Whale and dolphin brains are special—for heat production, not for intelligence

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Scientific evidence shows specialized features in the large brains of whales and dolphins that are adapted for heat production.

Whales and dolphins have the largest brains on the planet, some of them weighing over eight kilograms, six times heavier than the average human brain.

These mammals' huge brains have often been cited as evidence of them being highly intelligent; however, does their large brain size mean they have the same mental—or better—capabilities as humans?

Scientific evidence from a study led by Professor Paul Manger from the School of Anatomical Sciences at the University of the Witwatersrand in Johannesburg, South Africa (Wits University), indicate that whales and dolphins' large brains lack the diversity, flexibility and adaptability in their mental processes and behavior that humans have, and that their large brains instead evolved to keep these brains warm in icy oceanic temperatures. This research has been published in the journal *Scientific Reports*.

"In water, mammals lose heat to the environment 90 times faster than we do to the air," says Manger. "The brains of all mammals produce heat independently of the heat-producing mechanisms of the body. This heat is required to keep their neurons warm enough to function efficiently."

Whale and dolphin brains became exceptionally large around 32-million-years ago, 20 million years after they became fully aquatic and around the time when there was a major drop in oceanic water temperatures across the planet.

Even a small drop in brain temperature makes many neurons inactive, greatly reducing mental activity. Manger and his team proposed that if changes in water temperature led to the emergence of large brains in whales and dolphins, then there should be a specialized brain-based heat producing system in whales and dolphin brains, not seen in the brains of other mammals.

"What we have found is that most of the cells forming the brains of whales and dolphins have the internal chemistry required to function as the brain's own heating elements," says Manger, who first proposed in

2006 that the large size of brains in whales and dolphins is an adaptive evolutionary response to the challenges of living in the cold aquatic environment. "These 'heating elements' are far fewer in the brains of land-living mammals, such as the closely related hippopotamuses, pigs, buffaloes, camels, and antelopes."

Manger and his colleagues found that there are three unusual, or specialized, features of a brain-based heat production system in whale and dolphin brains. Firstly, they found that around 90% of the neurons in whale and dolphin brains contain proteins called uncoupling proteins. These proteins make energy generation in cells very inefficient, giving off heat instead of producing the ATP required for normal neuronal functions. In closely related species, such as the river hippopotamus, a mere 35% of neurons contain these proteins.

Secondly, in whales and dolphins, 30-70% of glial cells, the cells that support neuronal function, contain uncoupling proteins. In other closely related species, these glial cells do not appear to contain uncoupling proteins in readily detectable amounts.

Finally, the nerve terminals that contain the neurochemical noradrenaline, which controls the concentration and activity of uncoupling proteins, are about 30% denser in whale and dolphin brains when compared to closely related species.

"These new findings, when merged with our current understanding of the structure and function of whale and dolphin brains, indicate that their brains are specialized for thermogenesis, probably in response to their cold aquatic environment, rather than for intellectual functions," says Manger.

While the concept that whales and dolphins do not appear to be any more intelligent than the average mammal might be a sobering thought

for some, Manger and his team believe it is crucial for conservation purposes to understand these unique mammals for what they really are, rather than for what we might imagine, or wish, them to be.

"Knowing how central water temperature is to their survival may allow us to understand what will happen to certain species of whale and dolphin during the inevitable rise in oceanic temperatures associated with human-induced climate change," says Manger.

"It is quite possible that some species may die through overheating, becoming victims of global warming. This understanding may allow us to direct our efforts in the most appropriate way to secure the future of as many whale and dolphin species as possible."

More information: Paul R. Manger et al. Amplification of potential thermogenetic mechanisms in cetacean brains compared to artiodactyl brains, *Scientific Reports* (2021). DOI: 10.1038/s41598-021-84762-0

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