mately twice as much CO_2 as the ordinary atmospheric samples. The ventilation system in the tunnel circulates air at a rate of 6600 metric tons per hour, but this is insufficient to reduce emission of CO_2 in bumper-to-bumper rush-hour traffic to a level well below that of atmospheric CO_2. A δ of 7.0 is obtained from a calculation based on estimates of emission of CO_2 under these circumstances. The samples reported in Table 1 were taken under moderate traffic conditions. The isotopic abundance of carbon in CO_2 from the tunnel provides an independent check on the technique.

Differences in δ's were observed in Manhattan near the tunnel exit on 37th Street and in the skyscraper canyons at 25th Street and near the Empire State Building. The evidence suggests that mixing of air in streets surrounded by closely spaced high-rise buildings is poor and that CO_2 from automobile exhausts contributes significantly to the inventory of atmospheric CO_2 in these areas. Normal higher values of δ's were found at Battery Park, at 115th Street and Broadway, and at the observation tower of the Empire State Building.

Sources of CO_2 other than automobile exhaust are not expected to contribute to the variation observed between ratios of samples taken at street level and at the Empire State Building observation tower. Samples taken in the center of the business district in lower Manhattan indicate that approximately 20 percent of the CO_2 in the atmosphere at street level is produced by automobile exhaust; this points up the need for ventilation of streets in areas of where there are high-rise buildings and a large concentration of motor vehicles.

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References and Notes

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3. J. F. Clarke and R. B. Faoro, *J. Air Pollut. Contr. Ass.* **16**, 212 (1966).
4. H. Craig (*1*) reported a variation in the isotopic composition of carbon in CO_2 obtained from air in Chicago. He tabulated values that differ by approximately 2.0 per mil in air sampled during the week and on Sundays. His technique did not include gas chromatographic purification prior to analysis by mass spectrometer; variations nearly as large as those observed between weekdays and Sundays were observed in samples taken during the week. Craig left open the ques-

tion of the role of industrially emitted CO_2 when he remarked that there was a need for data which would establish the isotopic composition of atmospheric CO_2 in uncontaminated air over the oceans. His work clearly suggests the possibility of a perturbation of the isotopic composition of atmospheric CO_2 by industrially emitted CO_2.

5. The firebrick was coated with Dow-Corning 710 silicone pump fluid.
6. Research performed under the auspices of the AEC. We thank Dr. Y. Y. Chu for assistance, and W. R. Suchanek and the management of the Empire State Building for their cooperation.

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Biohazards Symbol: Development of a Biological Hazards Warning Signal

Abstract. *The need for a symbol to warn of potential infection hazards became apparent during Public Health Service contract work on the development of containment facilities for virus-leukemia research. A program of direct inquiry and a search of the literature revealed that there was no universally used signal and that scientific and safety organizations concurred in the need for one. Criteria for symbol design were established, and final selection was based on "uniqueness" and "memorability." The National Institutes of Health is recommending use of the symbol as a warning of biological hazard.*

The scientific community, engaged in infectious disease research, has accepted as unfortunate, but unavoidable, the occasional accidental infection of microbiology laboratory personnel and associated nonlaboratory personnel. Since the mid-1940's, the seeming inevitability of such accidents has received an increasing amount of study. The eventual consensus was that perhaps most of these accidents need not happen, providing proper precautionary measures are taken and enforced. The last decade, in particular, saw great strides in the development of containment systems and in the design of safety equipment to protect the laboratory worker, his work, and the exterior environment from contamination by infectious agents. A new science of containment, founded on the concept of continuous agent control through the creation of intelligently designed barrier systems, has emerged. Design of these barriers is based on a rational assessment of risk; the barriers may be created in the form of solid walls, pressure differentials to control movement of air, controlled movement of personnel and materials, or inactivation of the infectious agents themselves. In the maintenance of the

barrier systems, one essential factor is that, at all times, the locations of the infectious agents must be known. In order not to inadvertently violate the barrier systems, each person in the vicinity must know what equipment, glassware, rooms, corridors, and ducts are contaminated by the infectious agents, and that thereby, they constitute a biological hazard.

Unfortunately, such biological hazards, like radiation hazards, are usually impossible to detect by cursory examination only. Being invisible, odorless, and tasteless, they require special procedures for detection. It seems logical, then, to mark the location of "biohazards," as they are commonly called, with a suitable warning sign that is readily noticed and easily recognized.

During investigations of biological control and containment conducted under contract for the National Cancer Institute, the need for such a symbol became apparent to the Dow biohazards research and development team. A search of the literature revealed that, while certain biological warning signs are used by various agencies, a *universal* symbol to warn of danger from infectious or potentially infectious agents —a symbol whose immediate significance is known to all—does not exist. Colleagues in the field of biological research concurred, in reply to direct query, that such a warning symbol is needed.

Universally accepted symbols for hazards that are not readily detectable have already been established, such as those used in denoting radioactive areas. Similar warning notices are being sought to point out danger due to laser emission. In biology laboratories, however, a number of different symbols are in use; none of these has been universally accepted, and none imply or encompass all possible biohazards. For example, an inverted blue triangle bearing the term "BIO" is used by the Army to warn of biological contamination; a rectangular "hot-pink" label, with radiating yellow bands, is used by the U.S. Navy laboratories in areas containing infectious organisms; a red and black sign is used by the National Institutes of Health to mark restricted areas; and the white snake-and-staff imprint on a violet field is sponsored by the Universal Postal Convention to mark infectious materials during transit.

In formulating the design for the proposed biohazards symbol, six criteria were established, mainly dealing

Fig. 1. Biohazard warning symbol. The design color stipulated in the standard form is fluorescent orange-red.

with the psychology of recognition and retention. These criteria, in order of their importance, are that the symbol be (i) striking in form in order to draw immediate attention; (ii) unique and unambiguous, in order not to be confused with symbols used for other purposes; (iii) quickly recognizable and easily recalled; (iv) easily stenciled; (v) symmetrical, in order to appear identical from all angles of approach; and (vi) acceptable to groups of varying ethnic backgrounds. Dow artists created more than 40 symbol designs, of which six were selected for testing. A survey to ascertain acceptability of the six symbols was conducted among Dow employees. This survey was directed toward determining uniqueness and memorability.

To select the final symbol, a nationwide survey, based on precepts well established in mass-psychology experimentation, was conducted in two parts. First, the candidate symbols were tested for uniqueness by determining which had the least prior association for the viewer. Three hundred subjects, males and females, from 25 cities and with various amounts of income and formal education were shown the six symbols along with 18 other commonly used symbols. They were asked what each symbol meant, or was used for. Participants were also encouraged, if uncertain, to guess at the meaning. A "meaningfulness score" was obtained for each symbol based on the percentage of respondents who offered any association whatever to the symbol. Since the purpose was to determine the least meaningful symbol, the smaller scores identified the most desirable symbols.

One week after the initial survey

had been conducted, participants were revisited for a "memorability" test. The original respondents were shown a group of 60 symbols which included the 24 seen during the first test. They were asked to identify those symbols which they had been shown on the first interview. Each symbol was given a "memorability score" that depended on the percentage of participants who correctly identified the symbol as having appeared in the earlier test.

Identical memorability scores were obtained for two of the six test symbols, and these scores exceeded the average for the other 18 symbols tested. Since one of the two also obtained the lowest score in the meaningfulness test, it emerged as the one symbol best qualified as being both unique and memorable (Fig. 1).

Having evolved a suitable symbol, the next step was to attach the desired significance to it. It became important to define as clearly as possible how and under what circumstances the symbol should be used. A use standard was therefore prepared. This standard stipulates that the symbol "shall be used to signify the actual or potential presence of a biohazard and shall identify equipment, containers, rooms, materials, experimental animals, or combinations thereof which contain or are contaminated with viable hazardous agents." It also defines the term "biohazard," for the purpose of the standard, as being: "those infectious agents presenting a risk or potential risk to the well-being of man, either directly through his infection or indirectly through disruption of his environment."

This symbol and the recommendations regarding usage have been submitted to the United States of America Standards Institute for inclusion in their next revision of the "Standard Specifications for Industrial Accident Prevention Signs," Z35.1 code.

This symbol, in fluorescent fire-orange color, has been evaluated during a 6-month period at the National Cancer Institute and other selected laboratories engaged in studies involving hazardous agents. These cooperating research groups included the U.S. Army Biological Laboratories and U.S. Department of Agriculture laboratories, as well as a number of commercial and academic laboratories working under National Institutes of Health research grants and contracts.

In view of its acceptance by the scientists during this evaluation, the National Institutes of Health is recommending that this symbol be used as a general biological hazard warning.

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Note

Congenital Malformations Induced by Mescaline, Lysergic Acid Diethylamide, and Bromolysergic Acid in the Hamster

Abstract. Malformations of the brain, spinal cord, liver, and other viscera; body edema; and localized hemorrhages were found in fetal hamsters from mothers injected subcutaneously with a single dose of mescaline, lysergic acid diethylamide, or 2-bromo-D lysergic acid diethylamide on the 8th day of pregnancy. In addition, all three drugs produced an increase in the percentages of small fetuses per litter, of resorptions, and of fetal mortality.

As part of (1, 2) an investigation of the various possible etiological factors involved in the induction of congenital malformations, I have studied the psychotomimetic alkaloid mescaline (MES), the active principle of the peyote cactus used in the rituals of certain Indian tribes, and the synthetic alkaloid lysergic acid diethylamide (LSD) used on a limited basis in drug therapy of mental disease. In addition, the monobromide derivative of LSD, 2-bromo-D-lysergic acid diethylamide (BOL), was also evaluated.

Pregnant hamsters were obtained from randomly bred stock of Lakeview