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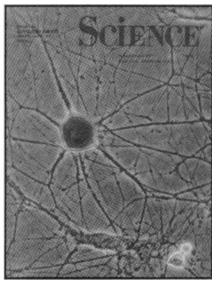

COVER Photomicrograph of a cultured rat sensory neuron 24 hours after infection with pHSViac, a defective herpes simplex virus 1 (HSV-1) vector that expresses *Escherichia coli* β-galactosidase (blue, X-gal reaction product). HSV-1 vectors have the potential to introduce any gene into a neuron to perform gene therapy or study neuronal physiology. See page 1667. [Alfred I. Geller, Massachusetts General Hospital, Boston, MA 02114]

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Rural and Urban Ozone

In the United States substantial improvements have been made since 1970 in the levels of most of the principal air pollutants. An exception has been a failure to achieve compliance with the National Air Quality Standards for ozone. At least 60 major urban areas experience peaks for 1 hour that exceed 120 parts per billion (ppb) more than once per year averaged over a 3-year period. The summer of 1988 has been among the worst on record for ozone. Lack of success of the program and evidence of the role of biogenic hydrocarbons in producing ozone are causing some geophysicists to question whether a continuation of current policies of the Environmental Protection Agency will achieve control of ozone levels.

Ozone is formed as a product of a complex series of photochemical events that involve reactive organic gases and NO_x. Both components are required. In attempting to control ozone, the EPA has relied on reducing the level of anthropogenic hydrocarbons such as those associated with motor vehicles. It is currently estimated that in the United States about 18 million tons of nonmethane anthropogenic hydrocarbons are added to the atmosphere each year. At the same time 30 to 60 million tons of biogenic hydrocarbons are emitted with maximum rates of production on hot summer days coincident with ozone peaks. In the past the accepted view has been that the natural hydrocarbons made a minimal contribution to ozone because their abundance in city centers was small in comparison with anthropogenic sources. But a recent report of the Office of Technology Assessment states that peak ozone concentrations occur during mid- to late afternoons about 30 miles downwind from centers of cities. At such locations the levels of biogenic hydrocarbons may approach those of anthropogenic origin. Another factor that may not have been fully weighted is the comparative reactivities of the two types of hydrocarbons. The gases from motor vehicles tend to be largely saturated hydrocarbons such as butane and isopentane with only about 10 percent olefins and 20 percent aromatics such as benzene. In contrast, the biogenic hydrocarbons are mostly unsaturated olefins. Smog chamber experiments have shown that the olefins are prolific sources of ozone.

Extensive measurements by gas chromatography have shown that all vegetation emits hydrocarbons. Deciduous trees mainly produce isoprene (C_5H_8), which has two double bonds. Emission of this chemical occurs only during daylight hours and the rate increases rapidly as temperature rises. The principal hydrocarbons of the evergreens are the olefins, α-, and β-pinenes. These are emitted throughout the 24 hours, but again the peak is associated with high temperatures.

Measurements at Scotia,* a rural site in central Pennsylvania, are producing solid evidence on the role of biogenic hydrocarbons in forming ozone. Source gases and some of the intermediate products are carefully monitored. Only small amounts of anthropogenic hydrocarbons, such as propane, butane, and pentanes, are found. Isoprene is the principal hydrocarbon present at times of high levels of ozone. In 1986 a peak of 110 ppb of ozone was observed. In 1988 peaks of 130, 130, and 150 ppb were noted.

Biogenic hydrocarbons are likely to have a substantial role in urban areas of the Southeast.† For example 60 percent of the Atlanta urban area is forested and about 400 tons of biogenic carbon are estimated to be produced each summer day. This is an amount comparable to the total of anthropogenic hydrocarbons emitted in the urban area. During the past decade the amount of anthropogenic hydrocarbons has been substantially reduced without a corresponding reduction in ozone. To obtain compliance with ozone standards may require reduction in NO_x emissions.

Crucial factors in other places differ. The geometry and meteorology of the Los Angeles Basin make ozone control there almost intractable. No single cure will suffice.

Those who are engaged in research on formation of ozone appear to be virtually unanimous in calling for more instrumentation to monitor the inputs, intermediates, and products. In comparison with the costs of controls on emissions, the amounts devoted to state-of-the-art monitoring are trivial. If EPA is to regulate intelligently, it must be better informed about the differing circumstances and mechanisms that exist in the various rural and urban areas.—PHILIP H. ABELSON

*M. Trainer *et al.*, *Nature* **329**, 705 (1987). †W. L. Chameides, R. W. Lindsay, J. Richardson, C. S. Kiang, *Science* **241**, 1473 (1988).