Barium and Strontium Concentrations in Eye Tissue

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(Received 5 May 1958)

The pigmented tissues of the eye have in many animals an extraordinarily high concentration of one or other trace metal. In some the trace metal is localized in a tapetum lucidum; in some the distribution within the tissue is not known. When a survey of the strontium and barium content of human bone was being made (Sowden & Stitch, 1957) it was decided to make a study of these metals in the different parts of the eye in man, cattle and rabbit. Early work by Ramage & Sheldon (1931) and Gerlach & Muller (1936) had provided evidence that both barium and strontium were more concentrated in the eye than in other soft tissues, and Oksala (1954) had noted a concentration of 22 mg./100 g. wet wt. of barium in the uvea of the cow. The methods used for these earlier surveys were not as specific nor as sensitive as the method of neutron-activation analysis used in the present investigations.

METHODS

Material. Cattle and calf eyes were brought from the slaughterhouse and dissected without fixation within an hour of death. The rabbit eyes came from the Laboratory stock of pure-bred Dutch rabbits; these were killed by an intravenous injection of Nembutal and the eyes dissected immediately. Human material was obtained *post mortem*, or from operation. A special set of stainless-steel instruments was kept for dissection. Tissue from several eyes was pooled to obtain sufficient material for analysis. Difficulty was experienced in getting clean separation of retina and choroid; this was simple in calf and cow eyes but with rabbit and man the connexion was much closer, and variable

amounts of pigment were brushed off with the retinal tissue. The tissues were ashed and analysed for barium and strontium by the method described by Sowden & Stitch (1957).

RESULTS

The concentrations of strontium in eye tissue are given in Table 1. In calf, cattle and rabbit the iris and choroid contain more strontium than the non-pigmented tissues. In most cases the concentrations in cow-eye tissues were greater than in calf, the levels in bovine tissue being generally higher than in human tissue.

The concentrations of barium in the same set of eye tissues is given in Table 2. Barium is remarkably concentrated in the choroid of the calf and cow and considerably so in the rabbit. In man the concentration is no greater than that of strontium although the choroid and iris show the highest content.

DISCUSSION

The function of this relatively high concentration of barium in the choroid of herbivores is unknown. It increases with age in both cattle and rabbit, but it is already present and preferentially concentrated in the choroid of the day-old calf. Zinc in the choroid of the dog, fox, badger and seal is present as crystals of zinc cysteine in the tapetum lucidum (Weitzel, Buddecke, Fretzdorff, Strecker & Roester, 1955), and these crystals appear to function as a reflecting device to aid vision in dim light; zinc may constitute 16–19% of the dry weight of the tapetum

Table 1. *Strontium content of eye tissues*

Results are expressed as $\mu\text{g./100 g. wet wt.}$ Results are single estimations on combined tissues from several eyes.

Species	Cornea	Iris	Lens	Vitreous body	Retina	Choroid	Tapetal choroid	Sclera
Calf	—	25, 40	6	—	4, 9, 27	55, 73	141	—
Cow	16	133, 78	5, 8	—	17, 4	100, 114, 136	115	31
Rabbit								
10 weeks	27	50	5	2	49	36	—	18
6–9 months	—	24, 57, 32	—	—	6, 8, 14	18, 20, 20	—	18, 16, 13
Man								
New-born	5	25	Detected	10	15	20	—	15
49–86 years	9	—	15	—	9	31, 10	—	50

Table 2. *Barium content of eye tissue*

Results are expressed as $\mu\text{g./100 g. wet wt.}$ Results are single estimations on combined tissues from several eyes.

Species	Cornea	Iris	Lens	Vitreous body	Retina	Choroid	Tapetal choroid	Sclera
Calf	39	740, 617	4	33	13, 5	1 730, 3 080	3 728	610
Cow	70, 3	18 700, 20 600	5, 6	—	56, 129	20 000, 66 000	17 700	1 700
Rabbit								
10 weeks	20	196	5	1	26	303	—	23
6-9 months	—	222, 590, 374	—	—	11, 13, 20	765, 775, 1 050	—	40, 28, 19
Man								
New-born	5	25	Detected	—	9	9	—	13
49-86 years	3	—	5	—	4	24, 10	—	30

in the silver fox, which is far greater than the barium concentration in any choroid we have examined. The choroid of the cow is also anatomically specialized as a tapetum but in this case the structure is not made up of cells which contain crystals but consists of parallel fine fibres which act as a diffraction grating reflecting light. We are unable to say whether the tapetal fibres are particularly rich in barium.

Chelating agents such as dithizone, injected into the dog (Weitzel, Strecker, Roester, Buddecke & Fretzdorff, 1954) or the rabbit (Butturini, Grignolo & Baronchelli, 1953), cause tapetal degeneration and retinal detachment with blindness. The dose of dithizone which caused eye change in the dog was insufficient to cause diabetes. It therefore appears that in these animals the presence of metals may be essential for the function and structure of the choroid and for vision. Dogs dosed with small amounts of radium show pigmentary changes in iris and tapetum which may be due to damage of the tissues owing to concentration of radium in them (Rehfeld & Stover, 1957).

Although the concentration of barium in the choroid of the cow is far less than that of zinc in the crystalline tapetum of the dog or fox, it is 10-1000 times greater than that of iron, aluminium, zinc, manganese, silicon and other trace metals (Oksala, 1954). Comparison of the concentration of barium and strontium in eye tissues with their concentration in other parts of the body shows that, in the herbivores, barium is very markedly concentrated in the choroid compared either with other soft tissues or with bone, and that strontium concentration may be 20 times that in the liver. The barium content of the human choroid is within the range of values for other soft tissues and is somewhat higher than that of bone when the concentrations in ash are compared. The strontium content of human choroid and iris is about a quarter that of bone (again comparing ash concentrations) and is of the

same order as that of liver ($4.3 \mu\text{g./100 g. wet wt.}$). The sclera of bovine and human samples also seemed to accumulate these metals. It is unlikely that the apparently high concentration is due to contamination of sclera by choroidal tissue.

These results emphasize the variation between species and the selective concentration of certain trace metals in the eye tissues of different animals. It would be interesting to investigate whether other trace metals known to be present in animal tissues are concentrated in the eye.

SUMMARY

1. The strontium and barium content of the different parts of the eye has been estimated by the method of activation analysis in cattle, rabbit and man.

2. The pigmented parts of the eye contain more strontium and barium than the other parts, and barium in particular is concentrated in the choroid of the cow.

3. These results are discussed in relation to the presence of high concentrations of zinc in the choroidal tapetum lucidum of other animals.

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