— Current Topics —

A Problem of Climate Change as Seen by a Pharmaceutical Researcher

Foreword

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Many scientific studies have presented evidence that the rise in average temperatures on the earth and the accompanying change in climate since the Industrial Revolution have been caused by increased concentrations of greenhouse gases, such as carbon dioxide, in the earth's atmosphere, and that emissions of these greenhouse gases must be reduced by 50% of current levels by 2050 in order to halt global warming.

The concentrations of carbon dioxide in the atmosphere increased markedly from 280 ppm before the Industrial Revolution to 379 ppm in 2005.[1] Atmospheric carbon dioxide concentrations increased dramatically over the hundred years of the 20th century, especially in the last forty years, and in step with this, the radiative forcing (a measure of the influence that a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system)[1] (Fig. 1) also increased. The 4th report of the International Panel on Climate Change (IPCC)[2] presented much scientific evidence that these increases in the atmospheric concentrations of carbon dioxide and other greenhouse gases were indeed anthropogenic. If we are to achieve a 50% reduction in greenhouse gas emissions, we will need not only technological advancements but also changes in our lifestyle. On reflection, actions against climate change may be regarded as the first example in human history of scientific knowledge becoming a driving force in altering our lifestyles.

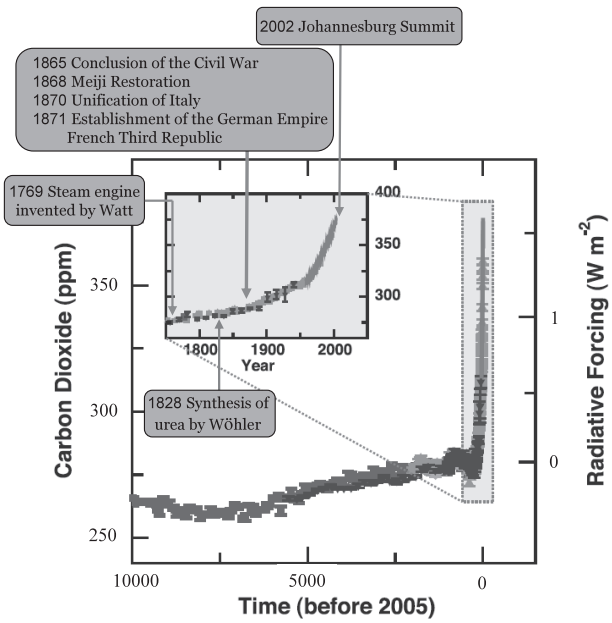

Fig. 1. Increases in Carbon Dioxide Concentrations in the Atmosphere and Historical Events
Constructed from figures contained in Reference 1).

The use of fossil fuels, such as petroleum and coal, beyond the ability of the earth to absorb emissions from those fuels has been a major cause of the increases in carbon dioxide concentrations in the 20th century (Fig. 1). These fossil fuels, however, are important not only as a source of energy generated by their combustion but also as raw material for synthetic chemicals. Synthesis of organic compounds dates back to 1828 when Wöhler successfully synthesized urea. The synthesis and use of

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man-made organic compounds essentially followed the expansion in the usage of fossil fuels. Combustion of fossil fuels releases 6.8×10^9 t of carbon annually into the atmosphere.[1)] At the same time, nearly all of the three aromatic hydrocarbons (benzene, toluene, and xylene) used for chemical synthesis are derived from fossil fuels, according to statistics of the 1980s. The annual worldwide production of these aromatic hydrocarbons is approximately 5×10^7 t.[3–5)] After these aromatic hydrocarbons and their derivatives are used, they are oxidized in the environment by burning and by other means, and are eventually released into the atmosphere as carbon dioxide. In broad terms, the use of chemicals derived from those three aromatic hydrocarbons generates and releases carbon dioxide into the atmosphere in an amount equal to almost 1% of the volume released by burning fossil fuels. The Pharmaceutical Society of Japan, which was established in 1880, has supported the development of organic synthetic chemistry in Japan and at the same time has supported the expansion of the use of chemicals. In other words, the Society has been a part of the problem by increasing carbon dioxide concentrations in the atmosphere.

In the history of science, the recognition of a link between global warming and increased carbon dioxide concentrations goes back more than a hundred years. It was Svante Arrhenius, a Swedish physical chemist and Nobel laureate, who first theorized near the end of the 19th century that carbon dioxide concentration in the atmosphere was a major factor in determining temperatures on the earth. Kenji Miyazawa already knew of this theory in spite of the fact that only a small number of scientists shared the knowledge at that time. In "Gusko Budori, a Biography" (1932), one of his well-known children's stories, Miyazawa had the title character Budori ask his teacher, "Sir, will an increase in carbonic acid gas in the atmosphere make the climate warmer?" to which the teacher replied, "It will, because they say volumes of carbonic acid gas in the atmosphere have largely determined temperatures on the earth since its birth." Kenji Miyazawa's understanding of the relationship between the concentrations of carbon dioxide in the atmosphere and global warming is simply astounding. While the fact has been pointed out in a variety of ways on the Internet,[6)] it was a feature article entitled "*The Earth Warns*" published in Kyoto Shinbun on February 14, 1997 that referred to Miyazawa's knowledge of the theory in the context of current global environmental issues. The article appeared ten months before the opening of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP3) in December 1997. The Kyoto Protocol was adopted at this conference. We can only admire the newspaper's deep insightfulness.

Increases in the concentrations of atmospheric carbon dioxide were confirmed by actual measurements in the late 1960s. These observations appear to have bewildered some scientists. For example, the 1973 admission examination for the University of Tokyo contained the following chemistry question: "A certain theory proposes that, since solar radiation energy is absorbed by carbon dioxide contained in the atmosphere surrounding the earth, the average surface temperature of the earth is associated with the amount of carbon dioxide in the atmosphere. Assuming the solar energy which is absorbed by carbon dioxide to be 6×10^{-3} calories per second per 1 cm^2 on the average... and the total carbon dioxide contained in the atmosphere to be 2×10^{18} grams, how many calories of the energy per second on the average will one carbon dioxide molecule absorb?" Thirty years later, knowledge of global warming due to increasing concentrations of carbon dioxide no longer remains in the realm of scientists. We all share it. Needless to say, common recognition of the problem is a result of contributions made by numerous researchers.

As stated earlier (Fig. 1), the increases in the carbon dioxide concentrations are often compared with those of the times before the Industrial Revolution. The monumental event that set off the Industrial Revolution was the invention of the steam engine by James Watt in 1769. The atmospheric concentrations of carbon dioxide, however, remained virtually unchanged even after this momentous event. It was near the end of the 19th century when the concentrations actually started to rise. Historically, important events preceded the increase in the carbon dioxide concentrations in a very short period. These included the conclusion of the American Civil War in 1865, the Meiji Restoration in Japan in 1868, the Unification of Italy in 1870, and the establishment of the German Empire and the French Third Republic in 1871. These historic events coincided with the formation around the world of civic states and social systems under which people could freely own the means of production. It was also the time in which the stage was set for the expansion of modern industrial societies around the world. The increase in carbon dioxide that began in

the end of the 19th century can be viewed as a result of the development of a social framework pertinent to increasing industrial output.

Efforts by scientists attempting to predict the evolution of global warming and its effects have moved politicians. The G8 Summit of 2007 declared the goal of reducing current greenhouse gas emissions by 50% by 2050.[7] Now governments around the world are tackling the challenge. Rising carbon dioxide concentrations in the atmosphere has altered our way of life significantly and now obliges us to develop a new social framework. This new framework must be able to achieve the goals clearly set out by the World Summit on Sustainable Development held in Johannesburg in 2002 to create a sustainable society under the constraint of restricted use of fossil energy. History shows us that the increase in carbon dioxide concentration was preceded by the development of a social framework that required mass consumption of fossil fuels. In that case, what kind of a social framework do we need to develop in order to control carbon dioxide emissions? This is the problem we must solve.

This review is an introduction of symposium on 'Problems of How to Take Measures against Climate Change and Contribution of Pharmaceutical Science to the Solution' in 129th annual meeting of the Pharmaceutical Society of Japan held in Kyoto in March 2009.

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