INDUSTRIAL DUST

Hygienic Significance, Measurement and Control

BY

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CHAPTER II

EFFECTS OF DUSTS AND FUMES UPON MAN

Exposure to dusts can produce four distinct types of disability: (1) the pneumoconioses, such as silicosis and asbestosis, are caused only by dust inhalation; (2) toxic dusts like lead, manganese, and cadmium can produce their effect as the result of

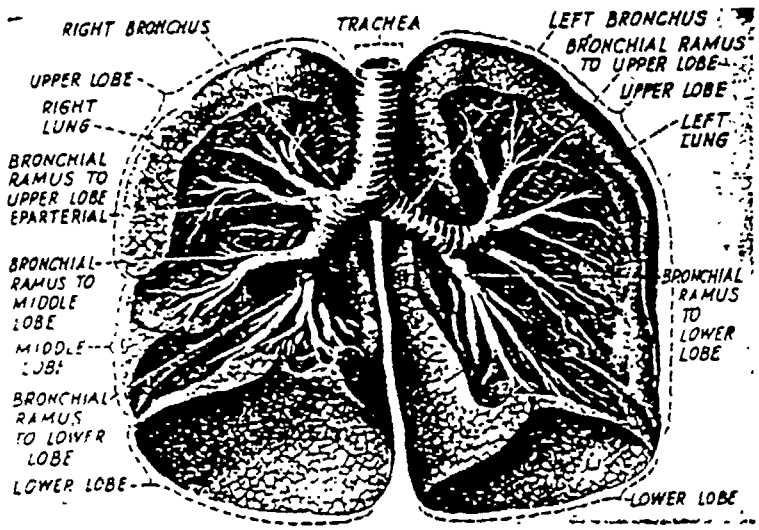

FIG. 10.—Lungs, bronchi, and trachea. (*After Sobotta and McMurrich.*)

either breathing or swallowing dust; (3) metal-fume fever is a temporary malady resulting from inhaling certain metallic oxide fumes; and (4) the allergic reaction or protein poisoning, as typified by hay fever, is the direct result of breathing pollen and other organic substances. In all four cases dust inhalation may be the sole cause of disability; only in the case of toxic dusts is there another mode of entrance.

Respiration and Dust Inhalation. The lungs are nonsymmetrical bilateral structures encased in a rather elastic cavity,

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TABLE 1.—OXYGEN CO

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Walking 2 m.p.h	
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Maximum exertio	

* After Henderson and Hac

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the chest, and they communicate with the nose and mouth through the trachea or windpipe. The left lung has two divisions or lobes and the right lung has three; the right lung is about 12 per cent larger than the left.

In the normal adult, the trachea is a tube some 1 to 2 cm. in diameter and 10 cm. long (Fig. 10); it is fortified with ringlike cartilage which gives it a strong and inelastic character. At the approximate level of the fourth rib, the trachea branches into the bronchi and these in turn subdivide into bronchioles which lead to the terminal air sacs or alveoli. It is in the alveoli that, as result of inspiration and expiration, gas exchange between blood and air takes place. Oxygen is taken up by the red blood cells and carbon dioxide is given off.

The amount of air breathed and the oxygen consumed vary with the task performed and with the individual's size. The rates at which an athletic man of 150 lb. breathes are shown in Table 1.

TABLE 1.—OXYGEN CONSUMPTION AND VOLUME OF BREATHING BY MAN[1]

	Oxygen consumed at 0°C. and 760 mm. pressure, liters per minute	Air breathed at 20°C., liters per minute
Resting in bed	0.24	6
Sitting	0 30	7
Standing	0 36	8
Walking 2 m.p.h	0 65	14
Walking 4 m.p.h	1.20	26
Slow run	2.00	43
Maximum exertion	3 00–4 00	65–100

[1] After Henderson and Haggard (125).

The ordinary individual seldom breathes more than 50 liters per minute, the high rates being limited to trained athletes, such as long-distance runners.

The inspiratory and expiratory phases are not exactly alike, but practically we may consider each as taking half the time required for a complete respiratory cycle and we can ignore the pauses that occur at the beginning and end of each inspiration. Thus with minute volume of 50 liters the actual inspiration is at the rate of 100 liters per minute and momentarily rather high

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DUST

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man, Table 2S).

OF SPUTUM

nasal discharge of persons
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The dust in phagocytic cells from human sputum was studied by Drinker (65), who was able to identify several minerals in the cells and to establish figures of average particle size in phagocytes. In order to examine dust in phagocytes, the sputum sample must be fixed when fresh, and it is best to make several slides, some stained and some unstained. Stains interfere seriously with the microscopy of the particles but help one to pick out the dust cells from extraneous matter. Aging of the sputum results in bacterial action upon the cells which destroys their outline, and must be avoided.[1]

The cells from silicotics (coal miners) which we have seen recently contained a great percentage of carbon and little else. Since there is little difficulty in getting such cells from patients with silicosis or with a history of recent dust exposure, more such examinations might easily and profitably be made.

It should be borne in mind that the presence of dust cells in human sputum does not of itself prove any lung pathology. This may be a normal finding and often occurs in the healthy city dweller, particularly if he is a smoker. But in the case of the individual with proved dust exposure, the presence of numerous dust cells in sputum may help in diagnoses.

THE IDENTIFICATION OF ASBESTOSIS BODIES

For the identification of the "curious" bodies (see Fig. 15, page 33) found in asbestos workers, Stewart (223) employs the following technique:

About half an ounce of sputum is dissolved in an equal quantity of undiluted antiformin in a wide test tube. This takes from a few minutes to an hour or so, and is aided by heat (37°C. incubator) and gentle agitation. Two or three ounces of water are then added and the mixture allowed to stand for a few hours or overnight. The bulk of the supernatant fluid is now poured off and the remaining 12 to 15 cc. centrifuged at moderate speed for 10 min. The amount of deposit which comes down varies in different specimens, but in any case the whole of the supernatant fluid may be poured off by simply inverting the centrifuge tube. The deposit and the trace of fluid which remain are thoroughly

[1] It is assumed that any person examining the dust particles in sputum or in nasal discharge will familiarize himself with the accepted routine of sputum examinations as carried out in ordinary medical diagnoses. He need observe only the methods of preparing the specimens and need not be concerned with bacteriological or pathological matters.

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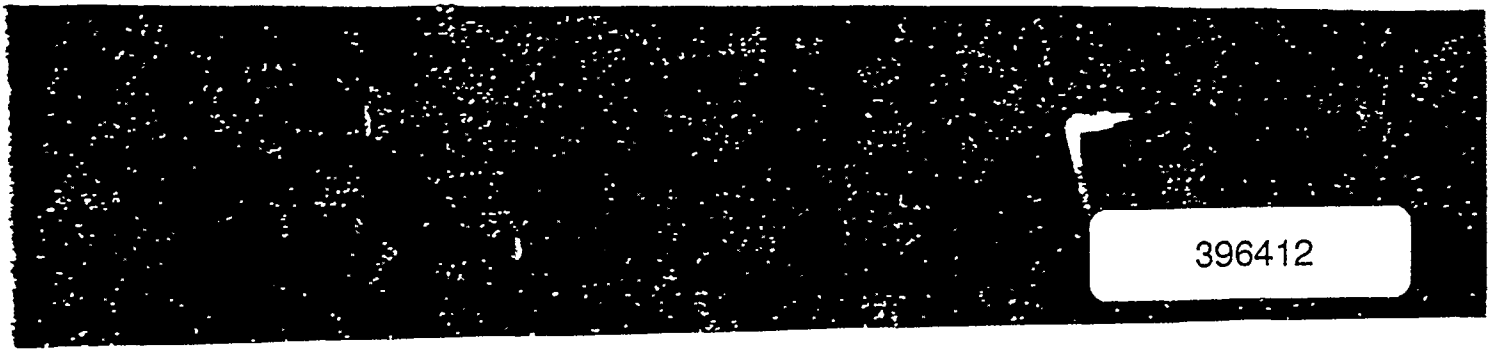

mixed by means of a fine pipette and transferred to an albuminized slide or slides. Too much force must not be used in the mixing process or at any previous stage in order not to disintegrate any *clumps of* asbestos bodies which may be present. As a rule the whole deposit from half an ounce of sputum may be spread over an area of 1 sq. in. of a microscope slide, or less, and in any case a thick film is desirable. After thorough drying on a hot plate and final fixation over a Bunsen, the film is very gently washed in water, dried and mounted in Canada balsam. The washing in water must be done with the greatest care, as, in spite of the albuminization of the slide, the film is very easily detached, especially if it is thick.

After washing and drying, the film may be treated with ferrocyanide of potassium and hydrochloric acid to demonstrate the Prussian blue reaction given by the bodies. It is then dried and mounted in balsam as before. Alternatively the centrifuged deposit may be covered with a small quantity of a 5 per cent solution of ammonium sulfide, when the bodies are colored black. No special staining is required, however, as the natural greenish yellow, golden, or brown color of the bodies renders them sufficiently conspicuous even under the low power. My practice is to examine films with the ⅙-in. objective and 10× ocular, confirming the presence of asbestos bodies with the ⅙-in. objective.

It is necessary to cleanse thoroughly all test tubes, centrifuge tubes, and pipettes after use; otherwise there is a risk of contamination of subsequent specimens from a positive sputum.

Asbestos bodies are demonstrable by this method in the great majority of asbestos workers provided they have any expectoration. In the older workers, especially during a bronchitic attack and in the later stages of pulmonary asbestosis, bodies are present in profusion, but, even in those who have only been engaged in the industry for a year or two, they may be demonstrable in small numbers. Their presence indicates merely that asbestos dust has been inhaled into the lung and that it has remained there long enough for "bodies" to form around individual fibers, a period of months at least. It does not necessarily mean that there is pulmonary fibrosis. The finding of radially arranged *clumps* of bodies similar to those demonstrable histologically within the lung alveoli has much more serious significance. It indicates disintegration of living tissue, either by suppurative bronchopneumonia or by tuberculous caseation, and may be taken also as presumptive evidence of an underlying asbestosis.

Bodies somewhat similar to asbestos bodies but much coarser and more irregular have been recovered from the lungs of coal miners who had never worked in asbestos. The morphological differences are so great, however, that there is little or no risk of confusion.

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