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Carbon Dioxide and its Role in Climate Change

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Climate is variable. In historical times, many significant fluctuations in temperature and precipitation have been identified. In the period from 1880 to 1940, the mean temperature of the earth increased about 0.6°C; from 1940 to 1970, it decreased by 0.3–0.4°C. Locally, temperature changes as large as 3–4°C per decade have been recorded, especially in sub-polar regions.

The cause of these changes has been under extensive study. One factor is the steady increase in carbon dioxide which has been observed, presumably as a result of the combustion of fossil fuels. In the late 19th century, prior to the industrial revolution, the carbon dioxide content of the atmosphere was about 290 ppm. This had risen to 314 ppm in 1960, and to just over 320 ppm in 1970. Aircraft observations by the Atmospheric Physics and Chemistry Laboratory of the Environmental Science Services Administration have clearly shown the importance of metropolitan areas as a source of carbon dioxide.

The effect of carbon dioxide is to increase the earth's temperature by absorbing outgoing terrestrial radiation. Recent numerical studies have indicated that a 10% increase in carbon dioxide should result, on the average, in a temperature increase of about 0.3°C at the earth's surface. The present rate of increase of 0.7 ppm per year would therefore (if extrapolated to 2000 A.D.) result in a warming of about 0.6°C—a very substantial change.

A second cause of climatic change is particulate loading of the atmosphere. Some meteorologists have attributed the cooling of the earth since 1940 primarily to such pollution of the atmosphere by man. However, the net effect of particulate matter on climate is difficult to analyze. Such pollutants, depending upon their size distribution and the elevation at which they occur, both intercept incoming solar radiation and trap outgoing radiation from the earth. The first process tends to depress the temperature of the earth's surface; the latter tends to increase it. To further complicate matters, the effect of pollution by natural volcanic activity must be considered. Unlike most activities of man, violent volcanic eruptions inject particulates directly into the stratosphere, where they are most effective in cooling the earth. The drop in the earth's temperature since 1940 has been paralleled by a substantial increase in natural volcanism. The effect of such volcanic activity is probably greater than the effect of man-made pollutants.

Finally, the possibility of other factors in climatic change must be considered. Solar radiation may change slightly in intensity or wavelength distribution; other natural explanations have been suggested. Our measurements of radia-

tion balance and our understanding of the dynamics of climate are not sufficient to evaluate quantitatively the possible importance of these other natural causes.

Several concluding statements may be advanced. Climate varies naturally, for reasons which are only poorly understood. Superimposed on natural climatic change are variations due to man, primarily as a result of the increase of carbon dioxide and particulate pollution. At present, the natural causes of climatic change are probably more important than the effects of man-made gaseous and particulate pollution. However, the balance is changing as industrialization, urbanization, and transportation continue to grow at an accelerating rate. Some years from now, man will control his climate, inadvertently or advertently. Before that day arrives, it is essential that scientists understand thoroughly the dynamics of climate. Only by such an understanding and by active intervention can man assure himself in the long run that this planet will continue to be a suitable place to live.