though adult Minamata patients in Japan were found to have middle- but not low-frequency deficits (high frequencies were not tested) with little or no constriction of visual fields (*16*).

Although deficits in peripheral vision, especially constriction of visual fields, may be the most conspicuous and extensive visual lesion in methylmercury poisoning, other visual changes seem to occur at the same time and possibly earlier under certain conditions.

DEBORAH C. RICE
STEVEN G. GILBERT
Toxicology Research Division, Bureau of Chemical Safety, Health Protection Branch, Health and Welfare Canada, Ottawa, Ontario K1A 0L2

References and Notes

1. S. Sabelaish and G. Hilmi, *Bull. WHO* **53** (Suppl.), 83 (1976); S. F. Al-Damluji and Clinical Committee on Mercury Poisoning, *ibid.*, p. 65; H. Rustam and T. Hamdi, *Brain* **97**, 499 (1974).
2. L. Chang, *Environ. Res.* **14**, 329 (1977).
3. Y. Harada, in *Minamata Disease, Study Group of Minamata Disease*, M. Kutsuna, Ed. (Kumamoto University, Kumamoto, Japan, 1968), pp. 73 and 93; T. Takeuchi, in *ibid.*, p. 141; P. Pierce *et al.*, *J. Am. Med. Assoc.* **22**, 1439 (1972); L. Amin-Zaki, S. Elnassani, M. Majeed, T. W. Clarkson, R. Doherty, M. R. Greenwood, *Pediatrics* **541**, 587 (1970).
4. R. de Valois and K. de Valois, *Annu. Rev. Psychol.* **31**, 309 (1980); W. Merigan, *Vision Res.* **20**, 953 (1980).
5. H. Evans, V. Laties, B. Weiss, *Fed. Proc. Fed. Am. Soc. Exp. Biol.* **34**, 1858 (1975); C.-M. Shaw, K. Mottet, R. L. Body, E. S. Luschei, *Am. J. Pathol.* **80**, 451 (1975).
6. M. Berlin, C. A. Grant, J. Hellberg, J. Hellstrom, A. Schutz, *Arch. Environ. Health* **30**, 340 (1975).
7. R. Garmon, B. Weiss, H. Evans, *Acta Neuropathol.* **32**, 61 (1975).
8. R. Willes, P. Kressler, J. Truelove, *Lab. Anim. Sci.* **27**, 90 (1971).
9. Total blood mercury was determined by flameless atomic absorption spectrophotometry [F. Iverson, R. H. Downie, H. L. Trenholm, C. Paul, *Toxicol. Appl. Pharmacol.* **27**, 1 (1974)]. Sampling frequency was every 14 days until 450 days of age, once monthly until 3 years of age, and quarterly thereafter.
10. It is believed that the spatial detection capacity of the visual systems is by means of multiple spatial frequency channels, each sensitive to a portion of the total spectrum [F. W. Campbell and J. G. Robson, *J. Physiol. (London)* **197**, 551 (1968); F. W. Campbell, in *The Neurosciences: Third Study Program*, F. O. Schmitt and F. G. Worden, Eds. (MIT Press, Cambridge, Mass., 1974), p. 95]. One can predict the detectability of any pattern on the basis of a Fourier analysis of the pattern and the sensitivity of the visual system (of an individual) to sine waves of different frequencies. Thus a determination of the contrast sensitivity function of an individual describes the spatial detection ability of that individual, in the plane of testing.
11. Contrast is defined as difference in luminance between the lightest and darkest part of the sine wave divided by their sum.
12. The first lever on which the monkey made three presses (fixed ratio 3) was considered to be the response choice. Correct choices were reinforced with juice; juice delivery was preceded by a 0.7-second tone. Incorrect choices resulted in a 7-second time-out period, which was signaled by a clicking noise. Each reinforcement or time out was followed by a 3-second intertrial interval. Responses during the time out or intertrial interval reset the component to its initial value. Monkeys were tested 5 days per week.
13. In each session, a series of five contrast values differing by 1-dB steps was tested for each of 20 frequencies. Contrasts were presented in a random order. The series of contrast values for the next session was chosen on the basis of each monkey's performance. Threshold was considered to have been reached when the threshold determination did not vary by more than one contrast level for four consecutive sessions. Frequencies were tested in sequential order to allow maximum practice effect.
14. The psychometric function for any particular frequency is represented as a plot of contrast versus percent correct. The steepness of the slope indicates how well the animals' behavior is under schedule control. A reduced slope suggests poorer control over the monkey's behavior, while a shift in the function to the right with no difference in slope indicates visual impairment.
15. *WHO Environmental Health Criteria I, Mercury* (World Health Organization, Geneva, 1976).
16. S. Ishikawa, R. Okamura, K. Mukuno, *Nippon Ganka Gakkai Zasshi* **83**, 336 (1979); K. Mukuno, S. Ishikawa, R. Okamura, *Br. J. Ophthalmol.* **65**, 284 (1981).

8 June 1981; revised 19 October 1981

Global Carbon Monoxide Fluxes: Inappropriate Measurement Procedures

Bartholomew and Alexander have calculated (*1*) that the global CO uptake by soil is 4.1 × 10^{14} g/year. Although we should be satisfied to see Seiler's earlier estimates (*2*) confirmed, we are deeply concerned about the experimental procedure used by Bartholomew and Alexander (*1*) and what we feel are misquotations from Seiler's earlier paper (*2*). Their calculation is based on laboratory experiments that represent disturbed conditions, whereas our experiments are based on measurements made in the field under natural conditions. We are also concerned about the application of an unrealistically high CO mixing ratio of 3 parts per million by volume (ppmv) and the use of the radiotracer technique with ^{14}CO as the tracer.

The CO uptake depends on concentration, and observed ambient CO mixing ratios in the lower troposphere are of the order of 0.05 to 0.30 part per million (ppm); thus reported uptake rates based on mixing ratios of 3 ppmv must be overestimated by approximately one order of magnitude. Furthermore, the report by Bartholomew and Alexander totally neglects the fact that CO is not only destroyed but also produced in soil. In summer at high soil surface temperatures and ambient CO mixing ratios (≤ 0.30 ppmv), the production sometimes exceeds the destruction. Under these conditions the soil acts as a source of atmospheric CO. Extrapolation of results obtained at 3 ppm to low ambient mixing ratios, however, indicates that the soil is always a net sink, an incorrect generalization.

The existence of simultaneous production and destruction of CO by different processes in the soil clearly demonstrates the inapplicability of a radiotracer technique that measures only the oxidation of ^{14}CO to $^{14}CO_2$ and not the production of CO by soil. The use of ^{14}CO is therefore inappropriate for the determination of the CO net flux between the soil and atmosphere. Thus we feel that agreement between Seiler's earlier data and those obtained by Bartholomew and Alexander (*1*) is fortuitous.

The global CO uptake rate of 5 × 10^{14} g/year (*2*) is based on in situ measurements carried out under ambient natural conditions, different types of soil, and different seasons and weather conditions, covering soil temperatures of 3° to 50°C. This is well documented in (*2*); we therefore do not understand the statement of Bartholomew and Alexander that Seiler's estimate is based on "measurements of a few European soils in the laboratory" and "multiplying the average uptake rate of a few soils at 15°C."

W. SEILER
R. CONRAD
Max-Planck-Institut für Chemie, D-6500 Mainz, West Germany

References

1. G. W. Bartholomew and M. Alexander, *Science* **212**, 1389 (1981).
2. W. Seiler, in *Environmental Biogeochemistry and Geomicrobiology*, W. E. Krumbein, Ed. (Ann Arbor Science, Ann Arbor, Mich., 1978), vol. 3, p. 773.

5 October 1981

We are surprised that Seiler and Conrad missed the crucial difference between their studies and ours. Atmospheric scientists accept the fact that the properties and behavior of CO, SO_2, and N_2O are different, and they would not assume that the average values of some properties of five gases could be used to predict the properties of all gases. If it is inappropriate to conclude that, "once you have seen one atmospheric component, you have seen them all," it would also seem reasonable to suggest that soils differ markedly, and that averaging numbers for five soils, all from one geographical area, does not provide a meaningful mean value for all soils. Soil taxonomists have labored long and hard to develop a meaningful and useful scheme for the categorization of soils, and it is incumbent upon atmospheric scientists, microbiologists, and others to base their extrapolations on, or at least link them to, the classification systems thus devel-

0036-8075/82/0514-0761$01.00/0

Science

Global Carbon Monoxide Fluxes: Inappropriate Measurement Procedures

W. SEILER and R. CONRAD

Science **216** (4547), 761.
DOI: 10.1126/science.216.4547.761