; the caption asserted that among his powers was the ability to explain recent Acts of Parliament, a feat "before never having been even *attempted* in these our realms!!!" In one print Pitt and his opponent Charles James Fox were both depicted as competing learned pigs.

Literature



Toby learning Latin grammar, a caricature by John Leech.

The concept of the "learned pig" became a common motif in satirical literature by the late 18th century, playing on the implied contrast between gross physicality and intellectual superiority. The poet William Cowper lamented that his fame had been unfavourably compared to both the pig and a notoriously promiscuous actress, Anne Bellamy. A poem published in 1785 referred to the fact that the pig had arrived in London just after Johnson's death,

Though Johnson, learned Bear, is gone,
Let us no longer mourn our loss,
For lo, a learned Hog is come,

And wisdom grunts at Charing Cross.

The anonymous pamphlet *The Story of the Learned Pig, By an officer of the Royal Navy* (1786) picked up the theme of reincarnation. This presents itself as the personal reminiscences of the pig, as told to the author. He describes himself as a soul that has successively migrated from the body of Romulus into various humans and animals before becoming the Learned Pig. He recalls his previous incarnations. After Romulus he became Brutus, and then entered several human and animal bodies. Adapting the Shakespeare theme, the pamphlet states that he became a man called "Pimping Billy", who worked as a horse-holder at a playhouse with Shakespeare and was the real author of his plays. He then became a famous British aristocrat and general — identified only by asterisks — before entering the body of a pig.

Puns on the name "Bacon", referring to the philosopher Francis Bacon, also appeared in the literature. In the poem "The Prophetic Pig", in *The Whim of the Day* (c.1794) a believer in reincarnation states, "I can easily trace...A metempsychosis in this pig's face!...And in transmigration, if I'm not mistaken,/This learned pig must be, by consanguinity,/Descended from the great Lord Bacon." Thomas Hood's poem *The Lament of Toby, The Learned Pig* also uses the Bacon pun, adding another on the poet James Hogg. He describes the thoughts of a learned pig forced to retire from his intellectual pursuits to be fattened for slaughter. The pig says "Goodbye to the poetic Hogg!/The philosophic Bacon!":

In this world, pigs, as well as men,
Must dance to fortune's fiddlings,
But must I give the classics up,
For barley-meal and middlings?

William Blake attacked debased public taste in a poem dedicated to the artist James Barry, writing that the nation which neglected Barry might "give pensions to the Learned Pig / Or the Hare playing on a Tabor". He also alludes to it in his satire *An Island in the Moon*. In 1807 Robert Southey parodied the contrast between real genius and meretricious celebrity by referring to the pig, noting that "the learned pig was in his day a far greater object of admiration to the English nation than ever was Sir Isaac Newton." William Wordsworth refers to the pig in *The Prelude*, describing it as one of the "freaks of nature" to be seen at Bartholomew Fair:

...Albinos, painted Indians, Dwarfs,
The Horse of knowledge, and the learned Pig
All out-o'-the-way, far-fetched, perverted things,
All freaks of nature, all Promethean thoughts
Of man, his dulness, madness, and their feats
All jumbled up together, to compose
A Parliament of Monsters.

The pig continued to be a common reference point for writers, mentioned by Mary Wollstonecraft and Charles Dickens among others. In *The Mudfog Papers* Dickens describes a moving lecture given at the *Mudfog Society for the Advancement of Everything* by Mr Blunderum on the dying moments of the learned pig. The lecturer was asked whether the learned pig was related to the Pig-faced Lady, causing embarrassment to an audience member who *was* related to the lady, but who refused to admit a family connection to the learned pig.

Even Mrs Beeton begins her recipe for cooking sucking pig with the observation that pigs are capable of "education" "and though, like the ass, naturally stubborn and obstinate, that he is equally amenable with other animals to caresses and kindness". This is proven by "the instance of the learned pig, first exhibited about a century since, but which has been continued down to our own time by repeated instances of an animal who will put together all the letters or figures that compose the day, month, hour and date of the exhibition, besides many other unquestioned evidences of memory."

Chapter 16

Orangutan

Orangutans



Scientific classification

Kingdom:	Animalia
Phylum:	Chordata
Class:	Mammalia
Order:	Primates
Family:	Hominidae
Subfamily:	Ponginae
Genus:	<i>Pongo</i> Lacépède, 1799

Type species

Pongo borneo
Lacépède, 1799 (= *Simia pygmaeus*
Linnaeus, 1760)

Species

Pongo pygmaeus
Pongo abelii



Orangutan distribution

Orangutans are the only exclusively Asian genus of extant great ape. The largest living arboreal animals, they have longer arms than the other, more terrestrial, great apes. They are among the most intelligent primates and use a variety of sophisticated tools, also making sleeping nests each night from branches and foliage. Their hair is typically reddish-brown, instead of the brown or black hair typical of other great apes.

Native to Indonesia and Malaysia, orangutans are currently found only in rainforests on the islands of Borneo and Sumatra, though fossils have been found in Java, the Thai-Malay Peninsula, Vietnam and Mainland China. There are only two surviving species, both of which are endangered: the Bornean Orangutan (*Pongo pygmaeus*) and the critically endangered Sumatran Orangutan (*Pongo abelii*). The subfamily Ponginae also includes the extinct genera *Gigantopithecus* and *Sivapithecus*. The word "orangutan" comes from the Malay words "orang" (man) and "(h)utan" (forest); hence, "man of the forest".

Taxonomic classification

- **Genus *Pongo***
 - Bornean Orangutan (*Pongo pygmaeus*)
 - *Pongo pygmaeus pygmaeus* - northwest populations
 - *Pongo pygmaeus morio* - east populations
 - *Pongo pygmaeus wurmbii* - southwest populations
 - Sumatran Orangutan (*Pongo abelii*)

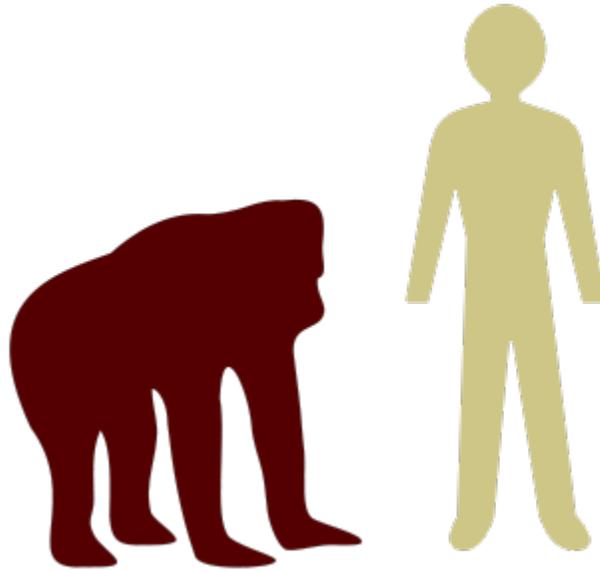
The populations on the two islands were classified as subspecies until recently, when they were elevated to full specific level, and the three distinct populations on Borneo were elevated to subspecies. The population currently listed as *P. p. wurmbii* may be closer to the Sumatran Orangutan than the Bornean Orangutan. If confirmed, *abelii* would be a subspecies of *P. wurmbii* (Tiedeman, 1808). Regardless, the type locality of *pygmaeus* has not been established beyond doubts, and may be from the population currently listed as *wurmbii* (in which case *wurmbii* would be a junior synonym of *pygmaeus*, while one of the names currently considered a junior synonym of *pygmaeus* would take precedence for the northwest Bornean taxon). To further confuse, the name *morio*, as well as various junior synonyms that have been suggested, have been considered likely to all be junior synonyms of the population listed as *pygmaeus* in the above, thus leaving the east Bornean populations unnamed.



Pongo pygmaeus

In addition, a fossil species, *P. hooijeri*, is known from Vietnam, and multiple fossil subspecies have been described from several parts of southeastern Asia. It is unclear if these belong to *P. pygmaeus* or *P. abeli* or, in fact, represent distinct species.

Anatomy and physiology



Size relative to a 6 foot (1.8 m) man

An orangutan's standing height averages from 4 to 5 ft (1.2 to 1.5 m). On average, an orangutan weighs between 73 to 180 pounds (33 to 82 kg). Males can weigh up to 250 lb (110 kg) or more. Orangutan hands are similar to humans' hands; they have four long fingers and an opposable thumb. Their feet have four long toes and an opposable big toe. Orangutans can grasp things with both their hands and their feet. The largest males have an arm span of about 7.5 ft (2 m).

Orangutans have a large, bulky body, a thick neck, very long, strong arms, short, bowed legs, and no tail. They are mostly covered with long reddish-brown hair, although this differs between the species: Sumatran Orangutans have a more sparse and lighter coloured coat.

The orangutan has a large head with a prominent mouth area. Adult males have large cheek flaps (which get larger as the ape ages) that show their dominance to other males and their readiness to mate. The age of maturity for females is approximately 12 years. On average, orangutans may live about 35 years in the wild, and up to 60 years in captivity. Both sexes have throat pouches located near their vocal chords that make their calls resonate through the forest, although the males' pouches are more developed. There is significant sexual dimorphism: females can grow to around 4 ft 2 in or 127 cm and weigh around 100 lb (45 kg) while flanged adult males can reach 5 ft 9 in or 175 cm in height and weigh over 260 lb (118 kg).

The arms of orangutans are twice as long as their legs, and an adult orangutan's arms can be well over seven feet from fingertip to fingertip. Much of the arm's length has to do with the length of the radius and the ulna rather than the humerus. Their fingers and toes

are curved, allowing them to better grip onto branches. Orangutans have less restriction in the movements of their legs than humans and other primates, due to the lack of a hip joint ligament which keeps the femur held into the pelvis. Unlike gorillas and chimpanzees, orangutans are not true knuckle-walkers, and are instead fist-walkers.

Ecology and behavior

Orangutans live in primary and old secondary forests, particularly dipterocarp forests and peat swamp forests. Both species can be found in both mountainous and lowland swampy areas. Sumatran orangutans live in elevations as high as 1500 m (4921 ft), while Bornean orangutans live no higher than 1000 m (3281 ft). The latter will sometimes enter grasslands, cultivated fields, gardens, young secondary forest, and shallow lakes. Orangutans are the most arboreal of the great apes, spending nearly all of their time in the trees. Most of the day is spend feeding, resting, and moving between feeding and resting sites. They start the day feeding for 2-3 hours in the morning. They rest during midday followed by traveling in the late afternoon. When evening arrives, they begin to prepare their nest for the night. Tigers are the major predatory threat to orangutans in Sumatra. Orangutans may also be preyed on by clouded leopards and crocodiles. The former can kill adolescents and small adult females but have not been recorded killing adult males. In Borneo, orangutans are not threatened by tigers and seem to descend to the ground more often than their Sumatran relatives. Orangutans do not swim. At least one population at a conservation refuge on Kaja island in Borneo have been photographed wading in deep water.

Diet



Flanged adult male

Fruit makes up 65–90 percent of the orangutan diet. Fruits with sugary or fatty pulp are favored. Ficus fruits are commonly eaten, because they are easy to harvest and digest. Lowland dipterocarp forests are preferred by orangutans because of their plentiful fruit. Bornean orangutans consume at least 317 different food items that include young leaves, shoots, bark, insects, honey and bird eggs.

Orangutans are opportunistic foragers, and their diets vary markedly from month to month. Bark is eaten as a last resort in times of food scarcity; fruits are always more popular.

Orangutans are thought to be the sole fruit disperser for some plant species including the climber species *Strychnos ignatii* which contains the toxic alkaloid strychnine. It does not appear to have any effect on orangutans except for excessive saliva production.

Geophagy, the practice of eating soil or rock, has been observed in orangutans. There are three main reasons for this dietary behavior; for the addition of minerals nutrients to their diet; for the ingestion of clay minerals that can absorb toxic substances; or to treat a disorder such as diarrhea.

Orangutans use plants of the genus *Commelina* as an anti-inflammatory balm.

Social life



Orangutans, Gunung Leuser NP, Sumatra

Orangutans live a more solitary lifestyle than the other great apes. Most social bonds occur between adult females and their dependent and weaned offspring. Adult males and independent adolescents of both sexes tend to live alone. The society of the orangutan is made up of resident and transient individuals of both sexes. Resident females live with their offspring in defined home ranges that overlap with other adult females, who may be their relatives like mothers and sisters. One to several resident female home ranges are encompassed within the home range of a resident male, who is their primary breeder. Transient males and females range broadly. They usually travel alone, but as sub-adults they may travel in small groups. However this behavior does not extend to adulthood. The social structure of the orangutan can be best described as solitary but social. As the ranges of males and females overlap, they commonly encounter each other while traveling and feeding and may have brief social interactions. Interactions between adult females range from friendly, to avoidance to antagonistic. Resident males may have overlapping ranges and interactions between them tend to be hostile.

During dispersal, females tend to settle in home ranges that overlap with their mothers. However, they do not interact with them any more than the other females and they do not seem to form bonds through affiliation, grooming, or agonistic support. Males disperse much farther from their mothers and enter into a transient phase. This phase lasts until a male can challenge and displace a dominant, resident male from his home range. There are dominance hierarchies between adult males that regularly encounter each other with the most dominant males being the largest and having the best body conditions. Adult males dominate sub-adult males. Both resident and transient orangutans aggregate on large fruiting trees to feed. The fruits tend to be abundant, so competition is low and individuals may benefit from social contacts. Orangutans will also form travelling groups in which members coordinate travel between food sources for a few days at a time. These groups tend to be made of only a few individuals. They also tend to be mating consortships, each made of an adult male and female traveling and mating.

Reproduction and parenting

Male orangutans exhibit arrested development. They mature at around 15 years of age by which they have fully descended testicles and can reproduce. However they do not develop the cheek pads, pronounced throat pouches, long fur or long-calls of more mature males until they gain a home range, which occurs when they are between 15 and 20 years old. These sub-adult males are known as unflanged males in contrast to the more developed flanged males. The transformation from unflanged to flanged can occur very quickly. Unflanged and flanged males have two different mating strategies. Flanged males use long calls to advertise their location which attract estrous females. Unflanged males wander widely in search of estrous females and upon finding one, will force copulation on her. Both strategies are successful, however females prefer to mate with flanged males and will seek them out for protection from unflanged males. Resident males may form consortships with females that can last days, weeks or months after copulation.

Female orangutans experience their first ovulatory cycle between 5.8 and 11.1 years. These occur earlier in larger females with more body fat than in thinner females. Like other great apes, female orangutans have a period of adolescent infertility which may last for 1-4 years. Female orangutans also have a 22-30 day menstrual cycle. Gestation lasts for nine months with females giving birth to their first offspring between 14 and 15 years old. Female orangutans have the longest interbirth intervals of the great apes, having eight years between births.



A two-week old orangutan

Male orangutans play almost no role in raising the young. Females are the primary caregivers for the young and are also instruments of socialization for them. A female often has more than one offspring with her, usually an adolescent and an infant, and the older of them can also help in socializing their younger sibling. Infant orangutans are completely dependent on their mothers for the first two years of their lives. The mother will carry the infant during traveling, as well as feed it and sleep with it in the same night nest. The infant doesn't even break physical contact with its mother for the first four months and is carried on her belly. The amount of physical contact soon wanes in the following months. When an orangutan reaches the age of two, its climbing skills are more developed and will hold the hand of another orangutan while moving through the canopy,

a behavior known as "buddy travel". Orangutans are juveniles from about two to five years of age and start to exploratory trips from their mothers. Juveniles are usually weaned at about four years of age. Adolescent orangutans seek peers and play and travel with peer groups while start having contact with their mothers.

Tool use and culture



A young Orangutan at the Toledo Zoo in Ohio. The Orangutan's opposable toes and fingers give them the ability to use tools.

Like the other great apes, orangutans are among the most intelligent primates. Wild chimpanzees have been known since the 1960s to use tools. Tool use in orangutans was observed by Birutė Galdikas in ex-captive populations.

Evidence of sophisticated tool manufacture and use in the wild was reported from a population of orangutans in Suaq Balimbing (*Pongo pygmaeus abelii*) in 1996. These orangutans developed a tool kit for use in foraging that consisted of insect-extraction

tools for use in the hollows of trees, and seed-extraction tools which were used in harvesting seeds from hard-husked fruit. The orangutans adjusted their tools according to the nature of the task at hand and preference was given to oral tool use. This preference was also found in an experimental study of captive orangutans (*P. pygmaeus*).

Carel P. van Schaik from the University of Zurich and Cheryl D. Knott from Harvard University further investigated tool use in different wild orangutan populations. They compared geographic variations in tool use related to the processing of *Neesia* fruit. The orangutans of Suaq Balimbing (*P. abelii*) were found to be avid users of insect and seed-extraction tools when compared to other wild orangutans. The scientists suggested that these differences are cultural. The orangutans at Suaq Balimbing live in dense groups and are socially tolerant; this creates good conditions for social transmission. Further evidence that highly social orangutans are more likely to exhibit cultural behaviors came from a study of leaf-carrying behaviors of ex-captive orangutans that were being rehabilitated on the island of Kaja in Borneo. The above evidence is consistent with the existence of orangutan culture as geographically distinct behavioral variants which are maintained and transmitted in a population through social learning.



Orangutan at Columbus Zoo and Aquarium

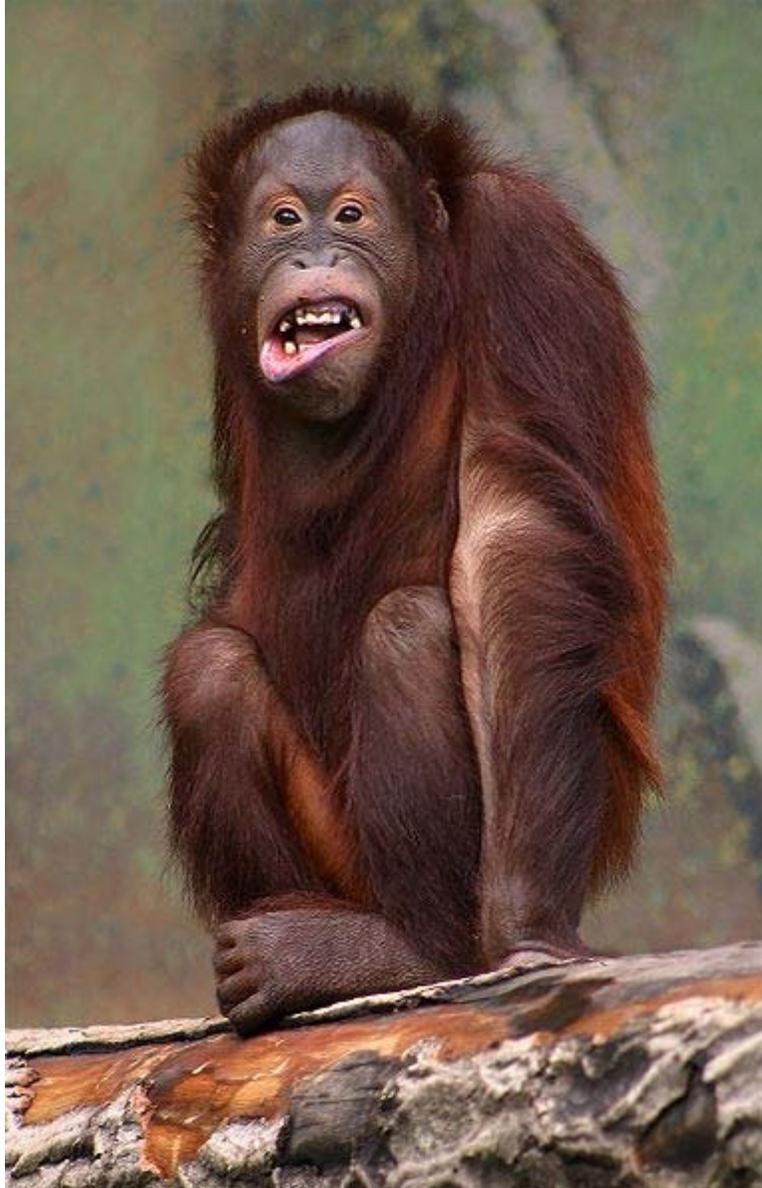
In 2003, researchers from six different orangutan field sites who used the same behavioral coding scheme compared the behaviors of the animals from the different sites. They found that the different orangutan populations behaved differently. The evidence suggested that the differences in behavior were cultural: first, because the extent of the differences increased with distance, suggesting that cultural diffusion was occurring, and

second, because the size of the orangutans' cultural repertoire increased according to the amount of social contact present within the group. Social contact facilitates cultural transmission. Carel P. van Schaik suggests that young orangutans (*P. abelii*) acquire tool use skills and cultural behaviors by observing and copying older orangutans.

Orangutans do not limit their tool use to foraging, displaying or nest-building activities. Wild orangutans (*P. pygmaeus wurmbii*) in Tuanan, Borneo, were reported to use tools in acoustic communication. They use leaves to amplify the kiss squeak sounds that they produce. Some have suggested that the apes employ this method of amplification in order to deceive the listener into believing that they are larger animals.

Communication

A two year study of orangutan symbolic capability was conducted from 1973-1975 by Gary L. Shapiro with Aazk, a juvenile female orangutan at the Fresno City Zoo (now Chaffee Zoo) in Fresno, California. The study employed the techniques of David Premack who used plastic tokens to teach the chimpanzee, Sarah, linguistic skills. Shapiro continued to examine the linguistic and learning abilities of ex-captive orangutans in Tanjung Puting National Park, in Indonesian Borneo, between 1978 and 1980. During that time, Shapiro instructed ex-captive orangutans in the acquisition and use of signs following the techniques of R. Allen and Beatrix Gardner who taught the chimpanzee, Washoe, in the late-1960s. In the only signing study ever conducted in a great ape's natural environment, Shapiro home-reared Princess, a juvenile female who learned nearly 40 signs (according to the criteria of sign acquisition used by Francine Patterson with Koko, the gorilla) and trained Rinnie, a free-ranging adult female orangutan who learned nearly 30 signs over a two year period. For his dissertation study, Shapiro examined the factors influencing sign learning by four juvenile orangutans over a 15-month period.



Orangutan "laughing"

The first orangutan language study program, directed by Dr. Francine Neago, was listed by *Encyclopædia Britannica* in 1988. The Orangutan language project at the Smithsonian National Zoo in Washington, D.C., uses a computer system originally developed at UCLA by Neago in conjunction with IBM.

Zoo Atlanta has a touch screen computer where their two Sumatran Orangutans play games. Scientists hope that the data they collect from this will help researchers learn about socializing patterns, such as whether they mimic others or learn behavior from trial and error, and hope the data can point to new conservation strategies.

A 2008 study of two orangutans at the Leipzig Zoo showed that orangutans are the first non-human species documented to use 'calculated reciprocity' which involves weighing the costs and benefits of gift exchanges and keeping track of these over time.

Orangutans, along with Chimpanzees, gorillas, and other apes, have even shown laughter-like vocalizations in response to physical contact, such as wrestling, play chasing, or tickling.

Sexual interest in human females

Male orangutans have been known to rape human women. The cook of noted primatologist Birutė Galdikas was raped by an orangutan. An orangutan tried to have sex with Actress Julia Roberts but was prevented by a film crew.

Conservation status



Male, child, and female Sumatran orangutans

The Sumatran species is critically endangered and the Bornean species of orangutans is endangered according to the IUCN Red List of mammals, and both are listed on Appendix I of CITES. The total number of Bornean orangutans is estimated to be less than 14% of what it was in the recent past (from around 10,000 years ago until the middle

of the twentieth century) and this sharp decline has occurred mostly over the past few decades due to human activities and development. Species distribution is now highly patchy throughout Borneo: it is apparently absent or uncommon in the south-east of the island, as well as in the forests between the Rejang River in central Sarawak and the Padas River in western Sabah (including the Sultanate of Brunei). The largest remaining population is found in the forest around the Sabangau River, but this environment is at risk. A similar development have been observed for the Sumatran orangutans.

A 2007 study by the Government of Indonesia noted in 2004 it was estimated that there was a total wild population of 61,234 orangutans, 54,567 of which were found on the island of Borneo. The table below shows a breakdown of the species and subspecies and their estimated populations from the report:

Scientific name	Common name	Region	Estimated number
<i>Pongo abelii</i>	Sumatran Orangutan	Sumatra	6,667
<i>Pongo pygmaeus</i>	Bornean Orangutan	Borneo	
<i>P. p. morio</i>	Northeast Bornean Orangutan	Sabah	11,017
<i>P. p. morio</i>	Northeast Bornean Orangutan	East Kalimantan	4,825
<i>P. p. wurmbii</i>	Central Bornean Orangutan	Central Kalimantan	>31,300
<i>P. p. pygmaeus</i>	Northwest Bornean Orangutan	West Kalimantan and Sarawak	7,425

This indicates a decline from some estimates between 2000 and 2003 which found 7,300 Sumatran Orangutan individuals in the wild and between 45,000 and 69,000 Bornean Orangutans. Thousands of orangutans don't reach adulthood due to human disruption. Orangutans are killed for food while others are killed because of disruption in people's property. Mother orangutans are killed so their infants can be sold as pets. Many of the infants die without the help of their mother. Since recent trends are steeply down in most places due to logging and burning, it is forecast that the current numbers are below these figures.

Orangutan habitat destruction due to logging, mining and forest fires, as well as fragmentation by roads, has been increasing rapidly in the last decade. A major factor in that period of time has been the conversion of vast areas of tropical forest to oil palm plantations in response to international demand (the palm oil is used for cooking, cosmetics, mechanics, and more recently as source of biodiesel). Some UN scientists believe that these plantations could lead to irreparable damage to orangutan habitat by the year 2012. Some of this activity is illegal, occurring in national parks that are officially off limits to loggers, miners and plantation development. There is also a major problem with hunting and illegal pet trade. In early 2004 about 100 individuals of Bornean origin were confiscated in Thailand and 50 of them were returned to Kalimantan in 2006. Several hundred Bornean orangutan orphans who were confiscated by local authorities have been entrusted to different orphanages in both Malaysia and Indonesia. They are in the process of being rehabilitated into the wild.

Conservation centres and organisations



Orangutans at a rehabilitation centre in Borneo

A number of organisations are working for the rescue, rehabilitation and reintroduction of orangutans. The largest of these is the Borneo Orangutan Survival Foundation, founded by Dr. Willie Smits, which employs between six hundred and a thousand people at a hundred sites. It operates a number of large projects, including the Samboja Lestari Forest Rehabilitation Program and the Nyaru Menteng Rehabilitation Program managed by Lone Drøscher Nielsen. Other major conservation centres in Indonesia include those at Tanjung Puting National Park and Sebangau National Park in Central Kalimantan, Kutai in East Kalimantan, Gunung Palung National Park in West Kalimantan, and Bukit Lawang in the Gunung Leuser National Park on the border of Aceh and North Sumatra. In Malaysia, conservation areas include Semenggoh Wildlife Centre in Sarawak and Matang Wildlife Centre also in Sarawak, and the Sepilok Orang Utan Sanctuary near Sandakan in Sabah.

Genomics

Orangutans have 48 diploid chromosomes, and its genome was sequenced in January 2011. Following humans and chimpanzees, the Sumatran orangutan has become the third species of hominid to have its genome sequenced. The draft of the genome sequence is based on a captive female named Susie.

The researchers also published less complete copies from ten wild orangutans, five from Borneo and five from Sumatra. It was found that genetic diversity was lower in Bornean orangutans (*Pongo pygmaeus*) than in Sumatran ones (*Pongo abelii*), despite the fact that Borneo is home to six or seven times as many orangutans as Sumatra. The comparison has shown that these two species diverged around 400,000 years ago, more recently than was previously thought. It was also found that the orangutan genome has evolved much more slowly than chimpanzee and human DNA.

The researchers hope that these data may help conservationists save the endangered ape, and also prove useful in further understanding of human genetic diseases.

Chapter 17

Emotion in Animals

There is no scientific consensus on **emotion in animals**, that is, what emotions certain species of animals, including humans, feel. The debate concerns primarily mammals and birds, although emotions have also been postulated for other vertebrates and even for some invertebrates.

Animal lovers, scientists, philosophers, and others who interact with animals, have suggested answers but the core question has proven difficult to answer since animals cannot speak of their experience. Society recognizes animals can feel pain as is demonstrated by the criminalization of animal cruelty. Animal expressions of apparent pleasure are ambiguous as to whether this is emotion, or simply innate responses, perhaps for approval or other hard-wired cues. The ambiguity is a source of controversy as there is no certainty which views, if any, reflect reality. That said, extreme behaviourists would say that human "feeling" is also merely a hard-wired response to external stimuli.

In recent years, research has become available which expands prior understandings of animal language, cognition and tool use, and even sexuality. Emotions arise in the mammalian brain, or the limbic system, which human beings share in common with other mammals as well as many other species.

Evidence

While humans have had differing views of animal emotion, the scientific examination of animal emotion has led to little information beyond a recognition that animals have the capacity for pain and fear, and such responses as are needed for survival. Historically, prior to the rise of sciences such as ethology, interpretation of animal behaviour tended to favour a kind of minimalism known as behaviourism, in this context the refusal to ascribe to an animal a capability beyond the least demanding that would explain a behaviour; anything more than this was seen as unwarranted anthropomorphism. Put crudely, the behaviourist argument is, why should humans postulate consciousness and all its near-human implications in animals to explain some behaviour, if mere stimulus-response is a sufficient explanation to produce the same effects?

The cautious wording of Beth Dixon's 2001 paper on animal emotion exemplifies this viewpoint:

Recent work in the area of ethics and animals suggests that it is philosophically legitimate to ascribe emotions to non-human animals. Furthermore, it is sometimes argued that emotionality is a morally relevant psychological state shared by humans and non humans. What is missing from the philosophical literature that makes reference to emotions in non-human animals is an attempt to clarify and defend some particular account of the nature of emotion, and the role that emotions play in a characterization of human nature. I argue in this paper that some analyses of emotion are more credible than others. Because this is so, the thesis that humans and nonhumans share emotions may well be a more difficult case to make than has been recognized thus far.

Jeffrey Moussaieff Masson expresses a similar view:

While the study of emotion is a respectable field, those who work in it are usually academic psychologists who confine their studies to human emotions. The standard reference work, *The Oxford Companion to Animal Behavior*, advises animal behaviourists that "One is well advised to study the behaviour, rather than attempting to get at any underlying emotion."

There is considerable uncertainty and difficulty related to the interpretation and ambiguity of emotion: an animal may make certain movements and sounds, and show certain brain and chemical signals when its body is damaged in a particular way. But does this mean an animal feels—is *aware* of—pain as we are, or does it merely mean it is programmed to act a certain way with certain stimuli? Similar questions can be asked of any activity an animal (including a human) might undertake, in principle. Many scientists regard all emotion and cognition (in humans and animals) as having a purely mechanistic basis.

Because of the philosophical questions of consciousness and mind are involved, many scientists have stayed away from examining animal and human emotion, and have studied instead, measurable brain functions, through neuroscience.

The author Marc Bekoff also provided evidence of animals having emotions in his book, *The Emotional Lives of Animals*. The following is an excerpt from his book:

A few years ago my friend Rod and I were riding our bicycles around Boulder, Colorado, when we witnessed a very interesting encounter among five magpies. Magpies are corvids, a very intelligent family of birds. One magpie had obviously been hit by a car and was laying dead on the side of the road. The four other magpies were standing around him. One approached the corpse, gently pecked at it—just as an elephant noses the carcass of another elephant— and stepped back. Another magpie did the same thing. Next, one of the magpies flew off, brought back some grass, and laid it by the corpse. Another magpie did the same. Then, all four magpies stood vigil for a few seconds and one by one flew off.

Primates

Primates and in particular great apes are candidates for highly developed capabilities for empathy and theories of mind. Great apes have highly complex social systems. Young apes and their mothers have very strong bonds of attachment. Often when a baby chimpanzee or gorilla dies, the mother will carry the body around for several days. Jane Goodall has described chimpanzees as exhibiting mournful behavior.

Canines

Research suggests that canines can experience negative emotions in a similar manner to people, including the equivalent of certain chronic and acute psychological conditions. The classic experiment for this was Martin Seligman's foundational experiments and theory of learned helplessness at the University of Pennsylvania in 1965, as an extension of his interest in depression:

A dog that had earlier been repeatedly conditioned to associate a sound with electric shocks did not try to escape the electric shocks after the warning was presented, even though all the dog would have had to do is jump over a low divider within ten seconds, more than enough time to respond. The dog didn't even try to avoid the "aversive stimulus"; it had previously "learned" that nothing it did mattered. A follow-up experiment involved three dogs affixed in harnesses, including one that received shocks of identical intensity and duration to the others, but the lever which would otherwise have allowed the dog a degree of control was left disconnected and didn't do anything. The first two dogs quickly recovered from the experience, but the third dog suffered chronic symptoms of clinical depression as a result of this perceived helplessness.

A further series of experiments showed that (similar to humans) under conditions of long term intense psychological stress, around 1/3 of dogs do not develop learned helplessness or long term depression. Instead these animals somehow managed to find a way to handle the unpleasant situation in spite of their past experience. The corresponding characteristic in humans has been found to correlate highly with an explanatory style and optimistic attitude and lower levels of emotional rigidity regarding expectations, that views the situation as *other than* personal, pervasive, or permanent. Such studies highlighted similar distinctions between people who adapt and those who break down, under long term psychological pressure, which were conducted in the 1950s in the realm of brainwashing.

Since this time, symptoms analogous to clinical depression, neurosis and other psychological conditions have been in general accepted as being within the scope of canine emotion as well.

Psychology research has shown that human faces are asymmetrical with the gaze instinctively moving to the right side of a face upon encountering other humans to obtain information about their emotions and state. Research at the University of Lincoln (2008) shows that dogs share this instinct when meeting a human being, and only when meeting

a human being (ie, not other animals or other dogs). As such they are the only non-primate species known to do so.

The existence and nature of personality traits in dogs have been studied (15329 dogs of 164 different breeds) and five consistent and stable "narrow traits" identified, described as playfulness, curiosity/fearlessness, chase-proneness, sociability and aggressiveness. A further higher order axis for shyness–boldness was also identified.

Felines

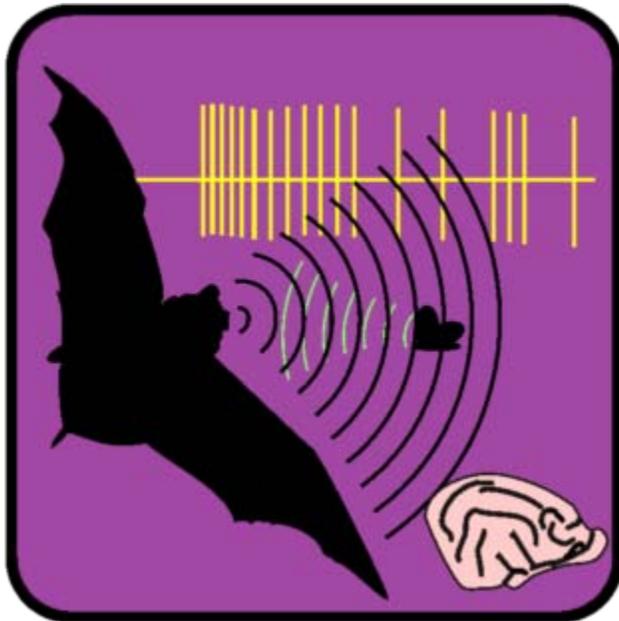
The emotions of cats have also been studied scientifically. It has been shown that cats can learn to manipulate their owners through vocalizations that are similar to the cries of human babies. Some cats learn to add a purr to the cry, which makes it less harmonious to humans and therefore harder to ignore. Individual cats learn to make these cries through operant conditioning; when a particular cry elicits a positive response from a human, the cat is more likely to use that cry in the future.

Fish

A 2007 study by the University of Guelph Scientists in Canada suggests that fish may have their own separate personalities. The study examined a group of trout that were visually identical. The study concluded that different fish within the same group exhibited different personality traits. Some fish were more willing to take risks in unknown waters than others when taken from their environment and introduced to a dark tube. Some fish were more social than others while some fish preferred being alone. Fish were also shown to have different preferences as far as eating habits.

Chapter 18

Neuroethology



Echolocation in bats is one model system in neuroethology

Neuroethology is the evolutionary and comparative approach to the study of animal behavior and its underlying mechanistic control by the nervous system. This interdisciplinary branch of neuroscience endeavors to understand how the central nervous system translates biologically relevant stimuli into natural behavior". For example, many bats are capable of echolocation which is used for prey capture and navigation. Their ultrasonic calls and auditory systems are highly specialized for this function. The auditory system of bats is often cited as an example for how acoustic properties of sounds can be converted into a sensory map of behaviorally relevant features of sounds . Neuroethologists hope to uncover general principles of the nervous system from the study of animals with exaggerated or specialized behaviors.

As its name implies, neuroethology is a multidisciplinary field composed of neurobiology (the study of the nervous system) and ethology (the study of behavior in natural conditions). A central theme of the field of neuroethology, delineating it from other branches of neuroscience, is this focus on natural behavior. Natural behaviors may be thought of as those behaviors generated through means of natural selection (i.e. finding mates, navigation, locomotion, predator avoidance) rather than behaviors in disease states, or behavioral tasks that are particular to the laboratory.

Philosophy

Neuroethology is an integrative approach to solving problems in animal behavior, drawing upon several disciplines. Often, neuroethologists choose to study animals that are “specialists” in a particular type of behavior the researcher wishes to study (i.e. honeybees and their social behavior, bat echolocation, owl sound localization). The idea that an ideal animal exists for studying specific behaviors is based on Krogh's principle. The neuroethological approach stems from the idea that animals' nervous systems have evolved to address problems of sensing and acting in certain environmental niches. Central to the dogma of neuroethology, therefore, is the idea that nervous systems are best understood in the context of the problems they have evolved to solve.

The scope of neuroethological inquiry might be summarized by Jörg-Peter Ewert, a pioneer of neuroethology, when he considers the types of questions central to neuroethology in his 1980 introductory text to the field:

1. How are stimuli detected by an organism?
2. How are environmental stimuli in the external world represented in the nervous system?
3. How is information about a stimulus acquired, stored and recalled by the nervous system?
4. How is a behavioral pattern encoded by neural networks?
5. How is behavior coordinated and controlled by the nervous system?
6. How can the ontogenetic development of behavior be related to neural mechanisms?

Often central to addressing questions in neuroethology are comparative methodologies, drawing upon knowledge about related organisms' nervous systems, anatomies, life histories, behaviors and environmental niches. While it is not unusual for many types of neurobiology experiments to give rise to behavioral questions, many neuroethologists often begin their research programs by observing a species' behavior in its natural environment. Other approaches to understanding nervous systems include the systems identification approach, popular in engineering. The idea is to stimulate the system using a non-natural stimulus with certain properties. The system's response to the stimulus may be used to analyze the operation of the system. Such an approach is useful for linear systems, but the nervous system is notoriously nonlinear, and neuroethologists argue that such an approach is limited. This argument is supported by experiments in the auditory system. These experiments show that neural responses to complex sounds, like social

calls, can not be predicted by the knowledge gained from studying the responses due to pure tones (one of the non-natural stimuli favored by auditory neurophysiologists). This is because of the non-linearity of the system.

Modern neuroethology is largely influenced by the research techniques used. Neural approaches are necessarily very diverse, as is evident through the variety of questions asked, measuring techniques used, relationships explored, and model systems employed. Techniques utilized since 1984 include the use of intracellular dyes, which make maps of identified neurons possible, and the use of brain slices, which bring vertebrate brains into better observation through intracellular electrodes (Hoyle 1984). Currently, other fields toward which neuroethology may be headed include computational neuroscience, molecular genetics, neuroendocrinology. The existing field of neural modeling may also expand into neuroethological terrain, due to its practical uses in robotics. In all this, neuroethologists must use the right level of simplicity to effectively guide research towards accomplishing the goals of neuroethology.

Critics of neuroethology might consider it a branch of neuroscience concerned with ‘animal trivia’. Though neuroethological subjects tend not to be traditional neurobiological model systems (i.e. *Drosophila*, *C. elegans*, or *Danio rerio*), neuroethological approaches emphasizing comparative methods have uncovered many concepts central to neuroscience as a whole, such as lateral inhibition, coincidence detection, and sensory maps. The discipline of neuroethology has also discovered and explained the only vertebrate behavior for which the entire neural circuit has been described: the electric fish jamming avoidance response. Beyond its conceptual contributions, neuroethology makes indirect contributions to advancing human health. By understanding simpler nervous systems, many clinicians have used concepts uncovered by neuroethology and other branches of neuroscience to develop treatments for devastating human diseases.

Historical origins

The field of neuroethology owes part of its existence to the establishment of ethology as a unique discipline within the discipline of Zoology. Although animal behavior had been studied since the time of Aristotle (384-342 BC), it was not until the early twentieth century that ethology finally became distinguished from natural science (a strictly descriptive field) and ecology. The main catalysts behind this new distinction were the research and writings of Konrad Lorenz and Niko Tinbergen.

Konrad Lorenz was born in Austria in 1903, and is widely known for his contribution of the theory of fixed action patterns (FAPs): endogenous, instinctive behaviors involving a complex sequence of movements that are triggered (“released”) by a certain kind of stimulus. This sequence always proceeds to completion, even if the original stimulus is removed. It is also species-specific and performed by nearly all members. Lorenz constructed his famous “hydraulic model” to help illustrate this concept, as well as the concept of action specific energy, or drives.

Niko Tinbergen was born in the Netherlands in 1907 and worked closely with Lorenz in the development of the FAP theory; their studies focused on the egg retrieval response of nesting geese. Tinbergen performed extensive research on the releasing mechanisms of particular FAPs, and used the bill-pecking behavior of baby herring gulls as his model system. This led to the concept of the supernormal stimulus. Tinbergen is also well known for his four questions that he believed ethologists should be asking about any given animal behavior; among these is that of the mechanism of the behavior, on a physiological, neural and molecular level, and this question can be thought of in many regards as the keystone question in neuroethology. Tinbergen also emphasized the need for ethologists and neurophysiologists to work together in their studies, a unity that has become a reality in the field of neuroethology.

Unlike behaviorism, which studied animals' reactions to non-natural stimuli in artificial, laboratory conditions, ethology sought to categorize and analyze the natural behaviors of animals in a field setting. Similarly, neuroethology asks questions about the neural bases of *naturally occurring* behaviors, and seeks to mimic the natural context as much as possible in the laboratory.

Although the development of ethology as a distinct discipline was crucial to the advent of neuroethology, equally important was the development of a more comprehensive understanding of Neuroscience. Contributors to this new understanding were the Spanish Neuroanatomist, Ramon y Cajal, and physiologists Charles Sherrington, Edgar Adrian, Alan Hodgkin, and Andrew Huxley. Charles Sherrington, who was born in Great Britain in 1857, is famous for his work on the nerve synapse as the site of transmission of nerve impulses, and for his work on reflexes in the spinal cord. His research also led him to hypothesize that every muscular activation is coupled to an inhibition of the opposing muscle. He was awarded a Nobel Prize for his work in 1932 along with Lord Edgar Adrian who made the first physiological recordings of neural activity from single nerve fibers.

Alan Hodgkin and Andrew Huxley (born 1914 and 1917, respectively, in Great Britain), are known for their collaborative effort to understand the production of action potentials in giant squid neurons. The pair also proposed the existence of ion channels to facilitate action potential initiation, and were awarded the Nobel Prize in 1963 for their efforts.

As a result of this pioneering research, many scientists then sought to connect the physiological aspects of the nervous and sensory systems to specific behaviors. These scientists – Karl von Frisch, Erich von Holst, and Theodore Bullock – are frequently referred to as the “fathers” of neuroethology. Neuroethology did not really come into its own, though, until the 1970s and 1980s, when new, sophisticated experimental methods allowed researchers such as Mark Konishi, Walter Heiligenberg, Jörg-Peter Ewert, and others to study the neural circuits underlying verifiable behavior.

Modern neuroethology

The International Society for Neuroethology (ISN) represents the present discipline of neuroethology, which was founded on the occasion of the NATO-Advanced Study

Institute "Advances in Vertebrate Neuroethology" (August 13-24, 1981) organized by J.-P. Ewert, D.J. Ingle and R.R. Capranica, held at the University of Kassel in Hofgeismar, Germany (cf. report Trends in Neurosci. 5:141-143,1982). The first president of ISN was Theodore H. Bullock. The ISN has met every three years since its first meeting in Tokyo in 1986.

Its membership draws from many research programs around the world; many of its members are students and faculty members from medical schools and neurobiology departments from various universities. Modern advances in neurophysiology techniques have enabled more exacting approaches in an ever-increasing number of animal systems, as size limitations are being dramatically overcome. Survey of the most recent (2007) congress of the ISN meeting symposia topics gives some idea of the field's breadth:

- Comparative aspects of spatial memory (rodents, birds, humans, bats)
- Influences of higher processing centers in active sensing (primates, owls, electric fish, rodents, frogs)
- Animal signaling plasticity over many time scales (electric fish, frogs, birds)
- Song production and learning in passerine birds
- Primate sociality
- Optimal function of sensory systems (flies, moths, frogs, fish)
- Neuronal complexity in behavior (insects, computational)
- Contributions of genes to behavior (Drosophila, honeybees, zebrafish)
- Eye and head movement (crustaceans, humans, robots)
- Hormonal actions in brain and behavior (rodents, primates, fish, frogs, and birds)
- Cognition in insects (honeybee)

Application to technology

Neuroethology can help create advancements in technology through an advanced understanding of animal behavior. Model systems were generalized from the study of simple and related animals to humans. For example the neuronal cortical space map discovered in bats, a specialized champion of hearing and navigating, elucidated the concept of a computational space map. In addition, the discovery of the space map in the barn owl led to the first neuronal example of the Jeffress model. This understanding is translatable to understanding spatial localization in humans, a mammalian relative of the bat. Today, knowledge learned from neuroethology are being applied in new technologies. For example, Randall Beer and his colleagues used algorithms learned from insect walking behavior to create robots designed to walk on uneven surfaces (Beer et al.). . Neuroethology and technology contribute to one another bidirectionally.

Neuroethologists seek to understand the neural basis of a behavior as it would occur in an animal's natural environment but the techniques for neurophysiological analysis are lab-based, and cannot be performed in the field setting. This dichotomy between field and lab studies poses a challenge for neuroethology. From the neurophysiology perspective, experiments must be designed for controls and objective rigor, which contrasts with the ethology perspective—that the experiment be applicable to the animal's natural

condition, which is uncontrolled, or subject to the dynamics of the environment. An early example of this is when Walter Rudolf Hess developed focal brain stimulation technique to examine a cat's brain controls of vegetative functions in addition to other behaviors. Even though this was a breakthrough in technological abilities and technique, it was not used by many neuroethologists originally because it compromised a cat's natural state, and, therefore, in their minds, devalued the experiments' relevance to real situations.

When intellectual obstacles like this were overcome, it led to a golden age of neuroethology, by focusing on simple and robust forms of behavior, and by applying modern neurobiological methods to explore the entire chain of sensory and neural mechanisms underlying these behaviors (Zupanc 2004). New technology allows neuroethologists to attach electrodes to even very sensitive parts of an animal such as its brain while it interacts with its environment. The founders of neuroethology ushered this understanding and incorporated technology and creative experimental design. Since then even indirect technological advancements such as battery-powered and waterproofed instruments have allowed neuroethologists to mimic natural conditions in the lab while they study behaviors objectively. In addition, the electronics required for amplifying neural signals and for transmitting them over a certain distance have enabled neuroscientists to record from behaving animals performing activities in naturalistic environments. Emerging technologies can complement neuroethology, augmenting the feasibility of this valuable perspective of natural neurophysiology.

Another challenge, and perhaps part of the beauty of neuroethology, is experimental design. The value of neuroethological criteria speak to the reliability of these experiments, because these discoveries represent behavior in the environments in which they evolved. Neuroethologists foresee future advancements through using new technologies and techniques, such as computational neuroscience, neuroendocrinology, and molecular genetics that mimic natural environments.

Case studies

Jamming avoidance response

In 1963, two scientists, Akira Watanabe and Kimihisa Takeda, discovered the behavior of the jamming avoidance response in the knifefish *Eigenmannia* sp. In collaboration with T.H. Bullock and colleagues, the behavior was further developed. Finally, the work of W. Heiligenberg expanded it into a full neuroethology study by examining the series of neural connections that led to the behavior. *Eigenmannia* is a weakly electric fish that can self-generate electric discharges through electrocytes in its tail. Furthermore, it has the ability to electrolocate by analyzing the perturbations in its electric field. However when the frequency of a neighboring fish's current is very close (less than 20 Hz difference) to that of its own, the fish will avoid having their signals interfere through a behavior known as Jamming Avoidance Response. If the neighbor's frequency is higher than the fish's discharge frequency, the fish will lower its frequency, and vice versa. The sign of the frequency difference is determined by analyzing the "beat" pattern of the incoming interference which consists of the combination of the two fish's discharge patterns.

Neuroethologists performed several experiments under *Eigenmannia*'s natural conditions to study how it determined the sign of the frequency difference. They manipulated the fish's discharge by injecting it with curare which prevented its natural electric organ from discharging. Then, an electrode was placed in its mouth and another was placed at the tip of its tail. Likewise, the neighboring fish's electric field was mimicked using another set of electrodes. This experiment allowed neuroethologists to manipulate different discharge frequencies and observe the fish's behavior. From the results, they were able to conclude that the electric field frequency, rather than an internal frequency measure, was used as a reference. This experiment is significant in that not only does it reveal a crucial neural mechanism underlying the behavior but also demonstrates the value neuroethologists place on studying animals in their natural habitats.

Feature analysis in toad vision

The recognition of prey and predators in the toad was first studied in depth by Jörg-Peter Ewert. He began by observing the natural prey-catching behavior of the common toad (*Bufo bufo*) and concluded that the animal followed a sequence that consisted of stalking, binocular fixation, snapping, swallowing and mouth-wiping. However, initially, the toad's actions were dependent on specific features of the sensory stimulus: whether it demonstrated worm or anti-worm configurations. It was observed that the worm configuration, which signaled prey, was initiated by movement along the object's long axis, whereas anti-worm configuration, which signaled predator, was due to movement along the short axis (Zupanc 2004).

Ewert and coworkers adopted a variety of methods to study the predator versus prey behavior response. They conducted recording experiments where they inserted electrodes into the brain, while the toad was presented with worm or anti-worm stimuli. This technique was repeated at different levels of the visual system and also allowed feature detectors to be identified. In focus was the discovery of prey-selective neurons in the optic tectum, whose axons could be traced towards the snapping pattern generating cells in the hypoglossal nucleus. The discharge patterns of prey-selective tectal neurons in response to prey objects – in freely moving toads – „predicted“ prey-catching reactions such as snapping. Another approach, called stimulation experiment, was carried out in freely moving toads. Focal electrical stimuli were applied to different regions of the brain, and the toad's response was observed. When the thalamic-pretectal region was stimulated, the toad exhibited escape responses, but when the tectum was stimulated in an area close to prey-selective neurons, the toad engaged in prey catching behavior (Carew 2000). Furthermore, neuroanatomical experiments were carried out where the toad's thalamic-pretectal/tectal connection was lesioned and the resulting deficit noted: the prey-selective properties were abolished both in the responses of prey-selective neurons and in the prey catching behavior. These and other experiments suggest that prey selectivity results from pretecto-tectal influences.

Ewert and coworkers showed in toads that there are stimulus-response mediating pathways that translate perception (of visual sign stimuli) into action (adequate behavioral responses). In addition there are modulatory loops that initiate, modify or

specify this mediation (Ewert 2004). Regarding the latter, for example, the telencephalic caudal ventral striatum is involved in a loop gating the stimulus-response mediation in a manner of directed attention. The telencephalic ventral medial pallium („primordium hippocampi“), however, is involved in loops that either modify prey-selection due to associative learning or specify prey-selection due to non-associative learning, respectively.

Computational neuroethology

Computational neuroethology (CN or CNE) is concerned with the computer modelling of animal behavior, including its underlying neural mechanisms. CN systems work within a closed-loop environment; that is, they perceive their (perhaps artificial) environment directly, rather than through human input, as is typical in AI systems. For example, Barlow et al. developed a time-dependent model for the retina of the horseshoe crab *Limulus polyphemus* on a Connection Machine (Model CM-2). Instead of feeding the model retina with idealized input signals, they exposed the simulation to digitized video sequences made underwater, and compared its response with those of real animals.

Model systems

- Bat echolocation – nocturnal flight navigation and prey capture
- Oscine bird song – zebra finch, canary
- Electric fish – navigation, communication, Jamming Avoidance Response (JAR), corollary discharge, expectation generators, and spike timing dependent plasticity
- Barn Owl auditory spatial map – nocturnal prey location and capture
- Toad vision – discrimination of prey versus predator --Video „Image processing in the toad’s visual system: behavior, brain function, artificial neuronal net“
- Cricket song – mate attraction and corollary discharge
- Fish Mauthner cells – C-start escape response and underwater directional hearing
- Fly – Microscale directional hearing in *Ormia ochracea*, sex differences of the visual system in Bibionidae, and spatial navigation in chasing behavior of *Fannia canicularis*
- Noctuid moths – ultrasound avoidance response to bat calls
- Aplysia – learning and memory in startle response
- Rat – spatial memory and navigation
- Salmon homing – olfactory imprinting and thyroid hormones
- Crayfish – escape and startle behaviors, aggression and formation of social hierarchies
- Cichlid fish – aggression and attack behaviors
- Honey bee – learning, navigation, vision, olfaction, flight, aggression, foraging
- More Model Systems and Information