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Comparative distribution on niobium-95 in maternal and fetal rats and rabbits[1]

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Summary. Pregnant rats and rabbits were injected with Nb95 towards the end of gestation. In rats, all maternal tissues showed higher concentrations compared to the fetal organs; the highest ratio was 0.6 in bone. In rabbits a different distribution was found. The fetal bone exhibited a 3.5 times higher concentration of Nb95 than the maternal one.
Key words. Niobium-95 diaplacental transfer; species dependence; bone.

Niobium, a rare earth element, is a trace constituent of stainless steels and an anti-cracking additive in steel compounds of reactor systems. It can be activated to give several isotopes, of which Nb94 has been pointed out to be the most hazardous to the environment because of its half-life of more than 20000 years and its high dose rate[2]. Former work[3] and a previous report[4] on the transfer and distribution of Nb revealed inconsistent results concerning its uptake into the fetal organs of different species. The calculation of the radiological risk to man after incorporation of these nuclides, however, is based on such animal data. The purpose of the work now to be reported was to compare the transplacental movement and the subsequent distribution of niobium in rats and rabbits under the same conditions.

Materials and methods. Virgin female Wistar rats aged 10–12 weeks were caged with males overnight and mating was confirmed by the presence of sperm next morning, at day 0. Groups of 5 animals were injected with 740 kBq Nb95 oxalate (carrier free; $t_{1/2}$ = 35 d) i.v. into the tail vein on day 18 and day 20 of gestation. The animals were killed 24 h later. From each female 5 fetuses were assayed for whole body measurements and 5 were dissected. Blood, liver, kidney and femur of dams and fetuses, and placentas, were removed and weighed. The samples were measured in a well-type scintillation counter and the activity was expressed as a percentage of the injected dose/g of tissue.

Pregnant New Zealand white rabbits at an age of 6 months were injected into the ear vein in groups of 3 animals on days 26 and 28 of gestation, receiving 3.7 MBq Nb95 of the same solution as the rats. They were also killed 24 h after injection and handled as described above. Immediately after injection, rats and rabbits were measured in a whole body counter to confirm the injected dose. The decrease in retention was determined by whole body γ-counting directly before killing the animals 24 h later. All data in this report were corrected for physical decay.

Results and discussion. The tissue concentrations of Nb95 in rats and rabbits are given in the table. Both species were investigated at the same stages of gestation. Calculating an average duration of pregnancy of 22 days for rats and 31 days for rabbits, both species had passed about 82% and 90% of the total gestational period when they were given the injection. For rats this was days 18 and 20, for rabbits it was days 26 and 28 of gestation. Maternal blood and kidneys showed high concentration of Nb in both species, whereas the corresponding fetal tissues demonstrated very low concentrations, leading to low fetal to maternal concentration ratios. Liver concentrations of rats and rabbits were considerably different.

However, the relation between maternal and fetal concentrations was similar in the two species, indicating a comparable biokinetic behavior of Nb in liver. The placentas contained high concentrations of Nb which even increased towards the end of gestation in both species.

The mean whole body concentrations of the mothers were calculated from the Nb retention 24 h after administration of the nuclide. For rats, the retention was 86.6% on day 18 and 84.2% on day 20; the maternal rabbits retained 91.6% and 91.8% of the injected dose on day 26 and day 28 of gestation, respectively. The total body concentration of maternal rats was 5–10 times higher compared with the rat fetuses. In rabbits, the ratio of whole body concentrations was 0.7–0.8, which indicates a similar total body burden of Nb in rabbit dams and fetuses at this gestational stage.

An apparent difference was seen between the femur concentrations of both species. The C_f/C_m in rats was 0.6. In rabbits, however, the ratio was 2.0 on day 26 and 3.5 on day 28 of gestation, thus presenting a different radiological hazard to the fetal bone. Although a former report on the Nb distribution in rabbits[3], quoting a ratio of 100, could not be confirmed, a definite difference between rat and rabbit results became evident. The actual reasons for these divergent results are difficult to find out. With respect to the placenta physiology of both species there were no obvious contradictions. The hemochorial placentas of rats and rabbits are so similar that they are both regarded as suitable models to study diaplacental transfer[5]. Taking into account that direct comparison of rat and rabbit data requests further transformation[6] because of the 10 times higher body mass of rabbits, at least the ratios of fetal to maternal tissue concentrations remain constant so that they can be compared. Bone physiology and histological bone structure in adult rats and rabbits show no particular differences. They both have a low differentiated Haversian system, where secondary Haversian channels are rarely seen[7]. But in the fetal bone development there is a significant difference between these two species. In the rat and the rabbit fetus, ossification of the femur starts at the same time, at about day 18 of gestation[8]. Ten days later, when rabbit fetuses were examined they were in a phase of

Concentrations of Nb95 in maternal and fetal organs of rats (5 dams, 25 fetuses each group) and rabbits (3 dams, 9 fetuses each group) on comparative stages of the total gestational period. Animals were injected after having passed 82% (a) and 90% (b) of the full duration of pregnancy. Values are expressed as % of injected dose per g tissue (mean ± SE). The ratios of fetal and maternal tissue concentrations are given as C_f/C_m

		Rats			Rabbits		
		Dam	Fetus	C_f/C_m	Dam	Fetus	C_f/C_m
a)	Blood	0.63 ± 0.03	0.04 ± 0.008	0.06	0.17 ± 0.01	0.001 ± 0.0002	0.06
	Liver	0.29 ± 0.01	0.02 ± 0.003	0.07	0.07 ± 0.008	0.001 ± 0.0001	0.01
	Kidney	0.82 ± 0.07	0.02 ± 0.002	0.02	0.12 ± 0.004	0.006 ± 0.001	0.05
	Femur	0.36 ± 0.15	0.21 ± 0.01	0.60	0.07 ± 0.01	0.14 ± 0.007	1.8
	Whole-body	0.28 ± 0.02	0.05 ± 0.004	0.2	0.024 ± 0.002	0.018 ± 0.001	0.8
	Placenta	0.91 ± 0.02	–	–	0.14 ± 0.004	–	–
b)	Blood	0.41 ± 0.003	0.01 ± 0.003	0.02	0.11 ± 0.09	0.001 ± 0.0004	0.01
	Liver	0.21 ± 0.01	0.004 ± 0.0007	0.02	0.03 ± 0.004	0.0006 ± 0.0002	0.02
	Kidney	0.54 ± 0.04	0.01 ± 0.002	0.02	0.08 ± 0.002	0.004 ± 0.001	0.05
	Femur	0.38 ± 0.06	0.23 ± 0.03	0.6	0.02 ± 0.006	0.07 ± 0.003	3.5
	Whole-body	0.27 ± 0.02	0.03 ± 0.003	0.1	0.026 ± 0.003	0.019 ± 0.01	0.7
	Placenta	1.17 ± 0.09	–	–	0.15 ± 0.02	–	–

very extensive bone formation and ossification, a process which occurs in rats during the early postnatal period.

Summarizing the findings of this report, the results clearly illustrate the problem of introducing serious errors in theoretical calculations of radiation dosages to maternal and fetal tissues by using data obtained only from one species.

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A blue light-reversible reaction in an animal system *(Daphnia pulex)*

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Summary. A photoreversible reaction, previously found only in plants and fungi, has now been found in an animal system. Activation of development in diapausing embryos of *Daphnia pulex*, induced with white light, was suppressed with subsequent exposure to narrow-band (470 nm) or wide-band (410–525 nm) blue light. Pulses of wide-band blue light repeatedly reversed white light activation.

Key words. Daphnia pulex; waterflea; photoreversibility; blue light; embryonic diapause.

Photoreversible reactions have been reported for plants and fungi[1–4]. Phytochrome, a red/far-red reversible receptor, senses shade[5] and regulates development in plants[6,7]. Mycochrome, a UV-B/blue reversible receptor, regulates sporulation in certain fungi[2,8,9]. Development in animals may also be regulated by light, especially blue light[10,11]. Unfortunately, most reported light reactions in animals are complicated by the coupling of a circadian oscillator with photoinduction[12,13]. However, in the waterflea *(Daphnia)*, a single pulse of light may reinitiate development following an embryonic diapause[14,15]. Near-UV and blue light activate most effectively, as shown by action spectra[16,17]. This evidence, in conjunction with reported blue-light reactions in fungi, prompted us to examine embryonic development in *Daphnia* for photoreversibility. In this paper we show that embryonic development, activated by white light, is repeatedly reversed by blue light. This is the first demonstration of the photoreversal of a light-induced reaction in an animal[18].

Materials and methods. Sediments containing diapausing embryos of *Daphnia pulex* Leydig were dredged from Saratoga Lake, N.Y. (43° N. Lat., 73°45′ W. Long.) from a depth of 27 m. The embryos exist at densities of 10^4 m^{-2} and appear permanently trapped in diapause by lack of light and oxygen. Egg pods, each containing two embryos, were separated from the sediments and stored in lake water in 20-ml serum bottles under one atmosphere of 5.14% CO_2 with a balance of N_2. Collections were made under natural night light and the embryos were held in the laboratory in the dark at 4 °C.

Aerated embryos, within their egg pods, were exposed from above for 30 min to white light from a 150 W xenon lamp. Immediately following, they were exposed for 60 min to one of 11 narrow-bands of light, as provided by interference filters (Schott) with a 7 nm half-band width (table). The embryos, submersed beneath 4 cm of water, were irradiated at 4 °C and transferred immediately thereafter to 15 °C. Photoactivation was