general phenomenon, must give rise to Liesegang bands exactly under those circumstances where these bands actually occur.

The role of the gel or membrane in the Hirsch effect must not be overestimated, the effect itself being independent of the presence of colloid material. Only for the quantitative measurement of the Hirsch effect are carrier membranes, or other porous walls, used to advantage, principally to avoid convection.

The Hirsch precipitates are best considered as barriers to the forming ions rather than as membranes. Actually, by the time Liesegang layers appear and can be inspected, they have already lost their property as barriers (except for the last layer, if one is quick enough). Thus, the occurrence of bands of widely spaced crystals in water does not exclude a Hirsch effect.

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Radioactive Fallout

Your issue of 22 May [*Science* **129**, 1412 (22 May 1959)] contained an assessment, issued by the General Advisory Committee of the Atomic Energy Commission, of the dangers to the human race of radioactive fallout. Without discussing the obvious impertinence of a collection of physicists, chemists, engineers, and what-have-you who presume to issue a pronouncement on a crucial biological question, I should like to offer comment on certain of the points which they raised.

1) The fact that "the amount of total body external radiation resulting from fallout to date, together with future fallout . . . from previous weapons tests, is: (i) less than 5 percent as much as the average exposure to cosmic rays and other background radiation" is repeated ad nauseam to reassure the public. However, this argument is a red herring designed to deceive. The principal dangers (both physiological and genetic) to the human race from fallout stem from the decay of the radioactive fallout material after it has been taken into the body and incorporated within certain cells and tissues. That the total quantity of radiation reaching the whole body from outside is far greater is largely irrelevant to the question of the potential dangers of fallout from nuclear tests. Throwing rubber balls at a person is not an intelligent way of finding out what would happen were he to swallow one.

2) With respect to the internal effects of strontium-90, they comfort us with the statement that "the amount of strontium-90 which has been found in food and water is less of a hazard than the

amount of radium normally present in public drinking water supply in certain places in the United States." Since it is impossible to assess as yet the effects in man of ingestion of Sr^{90}, which has been a factor in human ecology only since 1954, one wonders how they can be so sure that it is "less of a hazard" than radium or anything else. Doctors who were prescribing radium for a variety of conditions as recently as the 1920's were also sure that there was no hazard involved, but many people died of it nonetheless. We shall all await publication of the studies on the high-radium drinking water to which the committee refers, but until we have had the opportunity to study them we had better treat this statement with the same suspicion which we have learned to extend to all other reassuring pronouncements emanating from the Atomic Energy Commission and its creatures.

Meanwhile, I should like to offer the following comment on the hazard of Sr^{90}, in order to solicit a refutation by the committee; I suggest only that they consult a biologist first, and if they are not acquainted with any I should be delighted to suggest one or two.

Since 1955, the maximum permissible body burden for Sr^{90} has been set at 1 μc (I cannot find publishable words with which to comment on the fantastic action of the U.S. National Committee on Radiological Protection, which recently doubled this, to 2 μc). In their book *Bone and Radiostrontium* (Wiley, New York, 1957), Engstrom *et al.* state that a total body concentration of 1 μc of Sr^{90} would be expected to deliver, in approximately 10 years, roughly 1000 r to certain microscopic hot spots located in the spongious bone, close to the marrow, where the blood-forming tissues are located. (One thousand roentgens was about the whole-body dose absorbed by the Austrian miners of Joachimsthal over a 17-year period, the mean time required for the development of the fatal lung cancers which used to kill three-quarters of them). In view of this calculation, Engstrom *et al.* recommended that the maximum permissible body burden be reduced to 0.1 μc, a recommendation which, I understand from *Science* [**129**, 1473 (29 May 1959)], has been adopted by the International Commission on Radiological Protection.

If the maximum permissible body burden for workers known to be subjected to radiation hazards is 0.1 μc, that for the population at large should be reduced, according to the International Commission, by one order of magnitude—that is, to 0.01 μc.

In the recent article by Kulp *et al.* [*Science* **129**, 1249 (8 May 1959)], we learn that children seem to have on the average about three times the concentration of Sr^{90} in their bones that adults have; 1-year-old infants have some eight to ten times the adult concentration. In view of this, and since the biological effects of radiation are more serious on rapidly growing and metabolizing cells, it seems to me that a separate maximum permissible body burden should be set for children, at approximately 0.003 μc.

That this figure is not unreasonably low is apparent in studying data from some Russian studies (cited by Engstrom *et al.*) on the effects of injecting small amounts of Sr^{90} into dogs; these animals developed bone cancers approximately 3 years after injection of 0.0001 μc of Sr^{90} per gram. Engstrom *et al.* calculate that the retained dose in a 10-kg dog would be of the order of 0.01 to 0.1 μc. Now, a 1-year-old child weighs approximately 10 kg, and it seems evident, to me at least, that its maximal skeletal concentration must not be permitted to reach the order of concentration of Sr^{90} known to cause fatal bone cancers in dogs.

We learn from the article by Kulp *et al.* that in 1966, when the highest skeletal concentration of Sr^{90} in young children will occur, some 1 percent of the world's children are expected to have a skeletal concentration of 20 μμc per gram of calcium. Since the average 1-year-old infant, weighing 10.6 kg, has roughly 100 g of calcium in his body, it follows that in 1966 1 percent of these children will have a total Sr^{90} skeletal level of 0.002 μc, and beyond doubt a significant fraction of 1 percent (hundreds of thousands, millions ?) will have exceeded our suggested limit of 0.003 μc, and some may have skeletal concentrations of the order of those known to cause cancer in dogs.

This happy picture is based on the optimistic assumption that no further testing of nuclear weapons will occur (and neglects to consider the effect of other radioactive fallout elements). But what if nuclear tests continue?

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Imprinting

Eckhard Hess, in his stimulating survey of recent progress in studies of imprinting [*Science* **130**, 133 (1959)] referred briefly to his inability to attain auditory imprinting with mallard ducks, *Anas platyrhyncus*. He did not mention, however, that it has been possible to attain auditory imprinting with other species—for example, *Aix sponsa,* the wood duck [P. H. Klopfer, *Ecology,* **40**, 90 (1959)].

This point would not ordinarily be of great significance except that it illustrates the importance of attending to interspecific differences in the survival value of particular kinds of behavior. Hess' paper shows the wild mallard to be an excellent imprinter, while the wood duck is considered to be poor. But, if auditory rather than visual stimuli are used, quite the reverse situation obtains. To a zoologist this seems reasonable: mallards nest in comparatively open situations, wood ducks in holes recessed in trees. Mallard young can see their mother when she first leaves the nest, the wood duck young cannot. Thus, the seeming importance of visual patterns for imprinting may be a reflection of the dominant sensory modality of the subjects rather than a characteristic of a particular type of behavior. In fact, one of the earliest reports on this subject dealt with olfactory imprinting [W. H. Thorpe and F. G. W. Jones, *Proc. Roy. Soc.* (*London*) **B124**, 56 (1937)]. The importance of olfaction to most mammals should suggest that it would be a mistake to confine further work in this area to the otherwise ingenious apparatus devised by Hess.

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