who continue to violate the inexorable laws of nature would be to allow the endless settlement and development of every floodplain on every river in the country, with the result that each stream could then be encased in concrete from its headwaters to its delta mouth, at public expense.

According to the same logic, we should import gold and ore-bearing rocks from elsewhere so that Montana's metal mines could continue to sustain the communities that are dependent upon them. It would also follow that the United States should be obligated to reimburse the untold thousands of homesteaders who failed in their attempts to establish 160-acre farms on the arid Great Plains.

I hope the AAAS Committee on Arid Lands will fully assume its social responsibilities by clearly defining the natural constraints to which our species must accommodate if we are ever to have a sustained and productive coexistence with nature.

GEORGE DARROW
Montana State House of Representatives, District 9, Box 2001, Billings 59101

Mercury Compounds

G. F. Wright (Letters, 19 Nov. 1971, p. 771) gives additional support—although uncontrolled—to the already well-known fact that monoalkyl mercury compounds behave differently from dialkyl mercury compounds and from the aryl mercury compounds (mentioned as diuretics) in biological systems.

The recalcitrant monomethyl mercury entity (present in fish and used as seed dressing) has a biological half-life of about 70 days in man, whereas mammals rapidly excrete dimethyl mercury and aryl mercury compounds when exposed to them. The distribution in the body as well as the biological effects are also very different.

It is not advisable to take a 1-gram intravenous injection (or oral dose) of monomethyl mercury if one wishes to enjoy a meaningful life.

ERIK ARRHENIUS
GÖRAN LÖFROTH
CLAES RAMEL
Wallenberglaboratoriet, University of Stockholm, Lilla Frescati, S-104 05 Stockholm 50, Sweden

I fully agree with George Wright. He has been extremely lucky. Of all the mercury salts he mentions, not one is outside the class of dialkyl mercury salts. It has been said for some time, for example, that dimethyl mercury is biologically inert (*1*). Monomethyl mercury, however, has been implicated as a deadly environmental poison. The metabolic conversion of dimethyl to monomethyl mercury in the mammalian organism is reported to be less than 10 percent. To my knowledge, only the higher monoalkyl mercury salts ethyl mercury and propyl mercury, are toxic. The body finds it easy to metabolize the dialkyl and higher monoalkyl salts, breaking the carbon-mercury bond and rendering these lipid-soluble agents harmless in the low concentrations of inorganic mercury presented to the brain. The body cannot, however, metabolize the lower monoalkyl mercury salts.

Undoubtedly there is an element of biological variability involved in susceptibility to these compounds, but it is not rational, in the face of overwhelming evidence, to consider individual susceptibility as large a factor in gross toxicity as Wright implies. (It may be, however, that intellectual capability is lessened in those who are susceptible to the effects of such heavy metal compounds. More obvious would be the effect in younger organisms, whose intellectual capacity is forming. All men may be created equal but metabolize differently.)

MURRAY S. JACOBSON
33 East Elm Street,
Chicago, Illinois 60611

Reference

1. L. Fishbein, *Chromatogr. Rev.* **13**, 100 (1970).

We should like to offer the following criticisms of George Wright's letter:

1) Experience with dibutyl homolog cannot be extrapolated to the short-chain alkyl mercurials. The toxicity of the alkyl mercurial diminishes sharply when the carbon chain exceeds three carbon atoms.

2) Wright does not state the air levels in his experiments with rats exposed to dimethyl mercury. He does not record any blood levels. It seems impossible from the data he supplies to estimate the dose to the rats or the amount of mercury absorbed by these rats.

3) Wright does not draw any distinction between organomercurials and alkyl mercurial compounds. The alkyl mercurials are unique in their toxic effects. Probably the main reason for this distinction is that the alkyl mercurials are metabolically stable in contrast to all the other mercurial compounds, which break down rapidly to inorganic mercury.

4) Wright makes the point that in some experiments at Iowa State University it was found that the absorption of mercury was balanced by elimination. We do not see what this has to do with toxicity. It is well established that people exposed to methyl mercury reach an approximate state of balance in 1 year. For example, those who regularly ingest 300 micrograms per day will have a steady-state body burden of 30 milligrams after approximately 1 year. Those who ingest 30 micrograms per day will have a steady-state body burden of 3 milligrams. Both individuals will be in steady state, that is, in elimination and absorption balance. But one will have ingested a toxic dose and the other will not.

5) Wright's reference to penicillin is misleading. Penicillin is lifesaving in many situations, and therefore the risk of adverse response to penicillin is well worth taking. Although swordfish and tuna fish are important sources of food, they are certainly not lifesaving.

Very little is known of the efficiency of pulmonary absorption of alkyl mercury compounds. Wright quotes cases of undefined human and animal exposure in which no adverse effects were reported. In rebuttal, one might quote cases where serious or fatal poisonings have resulted from inhalation. The first two fatal cases to be reported were chemists who synthesized dimethyl mercury back in the 1860's. Last year a similar tragedy took place in Czechoslovakia. Many more cases are known of serious poisonings due to occupational exposure to the vapor or dust (*1*). However, the whole issue is misleading when raised in response to our present concern with the presence of methyl mercury compounds in certain foodstuffs—a concern stemming from the epidemics of poisoning in Minamata and Niigata, Japan, that resulted from the ingestion of contaminated fish. Absorption of methyl mercury compounds from food has been carefully measured in both animals and human subjects. All the ingested mercury is absorbed into the blood stream.

We agree that the majority of people do not face a significant hazard from the presence of methyl mercury in food. The average daily dose, according to our estimations, is about 6 micrograms of mercury per day as methyl mercury compounds; this is below the advised safety limit of 30 micrograms per day and very much below the estimated lowest toxic intake of 300 micrograms per day. The question is how to protect the few who, because of unusually high consumption of certain types of fish, are ingesting methyl mercury at an average daily rate of more than 30 micrograms per day. Wright's letter poses the question, but contains nothing that would help our overextended government agencies supply the answer!

THOMAS W. CLARKSON
Department of Radiation Biology and *Department of Pharmacology and Toxicology, University of Rochester, Rochester, New York 14642*
LASZLO MAGOS
Toxicology Unit, MRC Laboratories, Carshalton, Surry, England
GEORGE G. BERG
Department of Radiation Biology, University of Rochester

Reference

1. L. Friberg *et al.*, *Nord. Hyg. Tidskr.* **52**, Suppl. 4 (1971).

Wright is evidently unaware of K. Östlund's work (*1*), in which the drastically different metabolic pathways of dimethyl mercury and methyl mercury in mice are clearly demonstrated. Dimethyl mercury, being fat-soluble and nonionizable, is taken up by the fatty tissues and rapidly eliminated via exhalation, while the ionizable methyl mercury, when orally ingested, has a high retention rate (95 percent in man) and is concentrated, in cases of chronic intake, in the central nervous system, especially in the brain.

Wright also seems unaware that the behavior of methyl mercury in the body is quite different from that of the diuretics, which are relatively easily eliminated via the urine, either unchanged or, after breakdown, as inorganic mercury. The use of diuretics is also not without risk and has led to many fatal cases of "mercurialism" (*2*).

Wright wants to see evidence in support of the limit of 0.5 part per million set for the mercury content of fish. Such evidence is extensively described in the report "Methyl mercury in fish" (*3*), and also, quite adequately, in the report of Norton Nelson's study group (*4*).

These reports also describe the fatal poisoning of large numbers of Japanese fish-eaters, who frequently consumed fish with an average mercury content (on the basis of fresh weight), during certain periods, of approximately 10 parts per million (as methyl mercury). Tuna and swordfish contain considerably less, about 0.3 and 1.0 part per million, respectively, but 86 percent of the total mercury in tuna is in the form of methyl mercury (*5*). The average mercury content (on the basis of fresh weight) of some species of fish taken from polluted lakes in Canada and Scandinavia is 3 to 6 parts per million (as methyl mercury). Although scarcely any clinical cases of methylmercurialism have been diagnosed in these countries as yet, evidently because of the lower mercury content of fish and more especially the fact that less fish is consumed here than in Japan, nevertheless, the margin of safety was in many instances alarmingly narrow before the application of the "action limit."

JORMA K. MIETTINEN

Department of Radiochemistry, University of Helsinki, 00170 Helsinki 17, Finland

References

1. K. Östlund, *Acta Pharmacol. Toxicol.* **27**, Suppl. 1 (1969).
2. C. V. King, Ed., *Ann. N.Y. Acad. Sci.* **65**, 357 (1957).
3. L. Friberg *et al., Nord. Hyg. Tidskr.* **52**, Suppl. 4 (1971).
4. N. Nelson *et al., Environ. Res.* **4**, 1 (1971).
5. G. Westöö, *Var Föda* **21**, 99 (1969).