dition to the normal diet during 3 successive generations. Apparently manganese in amounts of 1/2 mg is even more effective.

Supplements of manganese alone in amounts of 2 mg a day result in interference with lactation and cannibalism, particularly marked after one generation.

It is inferred that manganese acts as an essential catalyst in oxidative processes in which vitamin B_1 is concerned. The vitamin B_1 requirement of an animal varies with the manganese content in its diet.

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Note on the Action of X-rays on Goldfish (*Carassius auratus*).

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The following experiments were undertaken in order to study the suitability of goldfish for the problems of experimental radiotherapy. Goldfish have already been used successfully in experimental pharmacology.

A total of 408 commercial goldfish (96 of which were used as controls) were divided into series of 12 for each exposure. After irradiation each series or controls were placed in an aquarium containing 7000 cc of water at a temperature of 19° to 22°C for observation.

The radiation factors were: 200 KV, 30 MA, no filter, HVL 6 mm Al, target distance 50 cm, field 15 x 15 cm, intensity 230 r/min. The fishes were irradiated in an open Petri dish, 15 cm in diameter, suspended between 2 layers of gauze, flush with the surface of the water in a water phantom. This was 32 x 32 x 32 cm, thus permitting the maximum back scatter (Quimby and coworkers[1]). Ionization measurements with a Victoreen chamber showed an increase in back scatter from the Petri dish of 3%.

The entire dose was given in one session and varied from 500 to 10,000 r without back scatter. When a dose of 1500 r up to 10,000 r was administered, all goldfish died 10 to 18, on an average 14 days after treatment, while nearly 100% of the controls remained alive

[1] Quimby, E. H., Marinelli, L. D., and Farrow, J. H., *Am. J. Roentgenol.*, 1938, **39**, 799.

at this period. After a dose of 1000 r only about 50% of the fishes were dead after a like period. The first intimation of a lethal effect was already noted after 500 r.

For about a week after irradiation the appearance of the fish did not change (latent period). On the sixth to ninth day, however, a brownish black pigmentation appeared on each side of the trunk. This was more marked when high doses were applied or where the fish's dorsal fin showed some black pigment. Fig. 1* illustrates this pigmentation 22 days after 1000 r (upper fish). Fig. 2* shows spread of astrospherical chromatophores. This phenomenon seems to be very interesting in connection with the results of Parker[2] con-

FIG. 1.

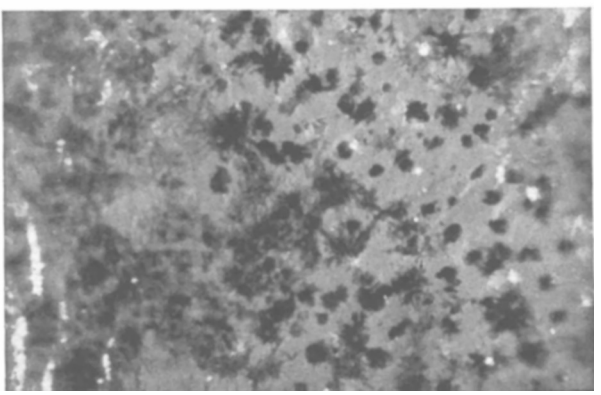

FIG. 2.
(Enlarged 80 ×.)

*I am indebted to Dr. E. Baender for the photographs.

2 Parker, G. H., *Cold Spring Harbor Symposia on Quantitative Biology*, 1936, 4, 358.

cerning the neuro-humeral activation of chromatophores as well as in relation to X-ray pigmentation of mammals and human beings. (Ellinger[3]).

Experiments carried out together with Dr. M. Sandberg have shown that while the red pigment (Astacene according to Lederer[4]) can be easily extracted by acetone, the X-ray pigmentation still remains. With the appearance of the pigmentation the otherwise very fast moving fishes become less active. They come to the surface and die exhibiting dyspnoea.

In accordance with these observations, autopsy shows marked shrinkage and atrophy of all lymphoid tissue and pycnosis of surviving lymphocytes with increase in the amount of fibrous tissue in the lymph-nodes. In the spleen there is complete disappearance of lymphoid elements, marked proliferation of macrophages containing blood pigment (hemosiderin).†

Further observation has shown that in the range of 1 : 4.5 cc the volume of the fish does not influence the lethal effect.

The similarity of the response of goldfish and mammals to X-ray, the relatively low lethal dose, as well as the possibility of getting small goldfish the year round seem to support the belief that goldfish may be used in experimental radiotherapy. The possibility of irradiating a considerable number of fishes at the same time also meets one of the prerequisites of experimental radiotherapy (Ellinger, l.c., p. 227). The fact that water, the most commonly used phantom material in depth dose measurement, is the natural medium of fish, suggests that fish may be suitable for biological depth dose measurement. Experiments along this line are in progress.

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[3] Ellinger, F., *Die biologischen Grundlagen der Strahlenbehandlung*, Berlin, 1935.

[4] Lederer, E., *C. r. Soc. Biol., Paris*, 1935, **118**, 542.

† I am indebted to Dr. D. Perla for the microscopical diagnosis.