Interactive Dialogue of the General Assembly on Harmony with Nature "Scientific findings on the impacts of human activities on the functioning of the Earth System"

The Harmony of Nature

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I'm holding in my hands two ball bearings, each about 2 centimeters in diameter. I propose to build a model of our cosmic environment. I'll let the first sphere represent the sun. On this scale the earth will be 2 meters away, and much too small for you to see it. Mars, even smaller will be another meter farther from the sun. On this scale, where shall we place the second sphere, representing the closest star to our own solar system? On top of the Empire State Building? At the JFK Airport? Much too close! It should be placed some distance beyond Toronto.

The sun and its neighbor are but two among the two hundred billion stars in our Milky Way Galaxy. That's some thirty stars apiece for every man, woman and child on earth. On the scale of our ball-bearing model our Milky Way Galaxy would extend beyond the moon! So now let's collapse our model by ten billion times, so that our disk-shaped pin-wheel galaxy would be the size of a two euro coin. Now where should I place this two pound coin to represent the next closest major spiral galaxy? In London? Be surprised! [holding coins about two feet apart] Collisions between stars are fantastically rare because stars are so far apart, whereas collisions between galaxies are common, though they take ages to happen, but what I'm here to talk about is the long history of the universe in contrast to the swift pace of our technological knowledge.

A most curious and interesting fact about the distant galaxies is that they are rushing away from each other, and the farther they are from us, the faster they are going. It's as if an immense explosion took place, and the faster fragments are now the farthest away. We can calculate from the speeds and distance when that explosion took place, 13.7 billion years ago, the creation of the universe, and the creation of time itself. This means we live in a universe with a history, a universe that has been changing throughout time. It is the history of the universe and our place within it, that I want to sketch briefly.

It was in the first three minutes of that fiery Big Bang that the two lightest elements were created, hydrogen and helium. Fire of sorts, yes, but no earth or air, and no water because there was no oxygen for H_2O. The Big Bang was over before the heavier elements had a chance to form.

The oxygen for our air and water and the carbon for our bodies was made very slowly over the next billions of years in the hellish cauldrons in the cores of evolving giant stars. Occasionally they would explode as supernovae, throwing into interstellar space the heavier elements including carbon and oxygen for our proteins, phosphorous for our DNA, iron for our blood, gold to plate our satellites, and uranium for our reactors. We are all born of the stars, our bodies are recycled star stuff. In time there were enough heavy elements for our sun and planetary system to form. That was just short of five billion years ago. At first the earth was a barren, volcanic place, battered by impacts of assorted asteroids, without permanent oceans or atmosphere. As the environment settled down, water vapor spewed forth from the volcanoes and condensed to fill the oceans. An atmosphere laced with carbon dioxide began to form. In those early days in the history of our solar system the sun was not so bright as it is now, and it took as much greenhouse effect as the carbon dioxide could provide to keep the oceans from freezing solid.

Happily the early atmosphere did not have too much oxygen — oxygen is a very active element, rusting any unprotected iron, and quite poisonous to the original living material. Early single-celled organisms slowly converted carbon dioxide into free oxygen, and the oxygen content of the atmosphere rose to around 20% just in time to provide more efficient fuel for the more complex life forming on earth in the Cambrian period, about 500 million years ago. So then planet Earth had water and air, and gradually it began to form the agricultural element earth—that is, soil—so the greening of the continents could take place. As I indicated our planet Earth has a history, and a complex one that took hundreds of millions of years to form the habitable surroundings we have today.

In the past five centuries, ever since Copernicus invented the idea of a solar system in which Earth was just one of a family of planets cycling around the sun, human beings have wondered if there are other habitable planets cycling around other stars, and whether habitable planets might indeed be inhabited by other sentient beings. In the past two decades astronomers have in fact started finding other planetary systems. Currently the so-called Kepler mission, a space-bourne observatory, is continuously monitoring the magnitudes of 100,000 stars to find the small dimming caused when a planet passes in front of a star. The project now has just over 2000 candidate stars where a temporary change in brightness has indicated that a planet might be present. The goal of the project is to find earth-sized planets cool enough to provide a habitable environment where life might have arisen.

But is a habitable environment enough to guarantee that life will form there? That is a giant question that scientists would like to answer, but first they would simply love to know if life has formed in at least one other place in our galaxy. Or are we alone? Now for Earth itself, for about two billion years the life on our planet was so primitive that we have no clues as to how it could have been detected from afar. Not until our atmosphere had gained enough oxygen would there have been a potential signal that something special was happening here. As I have mentioned, oxygen is a very active element, and unless it is continuously replenished, it will rust away, so astronomers hope eventually to find a planet where an oxygen atmosphere can be detected spectrographically. The discovery of such a signal will be a truly exciting event, because the presence of oxygen would suggest that there was some chemical activity, most probably some sort of life, to continually replenish it. But such a discovery would leave more questions unanswered than answered, because that signal would not reveal what kind of life is out there.

Many years ago I heard a fascinating lecture by the late Philip Morrison, an institute professor at MIT. It was entitled "Termites and Telescopes." He began his lecture by stating that human beings were supposedly the only creatures technologically advanced enough to construct arches, something discovered by the Romans for building bridges. But, he pointed out, termites had discovered this long ago and these insects use arches in constructing their impressive nest structures. Morrison then asked the provocative question, could termites ever discover how to build telescopes? Building nests is a quintessential example of instinct, some inheritable chemistry in the termites, poorly understood, but something that took eons to become embedded in their genetic structures. Presumably, if the termites were ever to build telescopes, it would take hundreds of millions of years to code the instructions into their genetic chemistry.

Early in the 19th century the French botanist Pierre Lamarck proposed an evolutionary system whereby acquired knowledge could be inherited, compared to Darwin's later theory of variations being chosen by natural selection, a very slow process indeed. Morrison chose his apparently ridiculous example of termites and telescopes to paint the contrast between the slow trial and error learning process of biological evolution and the rapid cultural evolution where newly acquired knowledge can be passed on from one generation to another in other ways than genetic coding — books, for example. Biological evolution has brought *Homo sapiens* to the Lamarckian divide, to the stage of cultural evolution where more information can be carried in our brains than in our DNA. Termites are still unimaginably far from building telescopes, whereas for us telescopes were invented a mere 500 years ago, and are now universal.

The almost incredible speed of scientific discovery and technological development is transforming the world at a dizzying rate. Our great great grandparents would be far more at home in the world of Christopher Columbus and Nicolaus Copernicus than in our world of today. 125 years ago no one knew about X-rays or radioactivity or the inner structure of atoms. Automobiles, communication by radio, and airplanes still lay in the future. Sixty years ago, when I was a graduate student, biochemists and anatomists did not yet know precisely how many chromosomes were found in human cells. Mobile phones were something for comic strips and science fiction. Lasers were unknown. Today I have a dozen in my house.

In 1955 I had a wonderful opportunity to participate in an expedition to observe a total solar eclipse in Ceylon. Thirty-two years later, in 1987, I was able to return to the eclipse site, and I was asked what did I notice that was different. I mused that Sri Lanka seemed much more crowded than Ceylon had been. That's right, our tour guide responded. The population had doubled in those three decades. Since 1900 the entire world population has tripled. The physical mass of human beings and domesticated animals now makes up 90% of the vertebrate mass, up from 0.1% 10,000 years ago.

The accelerating expansion of technological power, combined with the explosive growth of the world population together with unsustainable consumption and production patterns, brings unparalleled challenges for the unity of nations. Already some centuries ago the expanding human population began to change the environment. Today nearly 80% of Earth's land surface has been modified by humans.

The passenger pigeon, a bird whose giant flocks once darkened the skies of the American Midwest, is no longer alive. Neither are the giant moa or the Irish elk. A few days ago I met a palaeontologist who works on recent vertebrate fossils. She informed me that sixty vertebrate species just in Hawaii have gone extinct since the human population arrived in the islands (with their associated rats).

Around the world numerous species, some we don't yet know about, are being threatened by deforestation and other major environmental changes. This is the competition between human population growth and older environments. Recently I visited the Lemur Conservation Reserve in Florida. These endangered primates from Madagascar are our distant cousins. Madagascar is a particularly fascinating place for studying the antecedents of *Homo sapiens*, because it was isolated from Africa and uniquely preserves early species from the primate family. Today space pressures from the human population in their native land may well doom the future of many lemur species, though the Conservation Reserve may slow this catastrophe.

I have in my hand a shell of the green Manus tree snail. These attractive shells cannot be sold in the United States because they are listed as an endangered species. Although abundant in New Guinea, the snail is threatened by loss of environment because increasing numbers of people need to be employed and housed. Since the shell cannot be sold, there is no profit in letting it survive. I mention this in passing as a miniature case to show how ambiguous are many of the situations facing all of us attending this session of the General Assembly.

Our planet works as a biophysical system that creates soil and its fertility. As Thomas Lovejoy has pointed out, ecosystems provide a variety of services, not least of which is provision of clean and reliable water. Biological diversity is the essential living library for sustainability. Perhaps if we ourselves survive, in the distant future our age will be known for the greatest loss of biological species since the extinction of the dinosaurs.

The expanding human population has the power to alter the environment not only on land, but also in the sea through the run-off of pollutants such as nitrogen fertilizers. And we have as well begun to modify and poison our atmosphere. A case in point, though now a rare success story, was the discovery in the 1970s and early '80s that the ozone layer in the stratosphere was being depleted in large part because of the release into the atmosphere of chlorofluorocarbons used in refrigerants and aerosols. It is the ozone layer that filters out ultraviolet radiation that can cause skin cancer and cataracts. Despite one leading industry spokesman saying that all this was "a science fiction tale, a load of rubbish, and utter nonsense," the scientific evidence soon established the ozone depletion as a genuine man-made threat, and this led to the 1987 Montreal Protocol to phase out the manufacture of these halogenic chemicals. Eventually Kofi Annan stated that this UN-backed treaty was "perhaps the single most successful international agreement to date."

Homo sapiens, having crossed the Lamarckian divide, has now brought with astonishing speed many scientific and technological advances, including color television, the polio vaccine, and the internet. But, for the first time in history, humankind has stolen the secrets of the stars, and has brought to earth the power to wipe out all the higher forms of life. A nuclear disaster is not just science fantasy. The Chernobyl and Fukashima accidents give hints of the unintended devastation that can occur. Consider what destruction could be wrought by a delusional madman or a deliberate anarchist. A hair trigger response by a paranoiac society could bring an unplanned Armageddon to all the cultures of this world.

We do not know if there are other cultures and civilizations out there among the 200 billion stars in our galaxy. But if there are and if they blow themselves to bits within a century or two after getting the technology to communicate across space, then two or three hundred years is only a speck in the billions of years it takes to evolve a civilization. Then it would be featherbrained to think of finding such an alien outpost still alive in the ocean of time.

Three days ago was the hundredth anniversary of one of history's greatest maritime tragedies, the sinking of the Titanic. And just a few weeks ago a menu for the last first class dinner aboard that ill-fated ship was auctioned for £76,000. Imagine the hundreds of guests sitting in that luxurious dining room, with a wide choice of courses, never dreaming that in a few hours many of them would be drowning in the icy waters of the North Atlantic as that great ship went down to the bottom of the sea.

Today we are on a great ship, planet Earth, cruising through mostly empty space, little dreaming that humankind now has the means, in a split second, to destroy this entire city, to render this entire region radioactively uninhabitable for generations to come, and to destroy civilization as we know it. It may not happen here. Perhaps it will happen to Jerusalem and the much-competed-over Holy Land, which would become radioactively quarantined for every faith.

Or it may be something more subtle, that our climate will reach a tipping point, where within just a decade irreversible changes will heat our fields and forests beyond recognition. We are at a perilous point where our knowledge, our powers, and our masses have the newly acquired capability to irredeemably wreck our environment. Never has more been asked of diplomacy, and never has so much hard and dedicated work been required from men and women like you. Our world hangs in the balance. Don't let this unique cosmic ship carelessly sink to the bottom of the sea.