the amount of transmitter released by the receptors. Therefore, g_{Na}/g_i decreases and the membrane hyperpolarizes.

Externally applied aspartate and glutamate are believed to isolate the receptor component of the electroretinogram by depolarizing the horizontal cell membrane and eliminating the horizontal cell potential (*1, 16*). It has been suggested that in some species one of these amino acids might be the natural transmitter released from the photoreceptor terminal (*8, 17*). When we added 3 m*M* aspartate or glutamate to the control solution, the receptor potentials were unaffected. However, in these solutions, the horizontal cell membrane depolarized slightly and the light-evoked potentials disappeared (Fig. 3A). Figure 3B shows the hyperpolarizing effect of low Na_o solution on the horizontal cell membrane (see also Figs. 1 and 2), consistent with our suggestion that sodium is needed to maintain the horizontal cell membrane potential in the dark. If this suggestion is correct, and if aspartate and glutamate mimic the natural transmitter, their application should increase sodium conductance of the horizontal cell membrane. In a low Na_o solution, with or without aspartate or glutamate, the horizontal cell should be hyperpolarized relative to its level in the normal Na_o solution because of the much lower sodium equilibrium potential. The membrane should stay at this more negative level until sodium is reintroduced into the bathing solution. We found that the horizontal cell began to hyperpolarize and lose its ability to generate the horizontal cell potentials when bathed in a low sodium (4 percent normal) solution containing 3 m*M* aspartate (Fig. 3C). Instead of remaining hyperpolarized, the membrane potential gradually depolarized to a level similar to that obtained with aspartate in the normal Na_o solution. These results are incompatible with the idea of aspartate or glutamate increasing solely the sodium conductance of the horizontal cell membrane. The effect of these externally applied amino acids might be to cause an increase of conductance to several ions.

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18. We thank L. H. Pinto for his valuable assistance and J. E. Brown for many helpful discussions. This work was supported in part by NIH grants EY00033 and GM00779.
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9 October 1975; revised 23 December 1975

Selenium in Fly Ash

Abstract. *Selenium, at concentrations exceeding 200 parts per million (ppm) (dry weight), has been found in white sweet clover voluntarily growing on beds of fly ash in central New York State. Guinea pigs fed such clover concentrated selenium in their tissues. The contents of the honey stomachs of bees foraging on this seleniferous clover contained negligible selenium. Mature vegetables cultured on 10 percent (by weight) fly ash–amended soil absorbed up to 1 ppm of selenium. Fly ashes from 21 states contained total selenium contents ranging from 1.2 to 16.5 ppm. Cabbage grown on soil containing 10 percent (by weight) of these fly ashes absorbed selenium (up to 3.7 ppm) in direct proportion (correlation coefficient* r = .89*) to the selenium concentration in the respective fly ash. Water, aquatic weeds, algae, dragonfly nymphs, polliwogs, and tissues of bullheads and muskrats from a fly ash–contaminated pond contained concentrations of selenium markedly elevated over those of controls.*

Fly ash is the material trapped by electrostatic precipitators in coal-burning, electric power–generating plants. It is estimated that 26 million metric tons of this material will be produced in this country during 1975 (*1*). A very small percentage of the fly ash produced is used in concrete, ceramics, and other products; the bulk of it is disposed of in sanitary landfills. Since fly ash contains many elements and may be quite alkaline, studies of its possible utility as a soil amendment in agriculture have been conducted (*2*).

In a recent paper (*3*) mature (over 91 cm tall) yellow sweet clover (*Melilotus officinalis*) that was growing on fly ash, 4.5 m in depth, in Lansing, New York, was found to contain 5.3 parts per million (ppm) (based on the dry weight of the entire aerial portion of the plant, stems plus leaves) of selenium, according to the method of Olsen (*4*). This clover was formulated at 45 percent into a diet and fed to guinea pigs for 90 days. Liver, kidney, and muscle tissues taken from these guinea pigs after they had been killed were found to contain, respectively, 5.6, 3.3, and 0.8 ppm (dry weight) of selenium. Corresponding control tissues from animals fed diets containing 45 percent yellow sweet clover (0.07 ppm of selenium) grown on soil (Howard gravelly loam, *p*H 7) contained, respectively, 0.6, 1.3, and 0.3 ppm of selenium.

We have recently collected mature white sweet clover (*M. alba*) growing (i) on fly ash (15 m deep) at a second landfill site in Lansing, New York, and (ii) on fly ash (23 m deep) in a landfill in Endwell, New York. The selenium content of the clover at these sites was, respectively, 14 and 69 ppm (dry weight) and that of the corresponding fly ashes was 22.9 and 21 ppm. The topmost 15-cm portions of the plants containing much less stem material than the rest of the plants showed up to five times these concentrations (more than 200 ppm of selenium in the clover from the Endwell site). The honey stomachs of bees found foraging on this clover (Endwell site) were found to contain less than 0.01 ppm of selenium. This result is probably understandable since the contents of the honey stomach consist entirely of carbohydrates, and selenium is typically associated with the protein fraction of plants. This sweet clover is presently being fed to lambs and pregnant goats, and the results of milk and tissue analysis will be reported elsewhere.

Deep beds of fly ash in landfills result after many years of ash disposal from the burning of coal. It is possible that deeper layers of fly ash resulted from the burning of coal with a higher sulfur content (and therefore perhaps selenium) than is now permitted. Deep-rooted crops such as clover may therefore accumulate selenium from these lower layers.

We have also found that beans, cabbage, carrots, millet, onions, potatoes, and tomatoes grown in pots on soils containing 10 percent by weight of fly ash (from the first Lansing site) accumulated elevated concentrations of selenium [up to 1 ppm (dry weight)] as compared to control plants (0.02 ppm). The total selenium content of fly ashes obtained from 21 different states ranged from 1.2 to 16.5 ppm, with an average of 8.0 ppm. The selenium content of cabbage (*Brassica oleracea* variety, green winter) grown to maturity in soil (Teel silt loam, *p*H 7.2) in pots that were individually amended with 10 percent by weight of each of 15 of the above fly ashes (samples of the remaining six fly ashes were insufficient in quantity) ranged from 0.2 to 3.7 ppm (dry weight), and that of the control grown on soil alone was 0.05 ppm. The correlation coefficient (r) between the concentration of selenium in the fly ashes and that in the respective cabbages grown thereon was .89, being highly significant at the 1 percent level.

A farm pond that had been built and stocked with bullheads in 1972 was located at the first fly ash landfill site in Lansing. The pond was continually subjected to a drift of fly ash from nearby trucks that were unloading the material approximately every 20 minutes during daylight hours (450 metric tons per day). Analysis of the selenium content in various organisms of the pond and those of a control pond 16 km away showed, respectively, the following averaged results in parts per million (dry weight): sago pondweed (*Potamogeton pectinatus*), 3.7 and 0.3; algae (*Zygnema* sp.), 0.9 and 0.6; dragonfly nymphs (Libellulidae: *Plathemis lydia* Drury), 4.1 and 1.5; polliwogs (*Rana clamitans*), 4.7 and 1.5; liver of bullheads (*Ictalurus nebulosus*) 20 cm long, 9.0 and 4.5; liver of muskrats (*Ondatra zibethicus*), 2.8 and 1.2. The selenium content of the water in the pond contaminated with fly ash was 0.35 parts per billion (ppb), and that of the control pond was 0.15 ppb. Water taken from a small stream at a point just ahead of this fly ash landfill area contained 0.2 ppb of selenium and 0.5 ppb at a point about 0.8 km below the landfill site. When 2 g of this fly ash was stirred with 20 ml of distilled, deionized water for 8 hours, 0.52 μg of selenium was solubilized.

The data in two papers (*5*) dealing with the fate of selenium and other elements in coal during combustion indicate that selenium is about 310 times more concentrated in the electrostatically precipitated fly ash than in the bottom ash (slag) and about 1100 times more concentrated in the extremely fine fly ash which escapes the precipitator and goes into the atmosphere. The data also suggest that selenium is present as the element in the vapor phase and also in the slag and fly ash, possibly as a result of the reduction of tetravalent forms of selenium by sulfur dioxide generated during coal combustion. Subsequent oxidation of elemental selenium in fly ash landfills to higher valence and more water-soluble forms may be responsible for its leachability and availability to growing plants.

It is possible that certain low-selenium coals do exist. In common practice, however, the coal for coal-burning, power-generation plants is obtained from widely scattered geographical locations as determined by price and sulfur and ash content. The resulting fly ash dump sites may therefore contain fly ash with a random elemental composition.

These preliminary data indicate that further investigations are necessary before the use of fly ash on agricultural soils can be recommended. Furthermore, owing to the water solubility of selenium in fly ash and the known volatility of this element, the commercial addition of fly ash to certain soaps and charcoal briquettes warrants further study of the possible movement of selenium introduced into the environment through these means.

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15 September 1975; revised 18 November 1975