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INHALATION OF TALC BABY POWDER BY HAMSTERS

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Abstract—Groups of 50 male and 50 female Syrian golden hamsters were exposed to talc aerosol for 3, 30 or 150 min/day, 5 days/wk for 30 days, or for 30 or 150 min/day either until they died naturally or for a maximum of 300 days. The mean concentration of the 'respirable' aerosol fraction was approximately 8 μg/litre and the mass mean aerodynamic diameter was 6 μm. Following the exposures, the animals were observed for the remainder of their lifespan. At death, lungs, trachea, larynx, liver, one kidney, stomach, uterus, one ovary, or one testis, and all tissues showing gross lesions were collected for histopathological examination. Deposition of talc particles in the lungs of the exposed animals was demonstrated by X-ray fluorescence and by X-ray diffraction. The exposures to talc aerosol had no effect on body weight, survival or the type, incidence or degree of histopathological change in the exposed groups compared with sham-exposed controls.

INTRODUCTION

Autopsy and radiological findings of talc-induced pneumoconiosis include a heavy accumulation of macrophages, varying degrees of diffuse fibrosis, 'pneumoconiotic nodules', and asbestos bodies in a large percentage of the cases (Worth & Schiller, 1954). The presence of asbestos bodies indicates that the 'talc' to which the patients had been exposed contained appreciable quantities of asbestos and probably various other components, such as quartz.

In recent years, interest has focussed again on the potential health hazard of the dust commonly referred to as talc (Blejer & Arlon, 1973; Chodzikowski, 1975; Henderson, Joslin, Turnbull & Griffiths, 1971; Kleinfeld, Messite, Kooyman & Zaki, 1967; Kleinfeld, Messite & Langer, 1973; Kleinfeld, Messite, Shapiro & Swencicki, 1965; Kleinfeld, Messite & Zaki, 1974; Merliss, 1971; Miller, Tiersfein, Bader, Bader & Selikoff, 1971; Pelfrene & Shubik, 1975; Smith, 1973). It was considered necessary, therefore, to determine the biological effects of talc dust by means of inhalation studies in a suitable animal model under controlled laboratory conditions. Syrian golden hamsters (*Mesocricetus auratus*) were selected because studies in our laboratory have demonstrated the development of pulmonary lesions in these animals following prolonged inhalation of asbestos, cobalt-oxide and nickel-oxide dusts and cigarette smoke. Exposure to chrysotile asbestos aerosol (7 hr/day, 5 days/wk, for 11 months; mean aerosol concn 23 μg/litre) resulted in a 100% incidence of asbestosis in the exposed animals (Wehner, Busch, Olson & Craig, 1974b & 1975a). Exposure to aerosols of cobalt oxide (Wehner *et al.* 1974b) or nickel oxide (Wehner *et al.* 1974b; Wehner, Busch, Olson & Craig, 1975b) caused pneumoconiosis, and cigarette-smoke exposure significantly increased tumour incidence and epithelial lesions of the larynx (Wehner, Busch & Olson, 1974a). The positive response of the Syrian golden hamster to a variety of carcinogens has been reported by a number of investigators (Dontenwill, 1970; Dontenwill & Mohr, 1961; Herrold & Dunham, 1963; Mohr, 1970; Mohr, Wieser & Pielsticker, 1966; Montesano & Saffiotti, 1968 & 1970; Smith, 1974). Montesano, Saffiotti & Shubik (1970) used this species extensively as an animal model for the study of the pathogenesis of lung cancer and found it "markedly susceptible to various respiratory carcinogens and conveniently refractory to chronic pulmonary infections".

EXPERIMENTAL

Experimental design. The hamsters used were of the outbred Ela:ENG strain, from Engle's Laboratory Animals, Inc., Farmersburg, IN, and the experimental design is summarized in Table 1.

Three hundred 4-wk-old hamsters were randomly divided into three groups (1, 2 and 3) each of 50 males and 50 females. These groups were exposed for 30 days to talc aerosol for 3, 30 and 150 min/day, respectively. The mean total aerosol concentration was 37·1 ± 7·4 (SD) μg/litre with a respirable fraction of 9·8 ± 2·4 μg/litre. The sham-exposed control group (group 6) comprised 25 males and 25 females. Two hundred 7-wk-old hamsters were randomly divided

Table 1. *Experimental design for exposure of groups of hamsters to a talc aerosol for various lengths of time*

Group	Exposure regimen*		Calculated cumulative exposure	
	No. of min/day	No. of days	(hr)	(mg hr/m³)
1	3	30	1·5	12
2	30	30	15	120
3	150	30	75	600
4	30	300	150†	1200†
5	150	300	750†	6000†
6 (control)	150‡	30	75†	—
7 (control)	150‡	300	750†	—

*Animals (50 males and 50 females in groups 1–5 and 25 males and 25 females in groups 6 and 7) were treated on 5 days/wk. Desired respirable fraction of talc aerosol = 8 μg/litre.
†Most of these animals died before completion of 300 exposures.
‡Sham exposures.

into two groups (4 and 5) each of 50 males and 50 females and were exposed to talc aerosol for 30 or 150 min/day, respectively, for 300 days unless they died sooner. Mean total aerosol concentration was 27·4 ± 3·4 μg/litre with a respirable fraction of 8·1 ± 1·0 μg/litre. The sham-exposed controls (group 7) comprised 25 males and 25 females.

Aerosol concentrations and exposure times were based partly on results of simulated infant-exposure experiments conducted by F. D. Pooley (unpublished data, 1973), in which women dusted infant-size dolls with baby powder as they would dust infants, and partly on results of infant-dusting experiments conducted by A. N. Eden (unpublished data, 1971) and were chosen to simulate in young and adult hamsters, as far as was practical, multiples of median infant exposure (MIE) estimated from these data. The MIE was later recalculated using the data of Eden, who determined in a study involving 72 babies ranging from 1 to 24 months of age, that mothers applied talc from one to nine times each day with a median frequency of twice a day, and of R. S. Russell (unpublished data, 1976) who determined the time-weighted average exposure for "one dusting" to be 0·1 mg min/m³ with a standard error of 0·04 mg min/m³ in individual tests on 48 mother–infant pairs. Using all frequencies reported by Eden and all the reported "one dusting" exposure values determined by Russell, a computer was used to develop a cumulative frequency distribution of total daily infant exposures by randomly sampling a frequency, randomly sampling an exposure, and multiplying the two numbers together for a total of 1000 cycles. From the resulting cumulative frequency distribution, it was possible to determine that the MIE was 0·058 mg hr/m³/wk and the upper 95th percentile corresponded to 0·105 mg hr/m³/wk.

To prevent cross-contamination, the hamsters exposed to talc aerosol and the controls were maintained in separate but identical rooms controlled for temperature (73 ± 2°F) and humidity (45 ± 15%). After completion of the exposures the hamsters were maintained for observation for the remainder of their natural lifespan with the qualification that the experiments were concluded by the killing of all surviving animals when the number of deaths in the group with the most survivors exceeded 90%. Moribund animals were killed by ip injection of sodium pentobarbitone and exsanguination.

The hamsters had free access to Wayne Lab-Blox F6 (Allied Mills, Inc., Chicago, Ill.) and water. Body weights were measured every 2–3 wk during the growing period and every 4 wk thereafter (Figs 1 & 2) and the numbers of deaths were recorded throughout the treatment and observation periods (Figs 3 & 4).

Aerosol exposure system. Each stainless-steel 1500-litre aerosol exposure chamber (Fig. 5) was designed for single-tier exposure of four separate animal cages, which could be inserted and removed independently while the aerosol was being generated. Each 64 × 64 × 15-cm stainless-steel wire-mesh cage held 25 hamsters in individual 12·8 × 12·8-cm compartments, the cages being set in filing-cabinet-like drawers which sealed into the sides of the chamber in either of two positions—fully inserted or fully withdrawn. This arrangement allowed the desired aerosol concentration to be established within the chamber prior to insertion of the drawers with the loaded animal cages. Animals could then be inserted by closing a drawer, with only a relatively small effect on the aerosol concentration within the chamber. This facilitated exposure of animals to given aerosol concentrations for as little as 3 min.

Talc powder. The talc aerosol was generated from Johnson's® Baby Powder, lot 228p, provided by Johnson & Johnson. According to the manufacturers, a multi-step flotation process on Vermont talc is used to provide a high-grade cosmetic talc for the baby powder, lot 228p, a normal production lot, having been prepared as a part of that process. It consists of over 95% (w/w) platey talc with trace quantities of carbonates (magnesite and dolomite) as well as platey chlorite and rutile.

Aerosol generation and characterization. A Wright Dust Feed Mechanism (Wright, 1950) served as the aerosol generator, the talc powder being packed into the cup at a pressure of 263 kg/cm². The mechanism was operated with an air flow of approximately 20

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litres/min with an upstream air pressure of 5 lb/in.^{2}, to give a fairly reliable aerosol generation. Air-flow rate through the exposure chamber was 208 litres/min. The concentration of 'respirable' aerosol in the exposure at a sampling rate of 2·5 litres/min. The Casella Type 113A Gravimetric Dust Sampler, which included a horizontal elutriator to remove larger particles from the aerosol prior to collection of the respirable particles on a glass-fibre filter. A sample was taken continuously for the duration of each day's exposure at a sampling rate of 2·5 litres/min. The Whatman GF/A filters from the sampler were weighed before and after sampling to determine the quantity of talc deposited, and the sample volume was measured by the sampler. From these data the respirable fraction of the aerosol concentration was determined.

Total aerosol concentration was measured daily by means of two probes, inserted into opposite quadrants of the chamber. Two probes were used to monitor and ascertain even aerosol distribution within the chamber. Each probe sampled for 60 min concurrent with the Casella sampler at a rate of 2·3 litres/min through a vertically positioned 25-mm-diameter Metricel DM-450 filter paper, which was weighed before and after sampling. Weekly mean aerosol concentrations were computed from the daily data. The mean aerosol concentrations referred to in this paper are the means of the combined weekly means. To monitor the accuracy of the gravimetric data, filter paper samples were subjected periodically to chemical analysis in addition to being weighed. Particle size and particle-size distribution were determined periodically by collecting aerosol samples in an Andersen Cascade Impactor (Andersen, 1966).

Sham exposures consisted of placing the control animals in an identical exposure chamber for the specified periods of time to simulate the stress of handling. Instead of aerosol, filtered room air was drawn through the chamber.

Post-mortem procedures. A detailed autopsy was performed on each animal, and gross findings were recorded. Lungs with trachea and larynx, heart, liver, one kidney, stomach, one ovary and uterus, or one testis, and all tissues showing gross lesions were fixed in 10% neutral-buffered formalin, embedded in paraffin, sectioned at 5 μm and stained with haematoxylin and eosin for histopathological examination. For this procedure, the lungs were gently infused through the trachea with formalin, followed by tracheal ligation. All histopathological findings were recorded and coded according to the Systematized Nomenclature of Pathology (Committee on Nomenclature and Classification of Disease, 1969) to facilitate computer analysis of the data.

Qualitative analysis of lung tissue for talc. To identify the particles deposited in the lungs of the exposed hamsters, eight particles of talc were processed for scanning electron microscopy, photographed, and analysed by X-ray fluorescence. Portions of lung tissue from an exposed hamster and from a control animal, and particles removed from the lung of an exposed hamster, were also processed and analysed by X-ray fluorescence and diffraction, and the results were compared with those from the eight talc particles.

RESULTS

Aerosol exposure data

Aerosol data for the 30- and 300-day exposures are summarized in Table 2.

Clinical signs

No clinical signs were observed as a result of the talc exposures. Mean body weights as a function of age and treatment are shown in Figs 1 and 2, in which the 95% confidence intervals have been deleted for clarity. The exposures had no effect on either male or female hamsters as determined by comparison of the 95% confidence intervals of these means.

Number of deaths

There were no significant differences among the survival times of the exposed groups, nor between the exposed groups and the controls (Table 3). However, in all groups the mean survival time of the males was significantly ($P < 0.05$) longer than that of the females. The numbers of deaths in the 30- and 300-day exposure groups are shown in Figs 3 and 4, respectively. There was a marked sex-related difference in all groups, which became statistically significant at the age of approximately 12 months, but no treatment-related effect was apparent.

Table 2. *Talc aerosol data for 30- and 300-day exposures*

Interval	Particle size distribution*: Upper limit of interval† (μm)	Percentage of total mass in interval	Cumulative percentage mass smaller than upper limit size
	30-day exposures‡		
1	—	34·1	99·9
2	6·7	16·9	65·8
3	4·6	19·5	48·9
4	3·1	21·6	29·4
5	2·0	4·1	7·8
6	1·1	1·2	3·7
7	0·7	1·0	2·5
8	0·5	1·5	1·5
	300-day exposures§		
1	—	32·6	100·0
2	8	26·9	67·5
3	5	20·3	40·6
4	3	9·5	20·3
5	2	3·0	10·8
6	1	2·3	6·8
7	0·7	2·6	4·5
8	0·5	1·9	1·9

*Cumulative 'composite' of 10 (for 30-day exposure) and 53 (for 300-day) Andersen Cascade Impactor samples.

†Particle size expressed as aerodynamic equivalent diameter.

‡Mean aerosol concentrations (μg/litre $\pm$ SD), 37·1 $\pm$ 7·4 (total) and 9·8 $\pm$ 2·4 (respirable fraction); mass median aerodynamic diameter, 4·9 μm; distribution, bimodal with peaks at 0·6 and 2·6 μm.

§Mean aerosol concentrations (μg/litre $\pm$ SD), 27·4 $\pm$ 3·4 total and 8·1 $\pm$ 1·0 (respirable fraction; mass median aerodynamic diameter, 6·0 μm; distribution, bimodal with peaks at 0·6 and 4·0 μm.

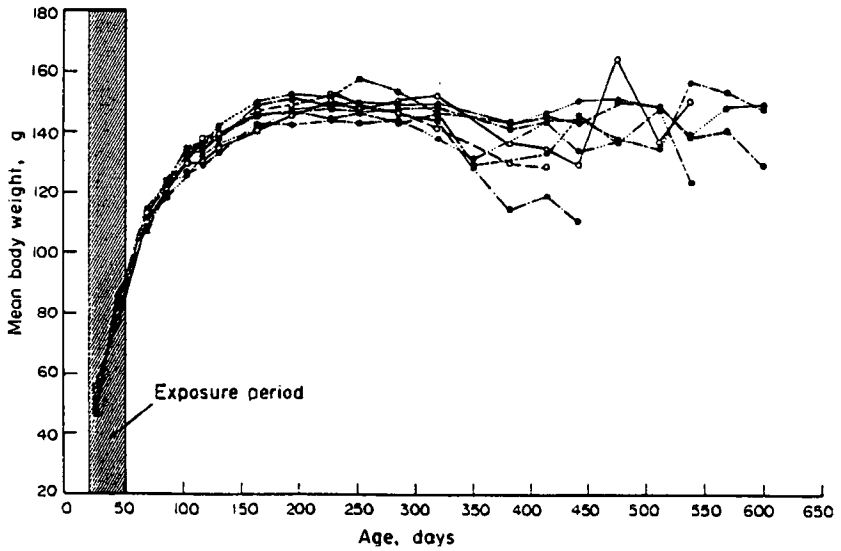


Fig. 1. Mean body weights of hamsters of groups 1 (———, males; —·—, females), 2 (—··—, males: —···—, females) and 3 (·····), males; -----, females), exposed to talc aerosol for 30 days, and of group 6 (——, males; – – –, females), the sham-exposed control group.

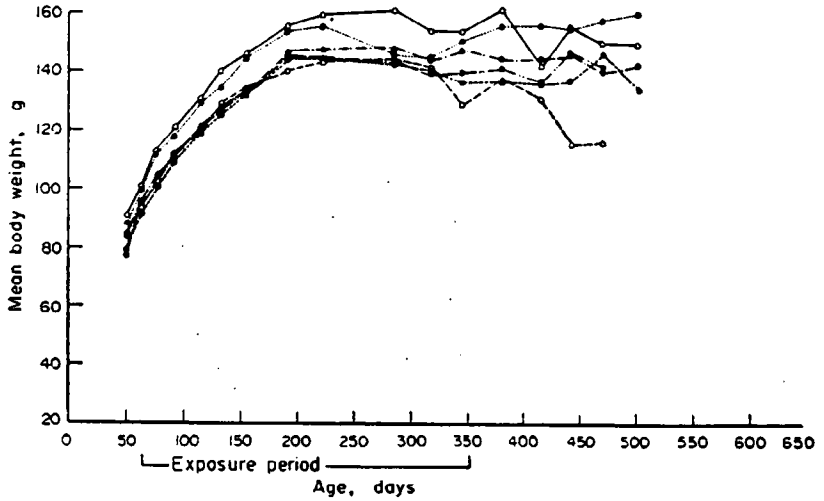


Fig. 2. Mean body weights of hamsters of groups 4 (—·—, males; —··—, females) and 5 (·····, males; -----, females) exposed to talc aerosol for 300 days, and of group 7 (——, males; – – –, females), the sham-exposed control group.

Table 3. *Mean survival times of groups of hamsters exposed to a talc aerosol and of sham-exposed controls*

Group	Daily aerosol exposure (min)	Actual cumulative exposure (mg hr/m³ ± SD)	Median survival time (days ± SD)			Mean survival time* (days ± SD)		
			Males	Females	M + F	Males	Females	M + F
			30-day exposures					
1	3	14·6 ± 3·6	430	370	398	442 ± 15	349 ± 15	396 ± 12
2	30	146 ± 36	398	363	382	415 ± 15	360 ± 13	387 ± 10
3	150	732 ± 180	434	367	388	453 ± 18	372 ± 9	412 ± 11
6	0	0	412	381	393	426 ± 17	372 ± 14	399 ± 8
			300-day exposures					
4	30	1210 ± 150†	482	400	428	491‡ ± 13	380 ± 12	436‡ ± 10
5	150	6060 ± 750†	481	396	428	462† ± 11	405 ± 12	433‡ ± 10
7	0	0	488	354	411	485‡ ± 21	361 ± 16	423 ± 16

*In all groups, the mean survival time for the males was significantly longer ($P < 0{\cdot}05$) than that for the females.
†Most of these animals died before completion of the 300 exposures (Fig. 5).
‡The survivors of groups 4, 5 and 7 were killed at the age of 20 months. At that time all females were dead and less than 20% of the males were alive. The male mean survival times and consequently the combined mean survival times are therefore artificially low.

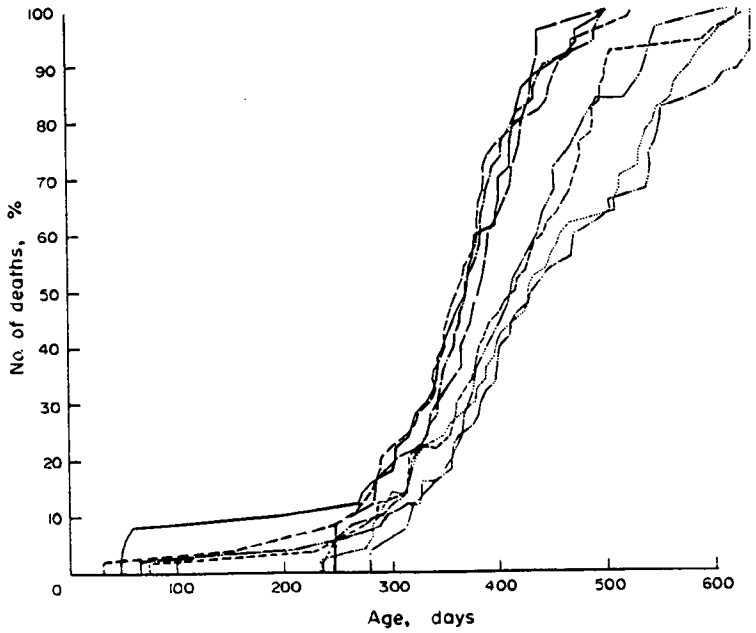


Fig. 3. Death rates in hamsters exposed for 30 days to talc aerosol for 3 min/day (group 1: ·····, males; ——, females), 30 min/day (group 2: ----, males; – – – –, females) and 150 min/day (group 3: —·—, males; —·—, females) and in the sham-exposed controls (group 6: —·····—, males; ——, females).

Qualitative analysis of lung tissue for talc

Figure 6 shows a photomicrograph of one of the eight talc particles processed. Analysis by X-ray fluorescence at 0–5 keV and at 5–10 keV showed that the particle was composed of magnesium, silicon and traces of iron. Figure 7 is a photomicrograph of lung tissue from a control hamster. One of many talc particles found in the lungs of exposed hamsters is shown in Fig. 8, its identity having been confirmed by X-ray analysis.

Summary of type and incidence of histopathological findings

The type, incidence and severity of the observed lesions indicated no trend toward a dose-response relationship and showed no significant differences between the exposed groups and the controls.

Larynx and trachea. Changes found in the larynx in both control and exposed hamsters included calcification of the mucosal tissue, calcification of the muscles of the larynx, dilation of the glands of the

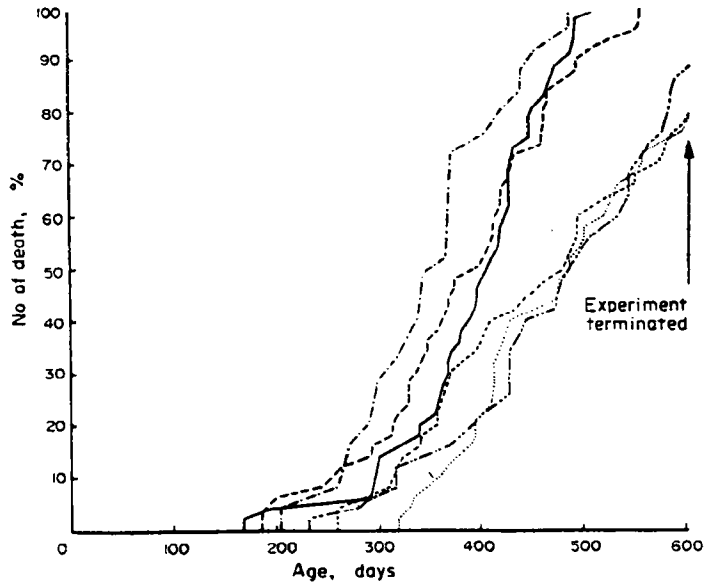


Fig. 4. Death rates in hamsters exposed for 300 days to talc aerosol for 30 min/day (group 4: ·····, males; ——, females) and 150 min/day (group 5: ----, males; – – – –, females) and in the sham-exposed controls (group 7: ———, males; —·— females).

Table 4. *Summary of incidence of common pulmonary changes observed in hamsters exposed to a talc aerosol*

Pulmonary change	No. of animals affected in group*														Total affected	Incidence (%)
	1		2		3		4		5		6		7			
	M	F	M	F	M	F	M	F	M	F	M	F	M	F		
No. of hamsters examined....	49	47	50	49	48	50	49	50	48	48	25	25	25	25	588	
Alveolar emphysema	16	8	17	5	14	5	4	5	6	8	3	3	3	3	100	17·0
Interstitial pneumonia	23	25	29	24	22	24	18	26	21	30	14	14	12	8	290	49·0
Calcification	21	5	16	5	9	7	3	9	7	12	5	2	3	4	101	17·2
Alveolar hyperplasia	10	5	5	5	11	6	14	11	15	9	7	2	5	0	105	17·9
Alveolar histiocytosis	4	1	5	3	2	4	5	9	6	6	2	2	4	1	54	9·2

*See Table 1 for the identification of groups 1–7.

mucosa and focal inflammation and hyperplasia of the mucosa. The most common change was focal mucosal calcification, the incidence of which was not a function of exposure time; for example, the combined data for male and female hamsters showed the highest incidence in group 3 (150 min/day for 30 days) and the lowest in group 5, which received the longest exposure (150 min/day for 300 days). The incidence of other laryngeal changes were similarly unrelated to treatment. Tracheal changes found in both control and exposed hamsters included focal mucosal calcification, mucosal-gland dilation and focal mucosal inflammation. The most common alteration was focal calcification of the mucosa. No treatment effects were evident in any of the alterations of the trachea; the highest incidence (combined male and female data) of focal mucosal calcification occurred in group 1, which had received the shortest exposure (3 min/day for 30 days), and the incidences in the other treatment groups did not differ much from the incidence of the combined sham-exposed control groups.

Lungs. Pulmonary changes (Table 4) in all groups included interstitial pneumonia, focal alveolar and bronchiolar calcification, focal alveolar emphysema, focal alveolar hyperplasia, focal alveolar histiocytosis and pulmonary vasculitis. Interstitial pneumonia was the most common lesion, the incidence being highest in group 2 and lowest in group 4 and in the sham-exposed controls. The other pulmonary changes also varied among the treatment groups without a consistent incidence pattern that could be related to level or duration of talc exposure. Alveolar and bronchiolar calcification and focal alveolar emphysema, for example, were found most frequently in group 1 and least frequently in group 4 of the treated animals.

Table 5. *Incidence of focal alveolar cell hyperplasia*

Exposure (min/day)	Incidence (%) of lesion in groups exposed for	
	30 days*	300 days*
0	18·0 (group 6)	10·0 (group 7)
3	15·6 (group 1)	—
30	10·1 (group 2)	25·2 (group 4)
150	17·4 (group 3)	25·0 (group 5)

*See Table 1 for the identification of groups 1–7.

The incidence of focal alveolar cell hyperplasia seemed to reflect an effect of treatment, as the highest incidences were found in groups 4 and 5 (Table 5). However, a two-way weighted analysis of variance of the arcsin transformation of the percentage incidence demonstrated that no significant pattern of incidence of focal alveolar cell hyperplasia was associated with the number of exposure days or with the number of exposure minutes per day.

Histological examination, with the aid of a Nomarski system, of a lung section from a randomly selected hamster of group 5 revealed foci of macrophages containing material resembling talc (Fig. 9). The hamster was killed 3·5 months after completion of the 300 days of exposure during which it had received a cumulative exposure of 6000 mg hr/m^3. In a lung section from a randomly selected group 3 hamster, which died during the 30 days of exposure after a cumulative exposure of 420 mg hr/m^3, no talc was observed.

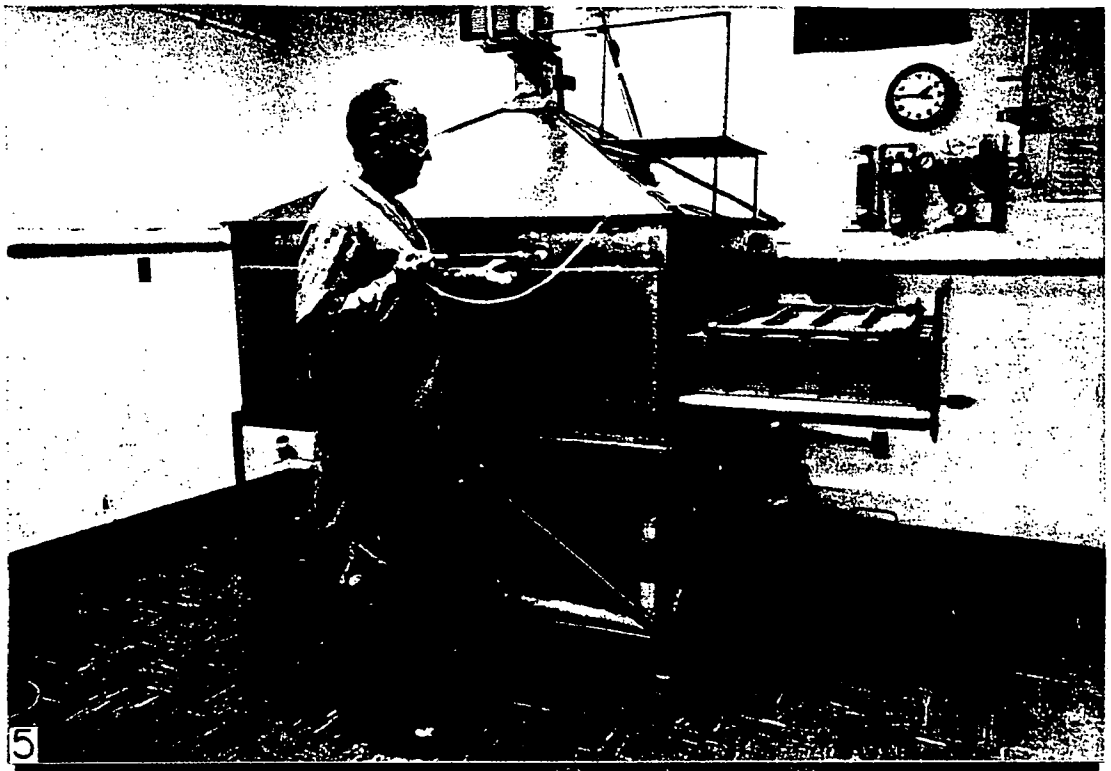
Heart. Common changes in the heart included valvular endocarditis, atrial thrombosis, calcification of the coronary vessels and myocardium and focal myocarditis. The incidence of these alterations did not appear to be related to treatment as no consistent pattern of incidences emerged and the incidence was similar for most of the groups.

Other organs. The incidences of hepatic amyloidosis and 'hepatitis' and of renal amyloidosis and 'nephrosis' were high and were similar for the several treatment groups and for the sham-exposed controls. Changes observed in the stomach included calcification of the mucosal tissues and of the tunica muscularis. No pattern was present to suggest that these alterations were related to the talc exposures. Atrophy of the germinal epithelium was common among the treatment groups, but no pattern consistent with a treatment effect was found. Few changes were found in the uterus, and treatment did not have any apparent effect on the incidence of any of these.

Tumours. Only a few neoplasms (Table 6) were found. They were of several different histological types and their incidence was not related to treatment. No primary neoplasms were found in the respiratory system.

DISCUSSION

The calcification observed in several organs, including the mucosa of the larynx and trachea, alveolar



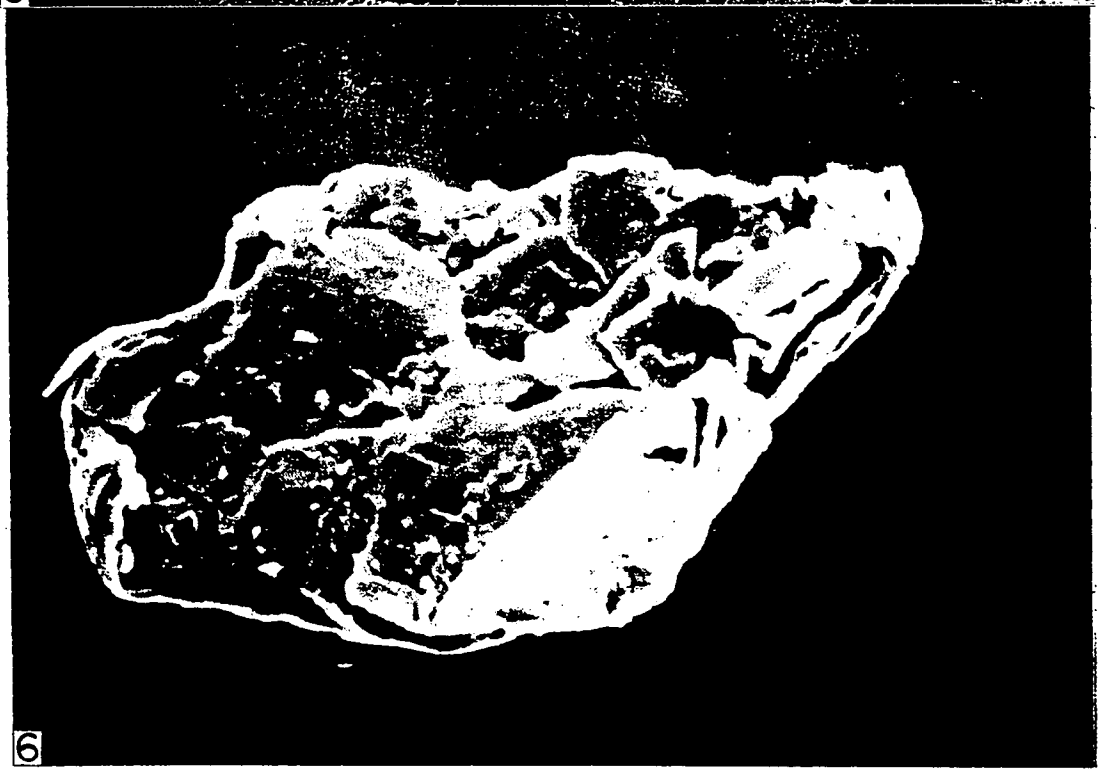


Fig. 5. Aerosol exposure system.

Fig. 6. Scanning electron micrograph of a talc particle. × 1800.

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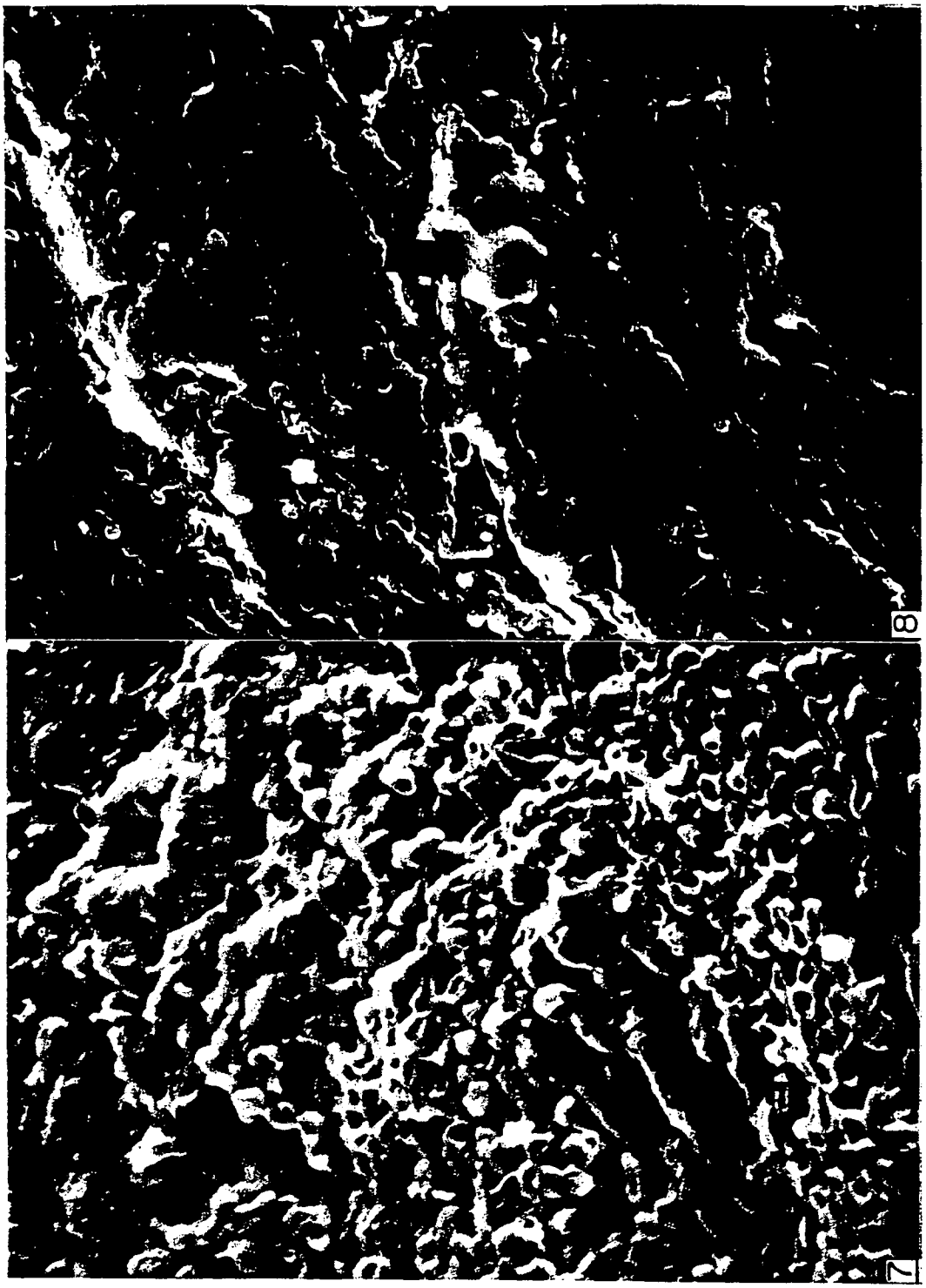

Fig. 7. Scanning electron micrograph of lung tissue. × 1400.

Fig. 8. Scanning electron micrograph of talc particle on lung tissue. × 650.

Fig. 9. Photomicrograph of section of hamster lung in Nomarski illumination, showing a cluster of alveolar macrophages containing particles believed to be talc. The male hamster was killed 3·3 months after completion of the 300-day exposure period, during which it had received a cumulative exposure of 6000 mg hr/m^3. Haematoxylin and eosin × 870.
Fig. 10. Transmission electron micrograph of talc particles. × 8000.

Table 6. *Summary of incidence of spontaneous neoplasms found in control and talc-exposed hamsters*

Site and neoplasm	No. of affected males and females (as specified)* in groups†					Total affected
	1(M)	3(F)	5(F)	6(F)	7(M)	
Adrenal gland						
Adenoma		1			1	2
Phaeochromocytoma		1				1
Uterus						
Leiomyoma			1			1
Unknown site of origin						
Carcinoma					1	1
Lung						
Carcinoma, metastatic	1				1	2
Thorax						
Rhabdomyosarcoma				1		1
Bone						
Osteosarcoma					1	1
Lymph node						
Malignant lymphoma					1	1
Liver						
Osteosarcoma			1			1
Cholangiocarcinoma	1					1
Malignant lymphoma, metastatic					1	1

*No neoplasms occurred in either sex in groups 2 and 4, in the males of groups 3, 5 and 6 or in the females of groups 1 and 7.
†See Table 1 for the identification of groups 1–7.

and bronchiolar walls, myocardium, coronary vessels and the gastric mucosa and muscularis, is a change commonly associated with ageing. Also, the renal and hepatic changes are common findings in old hamsters (Fortner, 1957). The 'nephrosis' could have altered the serum calcium–phosphorus balance to a marked degree and contributed to the soft-tissue calcification.

Some of the cardiac and pulmonary changes were apparently interrelated. It appears likely that valvular endocarditis was contributory to the atrial thrombosis and, by extension, responsible for the inflammatory lesions of the pulmonary vasculature, as well as contributory to the development of interstitial pneumonia. Thrombosis of the chambers of the heart of ageing hamsters has been described by Fortner (1957) and Chesterman (1972).

Amyloidosis is a common change in the ageing hamster and especially common is renal amyloidosis (Fortner, 1957). The stimulation to the immune system by persistent infection, as seen in the heart valves and lungs, could have contributed to the development of the hepatic and renal amyloidosis.

The incidences of the tissue changes associated with ageing varied greatly among the treatment groups and sham controls, and no consistent pattern was discerned to indicate that treatment increased or accentuated these changes.

The hamsters received cumulative exposures ranging from about 15 to more than 6000 mg hr/m^3 (Table 4). Estimates based on results of a pulmonary deposition study with neutron-activated talc show that 0·05–6 μg talc, depending on the length of exposure, was deposited in the hamster lungs at each exposure (Wehner, 1976). Estimates based on infant-dusting experiments show, according to J. N. Sivertson (personal communication, 1976), that the weekly hamster exposures, expressed in mg hr/m^3, exceeded the average of the weekly infant exposures by some 30 to 1700 times (Table 7).

Unknown quantities of talc also passed through the gastro-intestinal tract of the exposed hamsters. This talc comprised quantities deposited on the ciliated surface of the respiratory tract and subsequently brought up by the mucociliary clearance mechanism and swallowed, talc licked from the pelt and swallowed and talc deposited on the feed during exposure. However, there was no evidence of talc-induced lesions in the gastro-intestinal tract. A gavage study with neutron-activated talc is in progress to determine to what degree talc is absorbed during passage through the gastro-intestinal tract.

It is possible that markedly higher exposure levels would have caused talcosis eventually. Quick clearance of the talc particles from the lung could be at least partly responsible for the absence of talc-induced lesions, but this possibility can only be confirmed by

Table 7. *Comparative levels of exposure to talc aerosols in different groups of hamsters*

Hamster group*	Calculated weekly exposure (mg hr/m^3)	Weekly hamster exposure expressed as multiples of weekly infant exposure†	
		50th percentile	Upper 95th percentile
1	2	30	19
2	20	300	190
3	100	1700	950
4	20	300	190
5	100	1700	950

*See Table 1 for the identification of groups 1–7.
†J. N. Sivertson (personal communication 1976).

determining the fate of the talc particles in the hamster. Early efforts to determine pulmonary deposition and clearance using atomic absorption spectrophotometry were unsuccessful because the relatively high and varying tissue background levels of the elements to be analysed interfered with the measurements. A study is now in progress using neutron-activated talc to determine pulmonary deposition and clearance.

The most plausible explanation for the absence of talc-induced lesions in our hamsters appears to lie in the nature of the talc. It was cosmetic-grade talc (Fig. 10), in which no asbestos fibres were found. Industrial-grade talc, by comparison, contains varying and appreciable quantities of other minerals, including asbestos which is a proven fibrogen and carcinogen. Our results, therefore, should not be interpreted as being in disagreement with the findings in workers engaged in such industries as talc mining and milling, rubber-tyre and cable manufacture and battery-plate casting, in which (prior to the initiation of protective measures) the workers were chronically exposed to atmospheric concentrations of talc-mine dust or industrial-grade talc averaging up to several hundred million particles/ft^3 (Kleinfeld *et al.* 1967). Some of the controversy and confusion about talc can be attributed to the loose application of the term 'talc' for widely varying mixtures of components of different pathogenicity.

We recommend, therefore, that (a) the dust mixtures now commonly referred to as talc should be analysed and graded uniformly according to the type and quantity of their components, (b) an appropriate nomenclature should reflect the type or quality of the dust mixture in question, the term 'talc' being reserved for powder consisting of at least 95% (w/w) platey talc and no asbestos with different names (e.g. talcoid) being assigned to the powder categories of lesser purity, and (c) rather than having one threshold limit value (2×10^7 particles/ft^3 at present) for the dust mixtures now collectively referred to as 'talc', different threshold limits should reflect the differences between the adverse biological effects of cosmetic-grade talc and those of different talcoid mixtures containing varying degrees of asbestos and quartz.

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