What Do Whales Feel?

An examination of the functioning of the senses in cetaceans, the group of mammals comprising whales, dolphins and porpoises

Some of the senses that we and other terrestrial mammals take for granted are either reduced or absent in cetaceans or fail to function well in water. For example, it appears from their brain structure that toothed species are unable to smell. Baleen species, on the other hand, appear to have some related brain structures but it is not known whether these are functional. It has been speculated that, as the blowholes evolved and migrated to the top of the head, the neural pathways serving sense of smell may have been nearly all sacrificed. Similarly, although at least some cetaceans have taste buds, the nerves serving these have degenerated or are rudimentary.

The sense of touch has sometimes been described as weak too, but this view is probably mistaken. Trainers of captive dolphins and small whales often remark on their animals' responsiveness to being touched or rubbed, and both captive and free- ranging cetacean individuals of all species (particularly adults and calves, or members of the same subgroup) appear to make frequent contact. This contact may help to maintain order within a group, and stroking or touching are part of the courtship ritual in most species. The area around the blowhole is also particularly sensitive and captive animals often object strongly to being touched there.

The sense of vision is developed to different degrees in different species. Baleen species studied at close quarters underwater - specifically a grey whale calf in captivity for a year, and free-ranging right whales and humpback whales studied and filmed off Argentina and Hawaii - have obviously tracked objects with vision underwater, and they can apparently see moderately well both in water and in air. However, the position of the eyes so restricts the field of vision in baleen whales that they probably do not have stereoscopic vision.

On the other hand, the position of the eyes in most dolphins and porpoises suggests that they have stereoscopic visionforward and downward. Eye position in freshwater dolphins, which often swim on their side or upside down while feeding, suggests that what vision they have is stereoscopic forward and upward. By comparison, the bottlenose dolphin has extremely keen vision in water. Judging from the way it watches and tracks airborne flying fish, it can apparently see fairly well through the air-water interface as well. And although preliminary experimental evidence suggests that their in-air vision is poor, the accuracy with which dolphins leap high to take small fish out of a trainer's hand provides anecdotal evidence to the contrary.

Such variation can no doubt be explained with reference to the habitats in which individual species have developed. For example, vision is obviously more useful to species inhabiting clear open waters than to those living in turbid rivers and flooded plains. The South American boutu and Chinese beiji, for instance, appear to have very limited vision, and the Indian susus are blind, their eyes reduced to slits that probably allow them to sense only the direction and intensity of light.

Although the senses of taste and smell appear to have deteriorated, and vision in water appears to be uncertain, such weaknesses are more than compensated for by cetaceans' well-developed acoustic sense. Most species are highly vocal, although they vary in the range of sounds they produce, and many forage for food using echolocation[1]. Large baleen whales primarily use the lower frequencies and are often limited in their repertoire. Notable exceptions are the nearly song-like choruses of bowhead whales in summer and the complex, haunting utterances of the humpback whales. Toothed species in general employ more of the frequency spectrum, and produce a wider variety of sounds, than baleen species (though the sperm whale apparently produces a monotonous series of high-energy clicks and little else). Some of the more complicated sounds are clearly communicative, although what role they may play in the social life and 'culture' of cetaceans has been more the subject of wild speculation than of solid science.

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[1]echolocation: the perception of objects by means of sound wave echoes.

*Great thanks to volunteer **Lan Nguyen** has contributed these explanations and question markings.*

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Questions 1-7

Complete the table below.

*Choose **NO MORE THAN THREE WORDS** from Reading Passage for each answer.*

*Write your answers in boxes **1-7** on your answer sheet.*

SENSE	SPECIES	ABILITY	COMMENTS
Smell	toothed	no	evidence from brain structure
	baleen	not certain	related brain structures are present
Taste	some types	poor	nerves linked to their **1** _____ are underdeveloped

Touch	all	Yes	region around the blowhole very sensitive
Vision	**2**	Yes	probably do not have stereoscopic vision
	dolphins, porpoises	Yes	probably have stereoscopic vision **3**
	4	yes	probably have stereoscopic vision forward and upward
	Bottlenose dolphin	yes	exceptional in **5** and good in air-water interface
	boutu and beiji	poor	have limited vision
	Indian susu	no	probably only sense direction and intensity of light
Hearing	most large baleen	yes	usually use **6** ; repertoire limited
	7 whales and humpback whales	yes	song-like
	toothed	yes	use more of frequency spectrum; have wider repertoire

Questions 8-12

*Answer the questions below using **NO MORE THAN THREE WORDS** from the passage for each answer.*

*Write your answers in boxes **8-12** on your answer sheet.*

8 Which of the senses is described here as being involved in mating?

9 Which species swims upside down while eating?

10 What can bottlenose dolphins follow from under the water?

11 Which type of habitat is related to good visual ability?

12 Which of the senses is best developed in cetaceans?

The Birth of Scientific English

A. In today's world, science is based on a few languages including Japanese, French, and German, however, the English language is the one that is probably the widely-known global language of science. This fact is not due to the dominance of English-speaking countries like the USA in scientific research. But it's the scientists from the non-English speaking countries thinking that they need to write their research in English to gain a global outreach. Because of the prominence of scientific English in the present world, it may look astonishing that nobody would know how to write science in English back in the 17th century. Previously, Latin was considered the lingua franca for European intellectuals.

B. The European Renaissance (c. 14th-16th century) also known as the `revival of learning, a period of refreshing interest pertaining to the 'lost knowledge' of ancient times. Meanwhile, many research scholars also started to do research and spread their knowledge and experience. During this time, the developed countries in Europe created an atmosphere to develop competitive interest in world exploration and to intensify trade. This form of expansion policy, that is to spread the English language to the west in the US and to the east in India, was ultimately welcomed by scientific developments like the innovation of magnetism (resulting in the invention of the compass). Similarly, developments in cartography and - in fact the most significant revolution in the scientific world is - the new facts and theories of astronomy along the rotation of the Earth from the various stars and planets, described by Copernicus between 1473 and 1543.

C. Amongst various countries, England was the first country to come forward and adopt the Copernican ideas, and published happily by their scientists. Some of the research scholars include John Wallis and John Wilkins, who were patrons of language, pioneered in the Royal Society in the year 1660 to establish an empirical approach in scientific research.

D. Similar forms of academies and societies emerged in other parts of Europe, setting a path to a new national tradition of science. In the starting time of this scientific revolution, almost all published work in the national languages were from popular works, encyclopaedias, language translations, academic textbooks and so on. There was no sign of science in the English language till the mid 17th century. If we see an example, Newton researched and published officially his mathematical treatise, called the Principa, in Latin. However, he later published research on the properties of light - Opticks in the English language.

E. Original science continued to write in Latin for various reasons. The major reason was to reach a wider audience. Since Latin was comfortable for international audiences consisting of research scholars, many choosed Latin. Whereas, English was emerging and spread to a socially wider population, more of the local community. Thus, popular science was developed in English.

F. The next best reason for preferring Latin, may be to maintain secrecy. Publishing openly and giving access to all might lead to some sort of danger. That is putting the research work into the public domain, where the initial ideas of the author did not reach its full potential. Besides above all, there was a rising concern about intellectual property rights during that time. It portrayed both the humanist intention of the individual, rational-thinking scientist who brings new inventions and discovers many things via private intellectual labour, followed by the rising attachment between original science and business exploitation. It is important to note that there was a social class distinction among scholars and gentlemen who could read, write, and understand Latin, and a pool of men of trade who didn't know much Latin or lacked knowledge on classical texts. When we go back to the mid - 17th century, many mathematicians had a common practice that they do not disclose their discoveries and proofs outside. They did it by writing them in cipher, in some other languages, or else in secret messages kept in a sealed box with the Royal Society. On the other hand, some scientists preferred Latin for ease because of its audience. Even though it is open to

international audiences, it was restricted socially.

G. The third reason for not writing the original science in English and being delayed may have been to work on the lack of linguistic capacity in English in the early modern era. Unlike other languages, English was not well prepared to face the argument based on scientific research. First, it did not have the technical vocabulary required for arguments. Second, it lacked the grammatical resources to represent the world and discuss the connections, like the cause and effect, that could come between complex and hypothetical entities.

H. Surprisingly, many members of the Royal Society showed a distinct interest in language and connected in various linguistic assignments. Some proposals came in the year 1664 to launch a committee for the purpose of developing the English language. The members of the Royal Society made several attempts, achieved a great deal to encourage the publication of science in English and encouraged the development of a convenient writing style. Besides that, some members also made publications on monographs in English. Amongst them, Robert Hooke was the first one. He was the first curator of experiments from the society who explained his experiments with the help of microscopes in Micrographia (1665). His entire work was based on narration style, an oral transcript and lectures.

I.A new scientific journal called 'Philosophical Transactions' was inaugurated in 1665. It is the first officially announced International English-language scientific journal that motivated a new form of scientific writing that highlighted the aspects of specific experiments. Hence, the 17th century is regarded as a starting stage for establishing the concept of scientific English. However, in the subsequent years, this momentum had gone in vain because the German language took the lead and became the leading European language of science. Before the beginning of the 19th century, it was evident that 401 German scientific journals were published compared to the 91 in France and 50 in England. Nevertheless, throughout the 19th century, the scientific English again flourished with the substantial growth of the lexical part as it supplemented the industrial revolution's need for new technical vocabulary.

It included new optimised societies filled with professionals in order to boost new disciplines and publish new research studies.

The Birth of Scientific English Reading Questions

Questions 1 - 7

Complete the notes below.

Write **NO MORE THAN THREE WORDS AND/OR A NUMBER** from the passage for each answer.

- proposals came in the year 1664 to launch a committee for the purpose of developing the 1. _____ .
- Many 2. _____ had a common practice that they do not disclose their discoveries and proofs outside.
- Some of the research scholars include 3. _____ and 4. _____, who were patrons of language, pioneered in the Royal Society.
- Reason for not writing the original science in English and being delayed may have been to work on the lack of 5. _____ .
- Besides that, some members also made publications on monographs in English. Amongst them, 6. _____ was the first one.
- A new scientific journal called 7. _____ was inaugurated in 1665.

The effects of light on plant and animal species

Light is important to organisms for two different reasons. Firstly it Is used as a cue for the timing of daily and seasonal rhythms in both plants and animals, and secondly it is used to assist growth in plants. Breeding in most organisms occurs during a part of the year only, and so a reliable cue is needed to trigger breeding behaviour. Day length is an excellent cue, because it provides a perfectly predictable pattern of change within the year. In the temperate zone in spring, temperatures fluctuate greatly from day to day. but day length increases steadily by a predictable amount. The seasonal impact of day length on

physiological responses is called photoperiodism, and the amount of experimental evidence for this phenomenon is considerable. For example, some species of birds' breeding can be induced even in midwinter simply by increasing day length artificially (Wolfson 1964). Other examples of photoperiodism occur in plants. A short-day plant flowers when the day is less than a certain critical length. A long-day plant flowers after a certain critical day length is exceeded. In both cases the critical day length differs from species to species. Plants which flower after a period of vegetative growth, regardless of photoperiod, are known as dayneutral plants. Breeding seasons in animals such as birds have evolved to occupy the part of the year in which offspring have the greatest chances of survival. Before the breeding season begins, food reserves must be built up to support the energy cost of reproduction, and to provide for young birds both when they are in the nest and after fledging. Thus many temperatezone birds use the increasing day lengths in spring as a cue to begin the nesting cycle, because this is a point when adequate food resources will be assured. The adaptive significance of photoperiodism in plants is also clear. Short-day plants that flower in spring in the temperate zone are adapted to maximising seedling growth during the growing season. Long-day plants are adapted for situations that require fertilization by insects, or a long period of seed ripening. Short-day plants that flower in the autumn in the temperate zone are able to build up food reserves over the growing season and over winter as seeds. Day-neutral plants have an evolutionary advantage when the connection between the favourable period for reproduction and day length is much less certain. For example, desert annuals germinate, flower and seed whenever suitable rainfall occurs, regardless of the day length. The breeding season of some plants can be delayed to extraordinary lengths. Bamboos are perennial grasses that remain in a vegetative state for many years and then suddenly flower, fruit and die (Evans 1976). Every bamboo of the species Chusquea abietifolio on the island of Jamaica flowered, set seed and died during 1884. The next generation of bamboo flowered and died between 1916 and 1918, which suggests a vegetative cycle of about 31 years. The climatic trigger for this flowering cycle is not yet known, but the adaptive significance is clear. The simultaneous production of masses of bamboo seeds (in some cases lying 12 to 15 centimetres deep on the ground) is more than all the seedeating animals can cope with at the time, so that some seeds escape being eaten and grow up to form the next generation (Evans 1976). The second reason light is important to

organisms is that it is essential for photosynthesis. This is the process by which plants use energy from the sun to convert carbon from soil water into organic material for growth. The rate of photosynthesis in a plant can be measured by calculating the rate of its uptake of carbon. There is a wide range of photosynthetic responses of plants to variations in light intensity. Some plants reach maximal photosynthesis at one-quarter full sunlight, and others, like sugarcane, never reach a maximum, but continue to increase photosynthesis rate as light intensity rises. Plants in general can be divided into two groups: shade-tolerant species and shadeintolerant species. This classification is commonly used in forestry and horticulture. Shadetolerant plants have lower photosynthetic rates and hence have lower growth rates than those of shade-intolerant species. Plant species become adapted to living in a certain kind of habitat, and in the process evolve a series of characteristics that prevent them from occupying other habitats. Grime (1966) suggests that light may be one of the major components directing these adaptations. For example, eastern hemlock seedlings are shade-tolerant. They can survive in the forest understorey under very low light levels because they have a low photosynthetic rate.

Questions 8-14 Complete the sentences. Choose NO MORE THAN THREE WORDS from the passage for each answer. Write your answers in boxes 8-14 on your answer sheet.

8 Day length is a useful cue for breeding in areas where 8..... are unpredictable.

9 Plants which do not respond to light levels are referred to as 9.....
10 Birds in temperate climates associate longer days with nesting and the availability of 10.....

11 Plants that flower when days are long often depend on 11..... to help them reproduce.

12 Desert annuals respond to 12..... as a signal for reproduction.

13 There is no limit to the photosynthetic rate in plants such as 13.....
14 Tolerance to shade is one criterion for the 14..... of plants in forestry

LISTENING

Questions 1 – 10

Complete the notes below.
*Write **ONE WORD AND/OR A NUMBER** for each answer.*

Buckworth Conservation Group

Regular activities

Beach

- making sure the beach does not have **1** …… on it
- no **2** ……Nature reserve
- maintaining paths
- nesting boxes for birds installed
- next task is taking action to attract **3** …… to the place
- identifying types of **4** ……
- building a new **5** ……

Forthcoming events

Saturday

- meet at Dunsmore Beach car park
- walk across the sands and reach the **6** ……
- take a picnic
- wear appropriate **7** ……

Woodwork session

- suitable for **8** …… to participate in
- making **9** …… out of wood
- 17th, from 10 a.m. to 3 p.m.
- cost of session (no camping): **10** £ ……

Questions 1 – 7

Complete the notes below.

*Write **ONE WORD ONLY** for each answer.*

Opportunities for voluntary work in Southoe village

Library

- Help with **1** …… books (times to be arranged)
- Help needed to keep **2** …… of books up to date
- Library is in the **3** …… Room in the village hall

Lunch club

- Help by providing **4** ……
- Help with hobbies such as **5** ……

Help for individuals needed next week

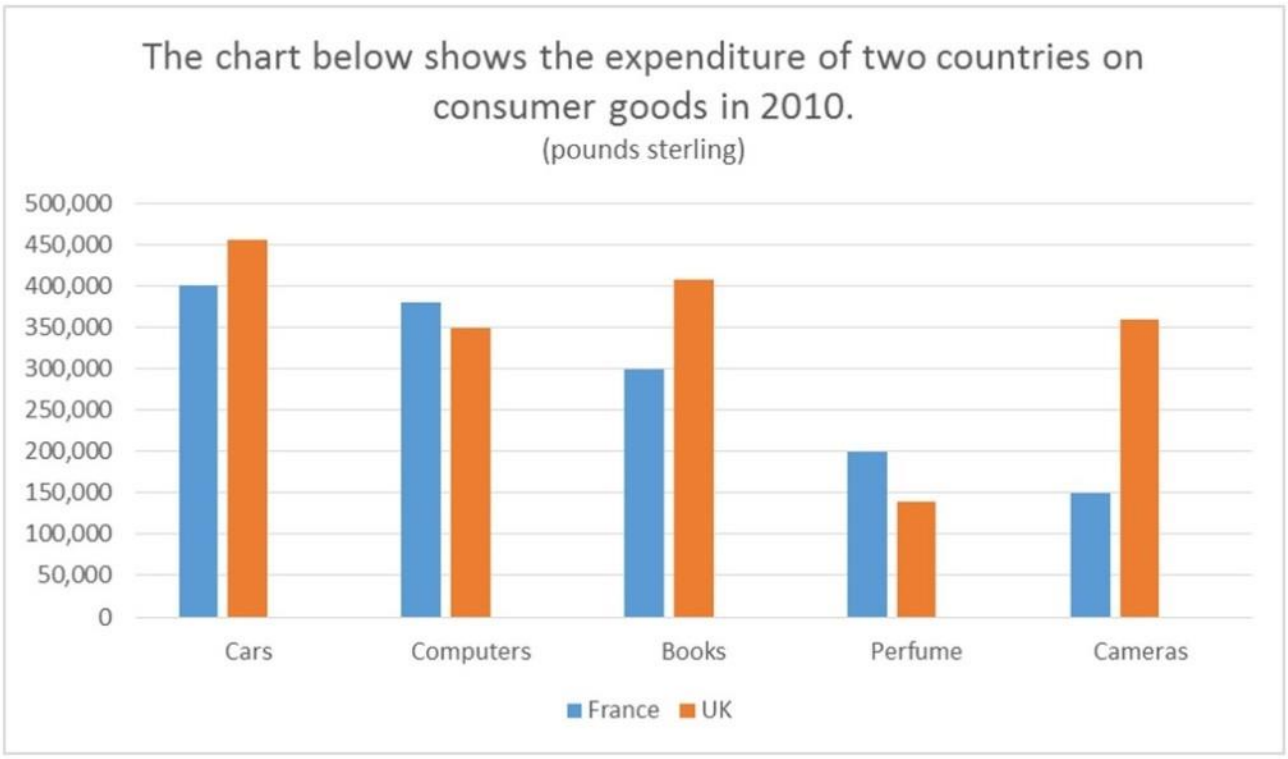
- Taking Mrs Carroll to **6** ……
- Work in the **7** …… at Mr Selsbury's house

Questions 8-10

Complete the table below.
*Write **ONE WORD ONLY** for each answer.*

Village social events

Date	Event	Location	Help needed
19 Oct	**8** ……	Village hall	providing refreshments
18 Nov	dance	Village hall	checking **9** ……
31 Dec	New Year's Eve party	Mountfort Hotel	designing the **10** ……


The chart below shows the expenditure of two countries on consumer goods in 2010.
(pounds sterling)
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
Cars
Computers
Books
Perfume
Cameras
France
UK