Ocean

(translated from a lesson for the very young, in a future language of clicks, whistles, grunts, and groans, over eight octaves)

We know now that the present state of our planet is due to good fortune, in the form of a carbonaceous chondrite. Before its fortuitous arrival from the asteroid belt the earth was partly dry land, unsuitable for advanced life. There was primitive life on land, which survived in part by hunting sea creatures, bringing them to the edge of extinction. Life in the ocean would have ended within a century or two had the impact not occurred. But then the asteroid arrived, showing yet again the unpredictability of fate. It had a diameter of half a kilometre and struck earth at what geologists call "mountains", which are like islands except that their bases were themselves on land. In fact, it struck at the highest of these land islands, where one tectonic plate was pushing up another. Moreover its composition contained a high proportion of water, so the effect was to flatten the overall variability of heights on the surface of the earth leaving a single ocean covering 90% of the planet's surface, broken by a scattering of small islands. Most life on dry land was extinguished, leaving only a small number of primitive species, mostly in the phylum *arthropoda*. These were confined to small islands and lacked the genetic diversity to evolve into well-adapted species, so that within a few centuries there was very little life outside the ocean.

Within the ocean, however, life flourished as it never had before, with a richness, diversity, and speed of evolution unmatched in the previous millennia. Before this event, the genetic code of life was restricted to a mere 20 of the more than 500 amino acids. But the meteor brought others, which were incorporated into the codes of one celled organisms at first, and then eventually into those of more complex creatures. Organic evolution could now produce more variety and occur more rapidly: mutations could result in a

richer array of proteins, and the range of mutations that could produce an advantageous protein was vastly greater.

Cetaceans, our ancestors, became dominant, and the abundance of food and the relative paucity of predators led to an explosion of species. The highly social nature and filter-feeding habits of one provided the conditions for intelligent cooperative life without the rivalry and warfare that marked some other species. This species developed rapidly and took charge of the coordination of all life. It is hard, looking back so many ages, to see ourselves in these animals with their strong resemblance to those that had lived marginal lives as prey of the land creatures. But both metaphor and genetics show our connection with them. Some scientists see the crucial link as being the capacity for song.

High frequencies are needed for echolocation and low frequencies for communication across a width of ocean, and our ancestors had both. They were thus well placed for widely distributed society. Moreover song is as beautiful as it is useful, so from the very beginning the descendants of these cetaceans combined art and organization. Both need intelligence, so we developed our enormous brains, so much larger and so much more intricately connected than anything that could have developed in any creature that cannot support itself with buoyancy. The earth was finally a domain for thinking, expression, and sharing.

A little known fact is how unsuited the land-based environment would be for astronomy. We suspect that land-based lifeforms did have some grasp of the wider universe. But they would not have had the advantages of using the transparent curvature of the ocean's surface as a lens, nor the capacity of water to filter and redirect high-frequency gamma rays. Nor would they have been able to place networks of observers on opposite sides of the planet in delicate communication, so that the interactions of neutrinos passing through

water and then through the metallic core of the earth before reaching water again could be studied. Any limited astronomical information that would have been available from land or mountain would have been inferior to the observations that we routinely make from deep in the ocean. It would also have been inferior to observations that can be made from beyond the Earth's atmosphere, even though these are not as accurate as those that can be made with the aid of a watery planet. So such creatures would have been tempted to travel or to send instruments into space, an environment in which air based creatures are if anything even less suited than we who have involved in water. Of course, we are immune to the temptation to venture beyond the ocean, and we have the intelligence to understand what a foolish move this would be; but we also have capacities that make it unnecessary. For from the time of our distant ancestors we have been capable of transmitting song over considerable distances. (The distances over which early cetaceans transmitted song may seem trivial to us now, but we must realize the importance of being able to sing to an audience on the other side of the planet.) Now we can transmit songs elsewhere in the solar system, and receive them. To develop teloidy we had to understand the harmonic properties of photons, which would be beyond the reach of more primitive minds. In this way we have been able to bring water-based life on Ceres, Ganymede, Europa, and Enceladus into the circle of communicating lifeforms. Some of our more advanced thinkers have dreams of a Galactic wide song system. If this proves to be possible, it will be as if the whole galaxy were one vast ocean.