EXPERIMENTAL BYSSINOSIS

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The symptoms of byssinosis were produced experimentally in one of three cotton-mill workers with pronounced byssinosis, by a dust prepared from the leaves of cotton plants. Dusts of calcium carbonate, bacteria, and fungi did not reproduce the symptoms. Two mild cases of byssinosis and two cases of chronic bronchitis did not react specifically to any of these dusts.

It is generally accepted that the cause of byssinosis lies in the dust in the air of textile mills. Environmental surveys have not provided any evidence to suggest which of the substances composing the dust may be responsible for the disease†. This paper presents the results of the inhalation of cotton-mill dust and some of its constituents upon five men with byssinosis and two with bronchitis.

Cotton dust consists of fragments of cotton fibre and cotton plant, bacteria, fungi, silica, and mineral salts. Of these, bacteria, fungi, and cotton plant leaf were selected for study.

Types of Dust

The following types of dust were used:

(1) *Calcium carbonate*. This was selected for use as a control since it has been shown that prolonged inhalation of pure calcium carbonate has no ill effects (Davis and Nagelschmidt, 1956). It was also used for diluting the powders of bacteria and fungi.

(2) *Bacillus pumilus*. This organism is one of the most common in the air of cotton mills and there is an association between its concentration and the incidence of byssinosis (Tuffnell, 1960). A strain, isolated from a cotton mill, was grown on nutrient agar, suspended in isotonic saline, and lyophilized. The granular powder so produced was finely ground in a mortar and diluted with calcium carbonate to give sufficient bulk to be handled easily in the dust dispersing machine.

(3) *Aspergillus niger*. This organism was the most common single species of fungus found in the air of

cotton mills. A strain recently isolated from cotton dust was grown on peptone-glucose agar until well developed (two weeks), allowed to dry in a 37°C. incubator, and then scraped off the plates. The resulting powder was diluted suitably with calcium carbonate.

(4) *Cotton plant leaf*. A quantity of cotton bolls was obtained from Nigeria. Fragments of leaf and bract were picked off the bolls and pounded with glass beads in a flask shaker until reduced to a fine dust which was then sieved through a 90 mesh sieve.

(5) *Cotton mill dust*. The material in the card-room air extraction plant filters of a mill spinning fine counts of Egyptian cotton was sieved through a 90 mesh sieve.

Cases

Seven males volunteered for the experiments. Two had chronic bronchitis and had never worked in a textile mill. The other five were cotton workers of whom three had been examined by a Pneumoconiosis Medical Panel and were receiving pensions for byssinosis; the remaining two had been diagnosed as cases of mild byssinosis during a field investigation.

Method

Dust Dispersion.—The dusts were dispersed by means of an apparatus consisting of a gauze-covered cylinder driven by an electric clock motor rotating beneath a small reservoir containing powder. A stream of air from a vacuum cleaner flowed across the lower surface of the cylinder into the atmosphere (see Fig.). The dust was discharged at a height of three feet above an electric fan at floor level, into an experimental room of 1,000 cu. ft. capacity.

Estimation of Dust Concentration.—The number of particles between 0.5 and 7.5 μ /ml. of air was estimated with a thermal precipitator. A Hexhlet apparatus was

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† Since this investigation was completed, Roach and Schilling (1960) have described a combined clinical and environmental study which attempts to provide some evidence as to the causal agent of byssinosis.

used to obtain samples which were analysed for nitrogen content. This was fitted with an elutriator which trapped particles of more than 7.1μ diameter and allowed most particles of less than 5μ to pass through (Wright, 1954).

Bacteria.—The concentration of viable bacteria was determined by a slit-sampler using the homogenizing technique described in a previous paper (Tuffnell, 1960).

Experimental Method.—Preliminary trials determined the amount of each dust required to produce concentrations similar to those found in the cotton mills. Measured quantities of the dusts were fed into the dispersing machine at hourly intervals, each sample taking about 10 minutes to disperse.

Samples were taken with the thermal precipitator for a period of 10 minutes in each hour, from 30–40 minutes after dispersal began. Samples with the slit sampler were taken for a period of half an hour commencing 15 minutes after dispersal began. Details of the mean dust concentrations, to which each subject was exposed, are shown in the Table below.

Case No.	Particles per ml. (Thermal Precipitator)			Viable Organisms per cubic foot (slit sampler)	
	CaCO ₃	Leaf	Mill Dust	<i>B. pumilus</i>	<i>A. niger</i>
1	434	269	179	3,050	350
2 and 3	377	451	249	1,510	2,360
4 and 5	689	299	—	12,700*	7,300
				7,400	
6 and 7	943	517 507*	413	2,390	3,750

* Two separate occasions.

As was to be expected there was no detectable nitrogen in the samples containing organisms. There was, however, an appreciable amount in the leaf and mill dust.

The experimental subjects were exposed to each dust for four hours, two hours in the morning and two in the afternoon with a one-hour interval between. Before and after each two-hour session the Maximum Breathing Capacity (M.B.C.) was estimated for each subject with a modified Gaensler apparatus (Gaensler, 1951). They did not exercise during the experiments.

Case Results

Case 1.—A retired blow-room worker, 61 years of age, was in receipt of 30% disability pension. Exposure to calcium carbonate produced no subjective or objective

reaction. The dust containing *Bacillus pumilus* and that containing *Aspergillus niger* produced no subjective effect, but with each dust there was a slight reduction in the M.B.C. Leaf dust produced a pronounced reduction in the M.B.C. and a subjective reaction that was similar to, but rather worse than, that he experienced while working on a Monday in the cotton mill. A similar effect was produced by inhaling the preparation of mill dust. Details are set out below:

Dust	M.B.C. (l./min.)			
	9.30 a.m.	12 noon	1.30 p.m.	4 p.m.
Calcium carbonate	54	59	—	55
<i>B. pumilus</i>	67	60	61	53
<i>A. niger</i>	72	62	69	55
Leaf	71	51	47	39
Mill dust	65	48	45	32

Cases 2 and 3.—Both these men were cardroom workers; Case 2 was 36 years of age and Case 3, 35 years. They had been diagnosed as mild cases of byssinosis during a field investigation. Neither developed any subjective or objective reaction to any of the dusts used in the experiment. Subsequently they were seen in the mill in which they worked, a dusty one, at the end of a normal working Monday. Their M.B.C.s were found to be similar to the values recorded at the same time of day during the experimental period. Neither man was breathless either objectively or subjectively, their only complaint being dryness of the throat. It would seem either that these two workers were not suffering from byssinosis or that the disease was in a very early stage. Details for Case 2 are set out below:

Dust	M.B.C. (l./min.)			
	9.30 a.m.	12 noon	1.30 p.m.	4 p.m.
Calcium carbonate	141	135	137	135
<i>B. pumilus</i>	140	135	138	138
<i>A. niger</i>	135	139	139	132
Leaf	127	129	125	131
Mill dust	139	136	130	130

Details for Case 3 are set out below:

Dust	M.B.C. (l./min.)			
	9.30 a.m.	12 noon	1.30 p.m.	4 p.m.
Calcium carbonate	144	138	138	144
<i>B. pumilus</i>	153	147	147	145
<i>A. niger</i>	148	147	147	148
Leaf	142	146	147	143
Mill dust	150	150	152	148

Case 4.—A cardroom worker, 60 years of age, was receiving a 40% disability pension for byssinosis. The disease was of moderate degree, less severe than Case 1. After exposure to dusts of calcium carbonate, *B. pumilus* and *A. niger* he complained of dryness of the throat, slight cough, and increased sputum, but there was no significant fall in the M.B.C. Exposure to leaf dust produced a fall in the M.B.C. which, however, was not accompanied by any subjective effect.

Dust	M.B.C. (l./min.)			
	9.30 a.m.	12 noon	1.30 p.m.	4 p.m.
Calcium carbonate	88	87	93	86
<i>B. pumilus</i>	92	85	91	87
<i>B. pumilus</i>	85	80	86	80
<i>A. niger</i>	88	87	85	85
Leaf	88	79	86	75

Case 5.—This man, 50 years of age, suffered from chronic bronchitis; he had never worked in a textile mill. All the dusts produced an increase in cough and sputum and some dryness of the throat. The M.B.C. showed a change of similar degree with each dust.

Dust	M.B.C. (l./min.)			
	9.30 a.m.	12 noon	1.30 p.m.	4 p.m.
Calcium carbonate	65	64	62	60
<i>B. pumilus</i>	65	56	55	52
<i>B. pumilus</i>	59	53	52	51
<i>A. niger</i>	60	—	56	52
Leaf	59	57	56	55

Case 6.—A retired cardroom worker, 67 years of age, received a 50% disability pension for byssinosis. He had no symptoms after exposure to any of the dusts except some feeling of dryness of the throat. The M.B.C. was reduced after exposure to the leaf dust (on two occasions) and after exposure to the mill dust.

Dust	M.B.C. (l./min.)			
	9.30 a.m.	12 noon	1.30 p.m.	4 p.m.
Calcium carbonate	67	63	70	75
<i>B. pumilus</i>	73	72	71	71
<i>A. niger</i>	73	72	75	71
Leaf	75	69	71	64
Leaf	75	71	72	67
Mill dust	72	69	68	67

Case 7.—This man, 49 years of age, suffered from chronic bronchitis and had never worked in a textile mill. All the dusts produced an increase in cough and sputum and similar, but not marked, changes in the M.B.C.

Dust	M.B.C. (l./min.)			
	9.30 a.m.	12 noon	1.30 p.m.	4 p.m.
Calcium carbonate	79	75	73	72
<i>B. pumilus</i>	78	83	79	76
<i>A. niger</i>	73	76	83	75
Leaf	71	76	75	68
Mill dust	71	71	74	67

Discussion

From the results obtained with Case 1 it seemed that it might be possible to reproduce, under experimental conditions, a type of reaction which resembled byssinosis. This man's reaction to leaf and mill dust was pronounced and exactly resembled his symptoms when working in the blowing room. It appeared to be specific in view of the absence of reaction to the other dusts. Unfortunately such

clear cut results did not follow with any of the other cases of byssinosis.

Cases 2 and 3, in whom mild byssinosis had previously been diagnosed, had no detectable reaction either symptomatic or in the M.B.C. The absence of any significant symptoms or abnormal M.B.C.'s in these two cases after an ordinary working Monday makes it reasonable to presume that they were very mild cases of byssinosis and only developed symptoms under extreme conditions.

Cases 4 and 6 both had moderately severe byssinosis and were in receipt of disability pensions. The reaction to leaf dust by Case 4 and to leaf and mill dust by Case 6 differed from their reaction to the other dusts only in respect of the reduction in the M.B.C. Neither experienced any symptoms which resembled byssinosis.

The two subjects with chronic bronchitis reacted, to a slight and similar extent, to each of the dusts, with increased cough and sputum and a slight fall in the M.B.C. There was no evidence of any specific reaction in either case.

There are several possible explanations for the inability to reproduce the symptoms of byssinosis experimentally in two of the three subjects with pronounced byssinosis. Though the concentration of dust was similar to that found in cotton mill cardrooms, working conditions were not simulated, for the subjects were exposed to the dust for only four hours and they were not exercising. Increased pulmonary ventilation for a longer period may be necessary to produce symptoms in some cases of byssinosis. Also, the dusts were prepared at one time so that they were several months old when used for the later subjects. It is possible that a freshly fractured leaf fragment may be active and that oxidation reduces the activity.

The occurrence of byssinosis in textile mills other than cotton, and also in the waste cotton industry, suggests either that byssinosis may be a pulmonary reaction to a variety of substances, or that there is a common substance causing the disease.

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