ONTOGENETIC DETERMINANCE OF REACTION OF INTERRENAL GLAND TO IRRADITION

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Histological and histochemical studies were made of the reaction of the interrenal gland of tailless amphibians at various periods of ontogenesis (larvae in the stage of premetamorphosis, yearlings, and adults) to irradiation in doses of 10,000, 5,000, 1,500, and 700 R. The time when functional activity of the gland appears coincides with completion of its morphological development, taking place at the beginning of metamorphosis. The radioresistance of the amphibians falls as the complexity of the organization increases during ontogenesis. This is connected with an increase in radiosensitivity of the cortical cells of the interrenal gland.

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The radiobiological literature contains abundant information on the high resistance of lower vertebrates, especially amphibians, to the action of ionizing radiation. These animals are particularly radioresistant at the larval stage of development [2]. The interrenal gland, analog of the adrenal in higher vertebrates, plays an active role in adaptation to external environmental conditions which change sharply during ontogenesis of amphibians (emergence from water on to dry land) [3]. Comparison of the character of morphological and physiological changes in the interrenal gland with the duration of life of the experimental animals can therefore contribute to elucidation of the causes of the high radioresistance of amphibians.

In the present investigation the response of the interrenal gland of tailless amphibians to irradiation was studied at various periods of ontogenesis.

EXPERIMENTAL METHOD

Experiments were carried out on larvae and adults of the species Rana arvalis and Rana temporaria. Larvae were taken from natural ponds at the stage of premetamorphosis (hind limb buds) and at the peak of metamorphosis (mobile fore- and hind limbs), and in addition, yearlings immediately after completing metamorphosis and adults were used. The animals were irradiated with γ-rays two days after being caught

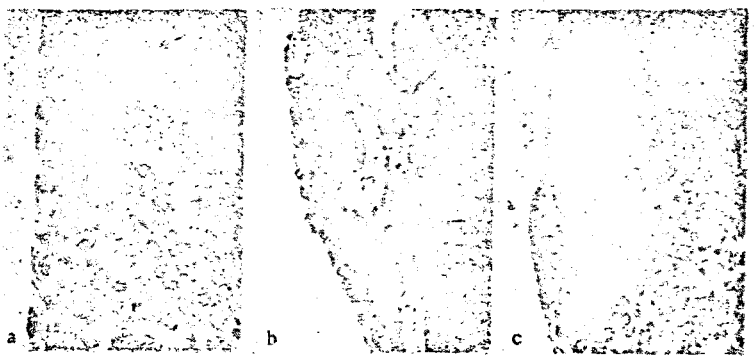

Fig. 1. Interrenal gland of Rana arvalis. a) Control (arrows denote islets of cortical cells containing lipids); b) 20 days after irradiation; c) 65 days after irradiation. Dose 700 R. Sudan black. Objective 6, ocular 8.

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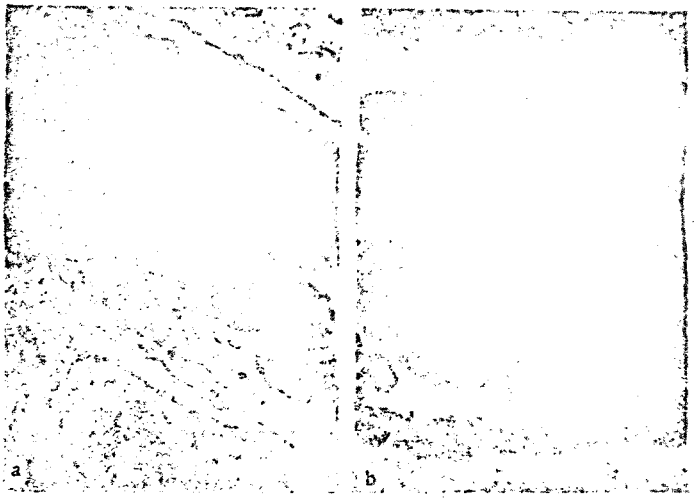

Fig. 2. Interrenal gland of Rana temporaria. a) Control; b) 20 days after irradiation. Dose 1,500 R. Sudan black. Objective 20, ocular 8.

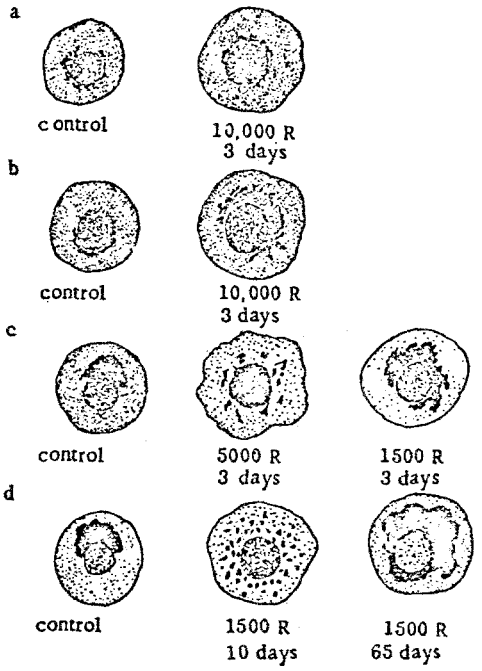

Fig. 3. Scheme showing changes in structure of Golgi complex in cortical cells of interrenal gland at different times of ontogenesis. a) Premetamorphosis; b) peak of metamorphosis; c) yearling; d) adult frog.

in doses of 10,000, 5,000, 1,500, and 700 R. All the tadpoles irradiated at the corresponding stage were sacrificed 1, 3, and 7 days later. Frogs irradiated in doses of 5,000 and 10,000 R were not investigated because of their rapid death. Frogs irradiated in doses of 7,000 and 1,500 R were sacrificed after 10, 20, and 65 days. The interrenal tissue was studied histologically and histochemically.

EXPERIMENTAL RESULTS

Immediately before metamorphosis the interrenal cells of the tadpoles were not yet arranged in a single layer. The cortical cells were round and contained oval nuclei, in which the nucleolus and chromatin were not yet clearly differentiated. The cytoplasm consisted of a narrow rim and showed practically no affinity for the dye. The formation of the definitive interrenal gland in R. temporaria coincides with the completion of metamorphosis, while in R. arvalis this process takes place rather earlier, in the culmination phase of metamorphoses. Irradition of larvae at all stages in doses of 700 and 1,500 R had no effect on formation of the definitive interrenal gland or on the course of metamorphosis. After irradiation at the stage of premetamorphosis in doses of 5,000 and 10,000 R, a complete block of morphogenic processes was observed. The same doses, given to larvae in stage IV, did not arrest the rapid culmination of metamorphosis, but the animals died soon after its completion. Yearlings, irradiated after completion of metamorphosis in a dose of 5,000 R, died within 5 days, while 80% of those irradiated in a dose of 10,000 R died within 24 h, the remainder surviving not more than two days. Adult frogs were least resistance to irradiation. In the course of 24 h mortality after doses of both 5,000 and 10,000 R was 100%.

The morphological response of the interrenal gland varied considerably with the age of the animals. Irradiation of larvae in doses of 5,000 and 10,000 R was accompanied by extreme hypertrophy of both cortical and chromaffin cells. The diameter of the nuclei was increased by 50-100%. The reticulumn of the Golgi organoid, which was practically undifferentiated in the interrenal cells of intact larvae, was clearly

outlined and hypertrophied, with numerous branches. Hypertrophy of the Golgi complex was particularly conspicuous in the chromaffin cells. In yearlings irradiated in the same doses the chromaffin cells were atrophied, while in the cortical cells the lipid content was reduced and the Golgi complex fragmented, indicating mobilization of hormonal substance. Some stimulation of the cortical cells was observed in the early periods after irradiation in a dose of 1,500 R; a dose of 700 R caused no changes in the interrenal gland of the yearlings. Meanwhile, in adult frogs after irradiation in the same dose, islets of cortical tissue were distinctly hypertrophied (Fig. 1). Hyperplasia of the cortical tissue became maximal after irradiation in a dose of 1,500 R (Fig. 2). The chromaffin tissue was concentrated in small and infrequent islets isolated from the cortical cells. These cells were increased in volume and their cytoplasm included a few pseudanophilic droplets and a hypertrophied Golgi complex (Fig. 3). In later stages after irradiation (2 months), an accumulation of lipids took place, much more marked than in the controls, and the Golgi complex showed the characteristic hypertrophy of cells with increased secretion formation.

The results show that the radiosensitivity of the secretory cells of the frog's internal gland is dependent on the stage of ontogenetic development. A dose of irradiation of 10,000 R is required to stimulate the cortical cells in the period of premetamorphosis. In the culmination phase of metamorphosis, this dose is halved. To obtain stimulation by irradiation of yearlings, a dose of 1,500 R is sufficient, and the adrenal of the adult frog reacts to a dose of 700 R.

In most amphibians the interrenal gland starts to function when it has attained its definitive morphological state [4, 5].

The results show that the radioresistance of amphibians diminishes parallel to the ontogenetic establishment of the functional activity of this gland. Since the sensitivity of the cortical cells to irradiation increases with age, it may be assumed that the reason for the decrease in radioresistance of the adults compared with the larvae is increased secretion of corticoid hormones. In fact, active proliferation of cortical tissue takes place in irradiated frogs, with an increase in level of hormones in the blood, adding considerably to the severity of radiation sickness [1]. Evidently this increase in function at the expense of the organism as a whole reflects a conflict between the phylogenetically established ability of the animal to react to harmful agents by an increase in secretion of corticoid hormones and the specific properties of radiation injury, in which hypercorticism is an unfavorable factor interfering with the efforts of the organism to overcome the disease.

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