Imagine a world much different than ours, one that is bitter, frigid and cold. The seas are in constant fluctuation and the landscape of much of the planet is barren. The animals are bigger, furrier, and strengthened by the icy weather they must endure to survive. Now, move slowly through time until you embrace the climatic change which ends with the present day, much different from the Ice Age you just pictured. However, this present age is surely not the end of the frozen landscape of our past, nor the warming that is to be felt in the coming years.

When you imagine the climatic shifts that our planet endures, there is more to be bargained with than just temperature fluctuations. The plants and animals that survived these changes gradually adapted and are the organisms that we share our world with today. Among those who inhabit this planet, there are few that we know of other than ourselves who display evolved cognitive functions. The role that climatic shifts played in the evolution of cetaceans may enable us to study the connection between climate, culture, the evolution of cognition, and what it may mean for our future survival.

Present day cetaceans, specifically whales, evolved from what are known as the oldest whales, Archaeocetes. These ancient creatures were much like present day whales, but had nostrils rather than blowholes, visible hind limbs, and a pelvis that was still attached to the skeleton. The Eocene period is the first known period of existence of ancestral whales with fossils displaying *Pakicetus* and *Basilosaurus*, two species from which modern whales evolved (Introduction
2). Climates in the Eocene were tropical with warm and mild weather, greater rainfall, and no winter frost (White 2). These mild climates started to shift and become cooler through the Oligocene Period into the Miocene Period. This period of time is where most common fossils of cetaceans are found, such as blue, right, and sperm whales, as well as present day dolphins and killer whales (Introduction 3).

It was at the end of the Miocene Period and into the dawn of the Pliocene era that the oceans began to cool and atmospheric and ocean circulations formed. During this time, whales flourished (White 1). As the first Ice Age hit a third of the way into the Pleistocene era, complex cognition was needed to survive the extreme climate change (Richardson 2). In efforts to survive these chaotic shifts, the evolution of increasing brain size may be liked to environmental adaptation acquired through cultural learning (Richardson 11).

The Encephalization Quotient (EQ) is the term used to describe brain size evolution. This refers to the brain size in relation to the expected brain size when looking at brain to body weight ratios. Cetaceans are known to have the highest level of EQ, however modern humans have the highest EQ value in regards to cognition. In scale, modern humans register at an EQ of 7.0 and cetaceans have levels close to 4.5 (Marino 25). Humans possess the highest EQ level due to the rapid evolutionary process they experienced, but cetaceans also underwent a rapid increase in the last 35 million years, a period much longer than humans (Marino 26).

Cognition in cetaceans is the focus of Lori Marino’s research. Marino’s work shows that the rapid evolution that cetaceans underwent produced an expansion of the neocortex (Marino, Lori et al 971). The neocortex of whales in particular contains 98.2 billion non-neuronal cells, or glia. This is the highest number of glial cells known to exist in any mammal. These
cells serve to play an important role in information processing, and may account for high cognitive functioning (Fields 1).

In addition to a high glia count, some cetaceans also exhibit the presence of spindle neurons, previously thought to only exist in humans and a few other mammals. These spindle neurons assist in rapid communication abilities and are also thought to be involved in cognitive functions (John 1). Cetaceans display complex social patterns, and advanced communication and cultural qualities. These abilities could be related to the complex brain functions that arose from evolution (John 1).

The idea that complex cognitive abilities are influenced by climate change or by brain size are controversial. In his article, “An Examination of Cetacean Brain Structure With a Novel Hypothesis Correlating Thermogenesis to the Evolution of a Big Brain,” P.R. Manger challenges that brain size and intelligence in cetaceans is due to a “combination of glial cells and uni-hemispheric sleep phenomenology.” He postulates that water temperature is the main factor in the evolution of increased brain size as an alternative explanation to the size and cognitive abilities of cetaceans. According to Manger, as water temperatures began to cool in the Eocene-Oligocene era, cetaceans evolved larger brains in response to the cooling waters (Manger 1).

Lori Marino addresses this hypothesis in her article, “Cetaceans Have Complex Brains for Complex Cognition.” She agrees that oceanic cooling was a factor in the Eocene-Oligocene era, but responds that cetaceans were already large enough physically to deal with any climatic changes (Marino, Lori et al 966). This suggests that any need to increase brain size to compensate for oceanic cooling was unnecessary. While Manger argues that brain size evolution has nothing to do with complex cognition, Marino poses that cetacean brains evolved to support complex cognition (Marino, Lori et al 966).
There is a link drawn between environmental deterioration and brain size increase in mammal evolution (Richardson 2). Brain size may indeed evolve to support complex cognition, but why? There is no question that cetaceans in late Miocene life needed to cope with environmental changes. In fact, the largest increase in EQ occurs in transitions between Miocene and Pliocene species (4). The adaptations that were needed to survive the oncoming Ice Age were not derived from future expectations, but from organisms adapting to current condition. In basic theory of evolution, **populations evolve due to the selection of characteristics that best fit the current conditions** (Edgehouse).

Manger argues that brain size was influenced by water temperature and Marino counters that brain size enlarged to encompass complex cognition. In regards to basic evolutionary theory, both may be involved. Water temperature may have been the environmental factor that set the evolution in motion for the enlargement of the brain at such a rapid rate. As the brain grew, so did cognitive abilities (Richardson 3). In Marino’s article, “Convergence of Complex Cognitive Abilities in Cetaceans and Primates,” she advocates that “humans have the highest EQ level due to the rapid evolutionary process they underwent” (Marino 26).

Natural selection adapts species to their particular environment and the changes that are occurring within that specific environment. Brains and behaviors will be specialized for species based on present environmental factors and challenges that are faced (Richardson 5). While brains and behaviors are slowly changing in the evolutionary process, other learned and innate factors also come into the picture that enable a species to successfully adapt (Edgehouse). Culture, for example, plays an important role in the development of cognition (Richardson 6). It can be noted here that the presence of spindle neurons, thought to be involved in cognitive function and complex cultural attributes, are thought to have appeared in hominids about 15 million years
The same neurons that are being found in cetaceans appeared much earlier, approximately 30 million years ago (John 1). This vast difference in time may imply that such neurons advocated the development of cognition in response to necessary environmental adaptation and survival. Evolved developments such as these neurons may be where the link concerning culture plays a significant role.

Human brains evolved to encompass hunting and gathering techniques as means of survival throughout the Pleistocene era (5). These tactics were adopted within the spectrum of human evolution that occurred only in the last 12,000 years, known as the Holocene era (White 2). Cultural traditions, including survival tactics, may be what could be referred to as “evoked culture.” Evoked culture can be defined as the innate information that is taught to offspring due to the environment that they live in (Richardson 5). Evolution does not allow for the development of such information based on what is to come, but rather by what is happening currently (Edgehouse). This point can be used in solidifying the theory that cognition and culture are closely entwined. Though physical adaptations are made to help species survive in their environment, there is also a plethora of behaviors that are learned and passed on from parent to offspring (Edgehouse).

Cetaceans possess a complex cultural system, shown specifically in killer whales. Pods of killer whales are suggested to be “the aquatic equivalent of a neighborhood populated by two different ethnic groups.” The cultural complexity of cetaceans involves everything from differing dialects and feeding habits to differing family units within the same species (Keim 2-3). These attributes stem from both innate and culturally learned behaviors displayed by many cetaceans. Culture may even play a viable part in some species’ ability to survive. Sperm whale clans, though part of the same species, form tightly knit groups that exist in differing parts of the
ocean. In the Atlantic, they are small and sparse, while in the Pacific they are more tightly woven. Warming waters that arise from El Nino fluctuations affect the wellbeing of the whales. While one clan responds negatively to the warming, the other clan improves from it’s present conditions (Keim 3).

The study of cognitive functions, culture, and climate change responses may be an important asset to help us in the coming years as the planet continues to warm. Maintaining diversity among populated species helps to ensure survival and is a viable component of natural selection (Edgehouse). Understanding the evolutionary process and how it fully functions may assist us in preparing for the future. However, being innately hardwired to respond to environmental challenges may not be something that is adequately possible, but is instead part of a cultural learning experience (Richardson 6).

We humans may be at the top of the list for our cognitive abilities, but are we adequately prepared to deal with climate shifts of the future? As stated by Marino, “Adaptation of cetaceans to a fully aquatic lifestyle represents one of the most dramatic transformations in mammalian evolutionary history.” Perhaps we can learn from these creatures how to adapt to our surroundings, how to prepare for our future. Knowing that culture serves an inherent purpose in our survival, and studying the world that surrounds us, may be the key to the survival of our species. More important than why cetaceans have big brains or complex cognition, is the mystery as to what they do with them and what they did with them to survive. We must not forget about the climatic changes they have endured and what knowledge they might be able to offer us about our future on this great planet.
Works Cited


http://www.des.ucdavis.edu/faculty/Richerson/Vienna.pdf