THE PHYSIOLOGICAL RESPONSE OF THE PERITONEAL TISSUE TO DUSTS INTRODUCED AS FOREIGN BODIES [1]

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The physiological response of the body tissues to dusts of various kinds has been a subject of much interest in the past few years, and the opinion that the injury due to dust is chemical rather than physical in action has recently gained greater ground. Mavrogordato, Gardner, Gye, and others have conducted experiments on the action of inhaled dusts. Kettle (*1*, *2*)[2] has studied the response to dusts injected into the subcutaneous tissues and intratracheally, and Policard (*3*, *4*) has used the cornea and conjunctiva in his recent studies. In 1924, experiments were begun at the Pittsburgh station of the United States Bureau of Mines to determine the action and fate of various dusts when injected into the peritoneal cavity of guinea pigs (*5*). The conclusions reached at that time were that live animal tissue in all parts of the body tends to react in essentially the same manner to foreign bodies and that fibrous tissue is formed in the peritoneal cavity by quartz and is not formed by limestone and coal. This paper reports a continuation and elaboration of these earlier studies.

Owing to the length of time required to obtain a reaction by inhalation methods and the desirability of determining the harmfulness of a dust in a relatively short time, other methods of introducing the dusts to be studied were considered. Injection into the peritoneal cavity seemed to give the most promise, because of the relatively circumscribed area of the cavity, the ease in controlling the amount of the dose, and the preservation of the sterility of the material introduced—a factor to be considered in inhalation and intratracheal methods. Mortality following intraperitoneal injection from peritonitis or peritoneal damage was found to be negligible. Identical reactions were found in each animal injected with the same dust under the same conditions and examined at the same time interval after injection. (Animals in groups of from 5 to 20 were used for each set of test conditions.) Therefore the fact that the reaction to the dust involves both epithelial and connective tissue is of no disadvantage.

The reaction is essentially the same microscopically as that produced in the lungs, and the gross appearance of the dust nodules is sufficiently differentiated to afford a means of classifying the physiological response to the dusts. In the series studied here, there were three types of reaction; namely, an absorption or dissolution of the

[1] From the Office of Industrial Hygiene and Sanitation.

[2] Italic figures indicate references cited.

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dust, a proliferative reaction, and an inert reaction. In the inert reaction the dust neither caused an increase in the size of the nodules nor disappeared from the tissues; instead there was more or less a change in its distribution in the peritoneum. These reactions will be discussed more fully under the different groups of dusts.

PREPARATION OF THE DUSTS FOR INJECTION

It was desirable for the particle size of each dust in the series to conform as closely as possible to that of the other dusts used, and also to be as small as possible without a change in the physical or chemical composition. Particles passed through 100-, 200-, and 325-mesh standard sieves were used in one series of tests with several dusts.

The 325-mesh size was found to be the most suitable, because of the greater facility with which a reaction is produced. The particles obtained by passing a dust through a 325-mesh sieve were less than 43 microns in size.

In a later series, a Roller type air separator (*6*) was used. This method of elutriation did not separate all the dusts in the series into fractions of the same size; yet it did produce, with one exception, samples less than 5 microns in maximum measurement. The exception, soapstone, measured 8 microns as a maximum particle size. The median size of the dusts used in this series varied from 0.75 to 1.7 microns, with soapstone at 3.5 microns. Such small variations in particle size appeared to be of no importance in comparing the physiological responses produced by the dusts. It can be readily seen that the air-separated particles more closely approximate those inhaled under industrial conditions (*7*). While the smaller particles were preferable, because of their greater assimilation by the cells, the particles that had been passed through a 325-mesh sieve gave the same gross reactions and, in the case of all dusts mentioned in this study, can be used in place of the more difficultly obtained smaller particles. Water separation was not attempted, because of the possibility of removing soluble portions of the dusts and thus producing a change in their chemical composition.

TECHNIQUE OF INTRAPERITONEAL INJECTIONS

A weighed portion of the dust and a few glass beads to facilitate suspension were placed in a small wide mouthed flask and sterilized in a hot-air oven for 1 hour at 150° C. After cooling, sufficient sterile physiological saline solution to make a 10 percent suspension was added, the bottle was closed with a sterile rubber stopper, and the whole was thoroughly shaken. Owing to the fact that a suspension of fine dust causes a locking of the plunger of a hypodermic syringe, air-bulb syringes of 3-cc capacity were used. Any small hypodermic

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syringe, fitted with a rubber bulb in place of the plunger, will serve the purpose. Needles of 21- or 24-gage were found most suitable for the injections. The needles and syringes were sterilized in boiling water before use.

The hair on the right side of the animal's abdominal wall was clipped and tincture of iodine was applied. For injection, 2 cc of the 10 percent suspension, equivalent to 0.2 g of dust, was introduced, intraperitoneally, into each pig at the iodine-painted site. As the needle was withdrawn, a very small quantity, about 2 drops, was injected into the subcutaneous tissue, to serve as a marker of the site of injection. This marker made it possible to observe whether any trauma was produced by the introduction of the needle into the peritoneal cavity and its effect on the reaction instituted by the dust.

Certain groups of animals were injected with air-separated material and other groups with 325-mesh material. The former were killed and examined 7, 14, 30, 56, and 90 days after injection; the latter at the same intervals and also at 112 days.

DISTRIBUTION OF THE DUST IN THE PERITONEAL CAVITY

With the exception of bituminous coal, the greater part of each of the dusts in this series was found in the peritoneum of the anterior abdominal wall, the most dependent portion of the peritoneal cavity. The site of the next largest collection was the omentum. Small nodules and dispersed collections of particles were also found in the inguinal canals, on the mesentery, liver, intestines, testes or uterus, and diaphragm. A very little was occasionally found on the posterior abdominal wall. In the case of bituminous coal, the greater portion was found in the omentum and mesentery, while a relatively small part was present on the anterior abdominal wall. As a basis of comparison (in describing the reactions caused by the dusts), the nodules formed on the anterior abdominal wall were used, since they were more accessible and were more constant and uniform in appearance. The response in the omentum or at any other point in the peritoneal cavity was, however, the same as that found on the anterior abdominal wall. Nodules were only infrequently found in the peritoneum at the site of the entrance of the needle—so rarely, in fact, that it was safe to assume that the trauma produced by the introduction of the needle was negligible.

ADHESIONS IN THE PERITONEAL CAVITY

Adhesions between the various abdominal viscera and the anterior abdominal wall or omentum were at first thought to be of some significance. However, it was noted that while the presence of adhesions was more frequent when dusts of a high silica content were used

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[4] A high grade Pennsylvan
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and correspondingly less frequent with such dusts as calcite and limestone, they were not of sufficient constancy to be used to draw any definite conclusions as to the activity of the dust. Adhesions were formed occasionally by calcite and by limestones of a very low silica content. They were likewise present to a marked degree in the animals injected with cement; yet subsequent observations showed that these dusts decreased appreciably in amount in the tissues as the tests progressed. It was concluded that the formation of adhesions was a result of the initial foreign body injury caused by the dust in the peritoneal cavity. Various attempts to alleviate this initial stage of irritation were tried without success. It can be readily seen that, while such a simple response as the formation of peritoneal adhesions would be of value in interpreting the activity of the dusts, the occurrence is of such irregularity and the factors involved in their formation depend so much on chance that their presence is of no particular importance.

THE PERITONEAL RESPONSE TO THE VARIOUS DUSTS

Calcite.[3]—Calcite, after being injected into the peritoneal cavity, formed nodules which were irregular, more or less discrete, but often clumped. A small amount of congestion and oedema was noted about the edges of the nodules in the early stages, but this had subsided before the end of 30 days after injection. This congestion and oedema were evidently due to the initial foreign body injury instituted by the dusts. The nodules became progressively smaller in size as the interval between injection and examination increased, and this decrease in size was accompanied by the production of brown pigment particles, which were first noted at the edges of the nodules, and later covered their entire surfaces and diffused into the adjacent peritoneum. The original dust eventually disappeared, leaving a small area of fine, brown pigment particles at the site of the nodule. These, in turn, soon disappeared without the formation of scar tissue. This type of reaction, namely the disappearance of the dust from the peritoneal cavity, has been designated, for the sake of description, as one of absorption.

Limestone.[4]—Limestone caused a reaction similar to that of calcite, one of absorption. The rate in which the dust disappeared from the tissues was much slower than in the case of the purer Iceland spar; yet there was such a marked decrease in the amount of dust found in 90 and 112 days after injection that it can be safely assumed that all of the dust will eventually disappear. The initial foreign body

[3] Pure Iceland spar. Chemical analysis: Calcium carbonate, 99.8; silica, 0.1 percent. Median size of the particles, 1.4 microns.

[4] A high grade Pennsylvania limestone. Chemical analysis: Calcium oxide, 54.4; magnesium oxide, 0.4; iron and aluminum oxides, 0.4; silica, 1.5 percent. Petrographic examination showed granular, irregularly rounded calcite. Median size of the particles, 1.45 microns.

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irritation and the production of the brown pigment and its disappearance from the peritoneum without the formation of scar tissue was identical with the process produced by calcite.

Precipitated calcium carbonate.[5]—Precipitated calcium carbonate prodnced a tissue response very much like that of calcite and limestone. The formation of the nodules was identical in character, and the original dust disappeared in about the same length of time as in the case of calcite; yet more brown pigmentation was produced, which lingered in the tissues for a longer time than did that formed by the calcite. This increased production of pigment might be attributed to the fact that the dust was in a state more easily assimilated by the cells. The pigment particles were much smaller in size and much greater in number than those produced by either calcite or limestone. No evidence of scar tissue formation was noted in any of the animals examined. The reaction was clearly one of absorption.

Gypsum.[6]—Gypsum eventually produced a response similar to that of calcite. In the early stages the dust appeared to lie inertly in the peritoneum without any appreciable change. By the end of 30 days a slight decrease in the amount of dust was noted, and by 90 days this decrease was marked. The color of the nodules became progressively darker as the interval between injection and examination increased, but the production of brown pigment, noted in the other three dusts, was absent. Fine, dispersed dust particles, more or less isolated, were noted in the peritoneum. These may have been the remains of nodules or else particles disseminated by phagocytes. The diminution in the size of the nodules and the disappearance of the dust from the tissues were not as rapid as in the case of calcite, limestone, and precipitated calcium carbonate; yet this response was sufficiently marked to designate the reaction as one of absorption.

Portland cement.[7]—Portland cement produced a reaction slightly different from that caused by calcite, limestone, precipitated calcium carbonate, and gypsum; yet the ultimate outcome appeared to be one of absorption. The initial foreign-body irritation was quite severe—so marked, in fact, that 16 of 36 guinea pigs injected with this dust died during the tests. This was probably due to the chemical properties of the cement. The animals that survived showed extensive peritoneal congestion and oedema in the early stages. After this reaction had subsided, the dust decreased in quantity, with the formation of a light brown pigment, similar to that produced by calcite,

[5] A chemical by-product. Chemical analysis: Calcium carbonate, 97.9; magnesium carbonate, 10.0; magnesium oxide, 0.1; iron and aluminum oxides, 0.6; silica, 0.4 percent. Median size of the particles, 1.28 microns.

[6] The uncalcined, natural mineral. Petrographic examination showed approximately 30 percent as calcite in the form of rounded granules and irregular rhomboidal crystals and approximately 70 percent as fragmented particles of gypsum. Median size of the particles 1.3 microns.

[7] Petrographic examination showed normal portland cement. The particles were sharp and angular. Median size of the particles, 1.05 microns.

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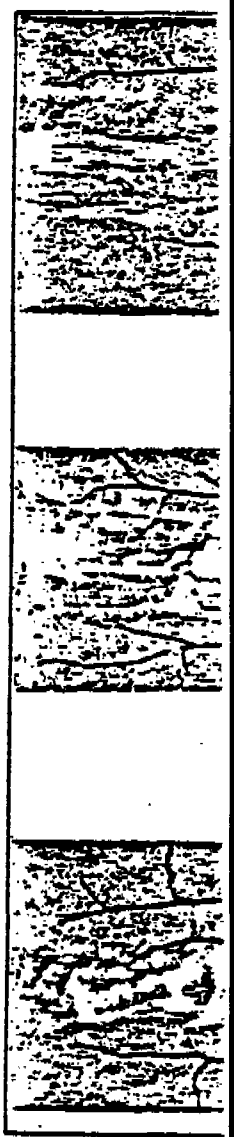
PLATE I



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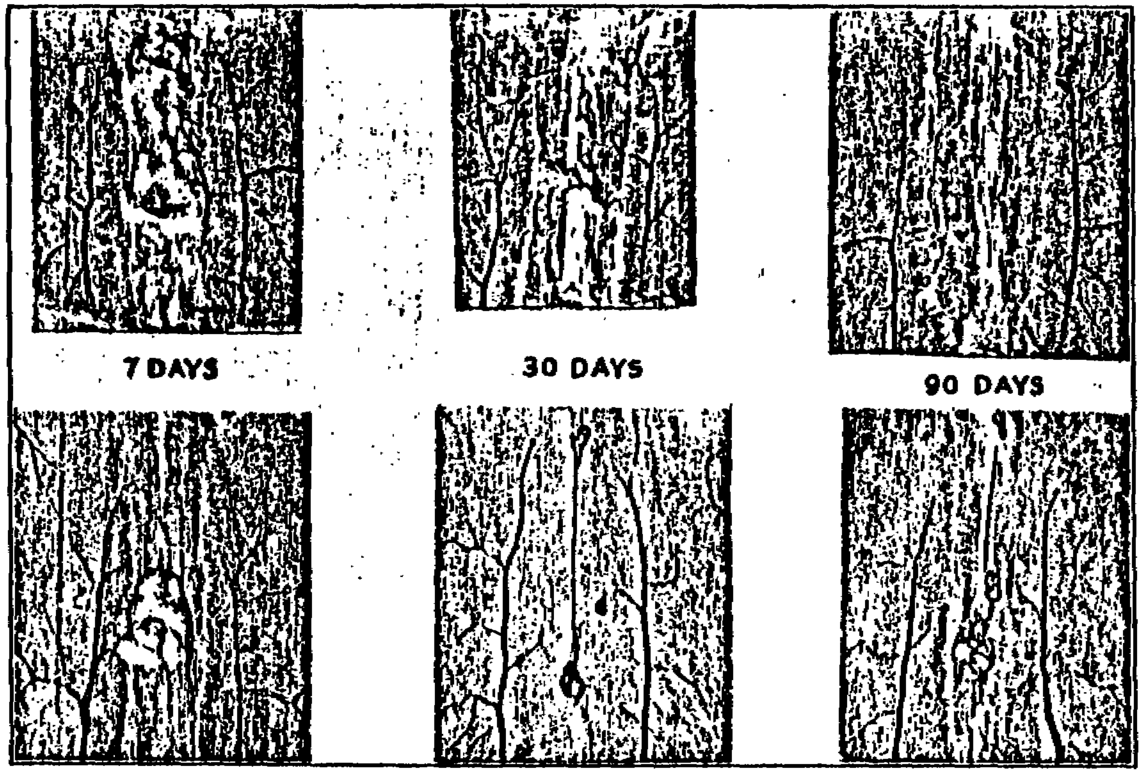

Above, calcite; below, limestone. Appearance of nodules on anterior abdominal wall 7, 30, and 90 days after injection.

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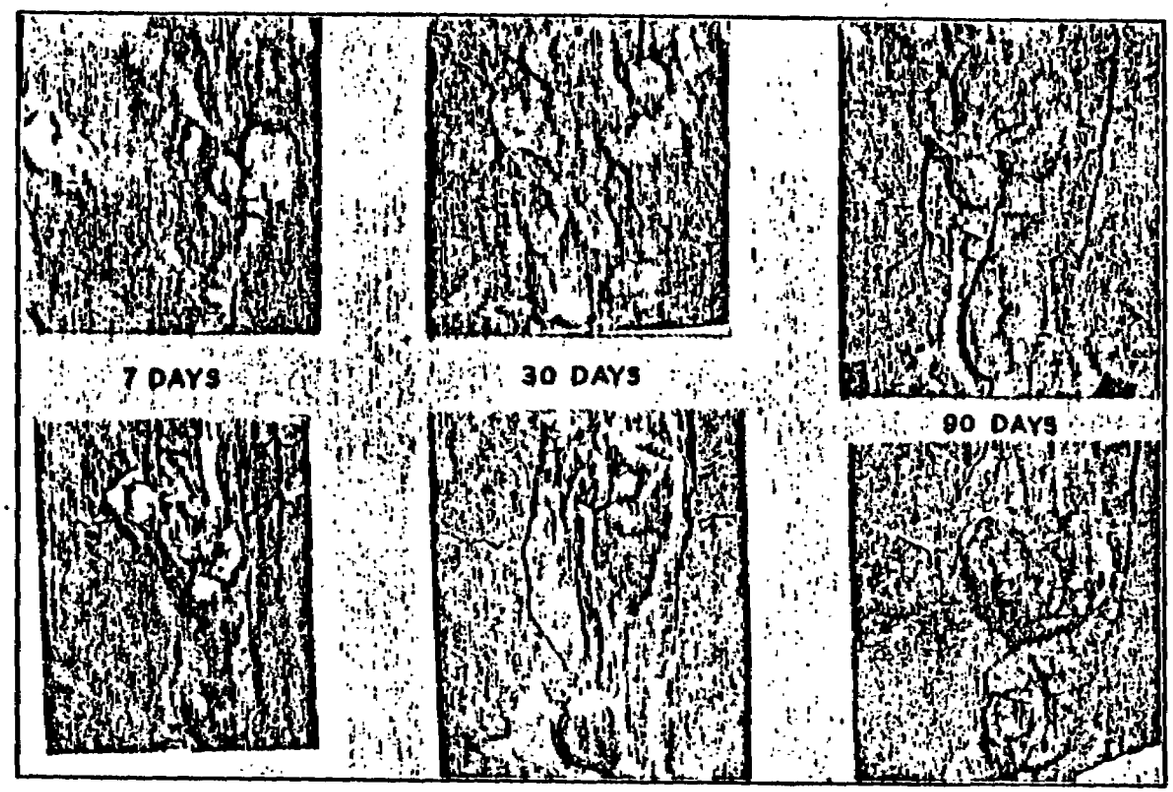

Above, first; below, etc. Appearance of nodules on anterior abdominal wall 7, 30, and 90 days after injection.

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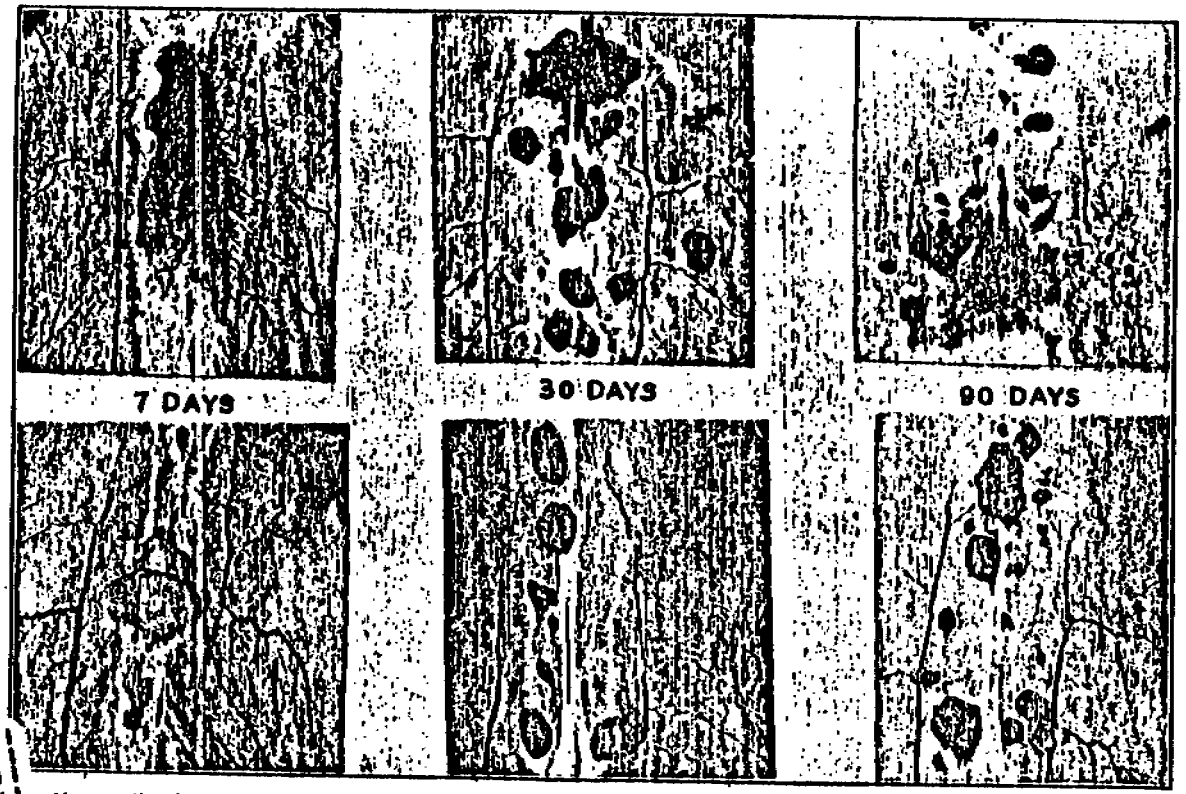

Above, anthracite coal; below, jewelers' rouge. Appearance of nodules on anterior abdominal wall 7, 30, and 90 days after injection.

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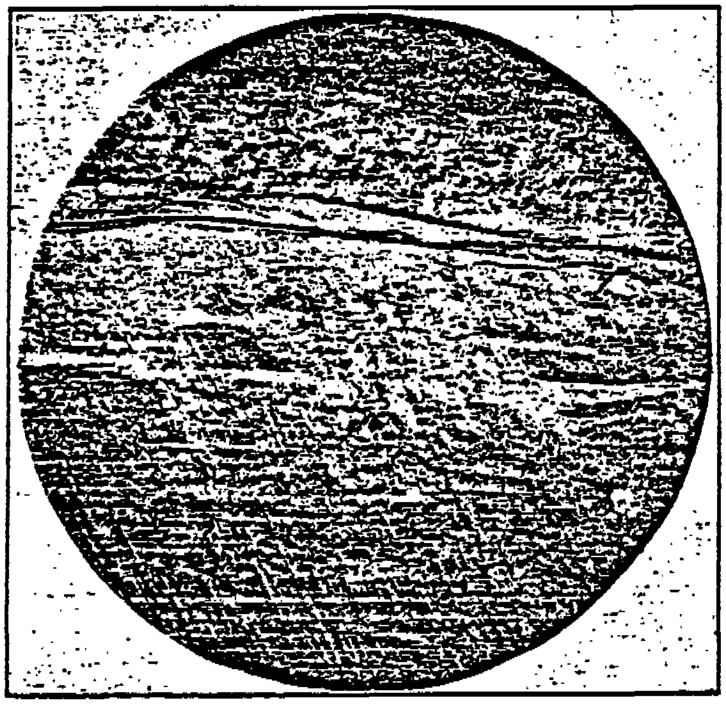
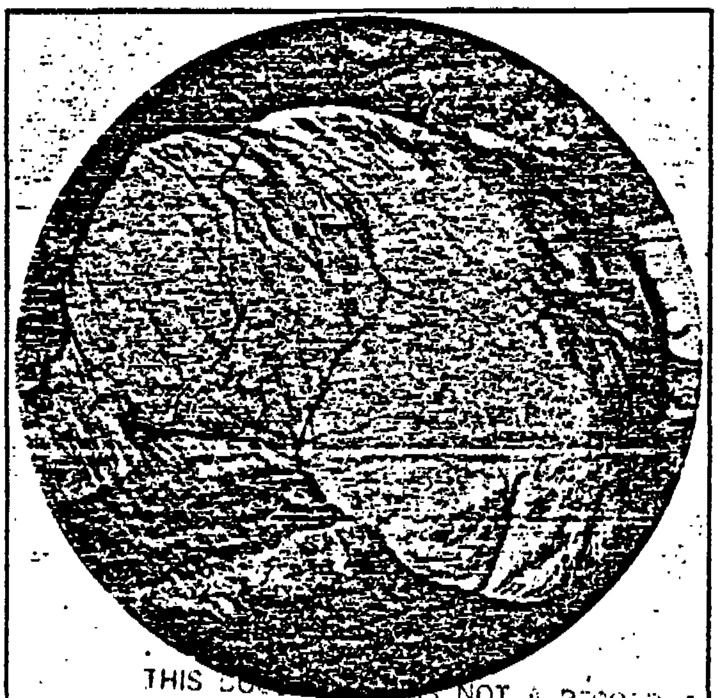
PLATE IV



Oakite, 90 days after injection. Note fine, brown pigment granules in the peritoneum. These are all that remain of the nodule.



Quartz nodule, 90 days after injection.

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limestone, and precipitated calcium carbonate. At the end of 90 days after injection a large amount of this pigment was still present in the peritoneum. Experiments to determine whether this pigment will eventually disappear are now in progress.

Quartz.[8]—Quartz, after an initial stage of foreign-body irritation, manifested by oedema and congestion about the collections of the dust in the peritoneum, produced nodules which progressively increased in size. These nodules, when occurring in clumps, fused together, forming a single large mass. Numerous capillaries were present on the surfaces and throughout the nodules. The appearance was that of cellular proliferation and was apparently due to the chemical irritation supplied by the solution of the silica in the tissue and presumably will continue as long as any silica remains. Whether these nodules disappear with or without the formation of scar tissue is now being determined; but, inasmuch as the majority of cells found in the tumor masses were macrophages, fibroblasts, and fibrous tissue cells, it seems likely that scar tissue will be the logical result. This type of reaction, for convenience of description, will be referred to as one of proliferation.

Chat.[9]—Chat caused a reaction similar to that of quartz though the nodules produced by the action of the dust were much larger in size than those formed by the more pure rock crystal. The nodules found 90 and 112 days after injection were markedly larger in size than those noted in 7 days. The color of the nodules, which was the same as that of the dust introduced, remained constant throughout the duration of the tests. The reaction produced by chat was decidedly one of tissue proliferation.

Flint.[10]—Flint caused the formation of nodules identical in appearance to those produced by quartz. They were, however, somewhat smaller in size than those produced by chat in the same intervals of time. The response to this dust was clearly one of proliferation.

Soapstone.[11]—Soapstone produced the same type of reaction in the first 2 weeks after injection that was noted in all of the other dusts; namely, an initial foreign body irritation. This early fixation reaction was not severe and subsided quite rapidly. As the time between injection and autopsy increased, the nodules, at first raised and rounded, became flattened and spreading. The edges became irregular, and numerous fine dust particles were noted in the peritoneum

[8] Ground rock crystal of high purity. Chemical analysis showed 99.4 percent silica. Petrographic examination showed clear, crystalline, normal quartz. Median size of the particles, 1.7 microns.

[9] The waste product from the concentration of lead and zinc ores. Chemical analysis showed 76.1 percent silica. Petrographic examination showed quartz and chert, stained with limonite, predominating. About 25 percent of the silica was normal, angular quartz fragments. Median size of the particles, 1.72 microns.

[10] Finely ground Pennsylvania quartz. Chemical analysis showed 99.1 percent silica. Petrographic examination showed quartz of high purity. Median size of the particles, 1.6 microns.

[11] Chemical analysis showed silica, 49.9; calcium oxide, 1.7; and magnesium oxide, 28.2 percent. Petrographic examination showed about 20 percent as tremolite, about 65 percent as talc, and about 5 percent as dolomite. Median size of the particles, 3.6 microns.

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adjacent to the edges of the nodules. Collections of these particles were found at various other points in the peritoneum. The amount f dust in the peritoneal cavity found 90 and 112 days after injection was approximately the same as that noted in 7 days. The injected dust was neither absorbed nor did it institute a cellular proliferation. The only change noted was that of the distribution of the dust in the peritoneum. The particles became more wide-spread in their dispersion as the interval between injection and examination increased, and this dissemination was shown microscopically to have been effected by macrophages. No appreciable change in the quantity of dust was noted in 112 days after injection; and, inasmuch as no dissolution of the dust or cellular proliferation occurred, this type of reaction, for the sake of description, will be referred to as one of inertness.

Carborundum.[12]—Carborundum, or silicon carbide, produced essentially the same type of reaction as soapstone. The initial stage of foreign-body irritation was not as severe, and the distribution of the fine-dust particles in the later stages of the tests was more extensive. Though the nodules became more flattened and spreading, the amount of dust found in the peritoneal cavity 90 days after injection was approximately the same as was noted in 7 days. The material is apparently a nonirritating, insoluble, foreign body and is readily transported throughout the peritoneum by phagocytes. As no absorption or cellular proliferation was noted, the reaction can be called one of inertness.

Jewelers' rouge.[13]—Jewelers' rouge, or ferric oxide, behaved in the peritoneum in a manner similar to that of soapstone and silicon carbide. The nodules became flattened, and many dust particles were extensively disseminated throughout the peritoneum as the time interval between injection and examination lengthened. The amount of dust observed 90 days after injection was approximately the same as that found in 7 days. The response of the peritoneal tissue to this dust is therefore one of inertness.

Anthracite coal.[14] [15]—Anthracite coal produced a more rapid response following injection than did soapstone, carborundum, or jewelers' rouge. Minute dust particles were noted in the peritoneum adjacent to the nodules as early as 7 days after injection. By 90 days this distribution was quite extensive. The amount of dust present in the

[12] Pure, manufactured silicon carbide. Petrographic examination showed no impurities. Median size of the particles, 1.15 microns.

[13] Pure ferric oxide in a finely divided state. Petrographic examination showed a high purity hematite as fine, uniform particles. Median size of the particles, 0.96 micron.

[14] A Pennsylvania anthracite. Petrographic examination showed about 95 percent as coal and 5 percent as inorganic materials. Of the latter, about 60 percent appeared as quartz and about 40 percent as calcite, siderite, and rutile. Median size of the particles, 0.73 micron.

[15] A coal similar in petrographic examination to that described in footnote 14. Median size of the particles, 1.11 microns.

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peritoneal cavity 90 days after injection was approximately the same as that found in 7 days, therefore it was concluded that anthracite coal dust was inert in reaction.

Bituminous coal.[16] [17]—Bituminous coal, like soapstone, carborundum, jewelers' rouge, and anthracite coal, appeared to be inert and insoluble in the peritoneum. The nodules behaved in a manner similar to those of the above-named dusts, and the dispersion of the dust particles throughout the peritoneum was particularly widespread. With this dust very few nodules were formed on the anterior abdominal wall, the most dependent portion of the animals' peritoneal cavity to which injected material would naturally gravitate; but the majority of the nodules were consistently found in the omentum. Many small nodules and diffuse areas of dust particles were also found in every portion of the peritoneal cavity. The amount of dust present 90 days after injection was approximately the same as that found in 7 days; therefore the reaction was one of inertness.

Precipitator ash.[18]—Precipitator ash, or "fly ash", produced a reaction similar to that of the other inert dusts mentioned in this series. The nodules behaved similarly in their progress to those formed by soapstone. Relatively coarse, black particles were noted on the surfaces of the dark gray nodules. These were evidently carbon particles, as the dust was of mixed composition. The dissemination of the original gray dust composing the bulk of the sample, while not as extensive as that of the coals, was well marked and apparently the same as was found with soapstone and silicon carbide. As there appeared to be no disappearance of this dust from the peritoneal cavity or cellular proliferation, it seems safe to class this dust as inert in type.

SUMMARY

1. A definite quantity (0.2 g) of dust in suspension was injected intraperitoneally into guinea pigs.

2. Dusts of two particle-size groups were used—one of screened material with particles less than 43 microns (325 mesh), and the other of air-separated material with particles varying from less than 2 to 8 microns in size.

3. The animals injected with the coarser material were examined 7, 14, 30, 56, and 112 days after injection, and those treated with the air-separated material were examined after 7, 14, 30, 56, and 90 days.

4. The response caused by the dust in the peritoneal cavity was

[16] From Pennsylvania. Petrographic examination showed from 1 to 2 percent inorganic content, essentially all calcite. Median size of the particles, 1.15 microns.

[17] From Pennsylvania. Petrographic examination showed from 1 to 2 percent inorganic content, mainly quartz, calcite, and clay. Median size of the particles, 1.19 microns.

[18] Collected from stacks by electric precipitation. Chemical examination showed 44.7 percent silica. Petrographic examination showed predominantly perfectly spherical fused glass, rounded semifused masses [illegible] of crystallites, some quartz fragments, calcite, and coal. Median size of the particles, 1.43 microns.

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constant in all of the animals injected with an individual dust and could be classified as an absorption, proliferative, or inert reaction.

5. In the absorption reaction the injected dust disappeared from the peritoneal cavity without the production of scar tissue.

6. In the proliferative reaction the nodules produced by the dust continued to increase in size up to 112 days after injection, the maximum duration of the tests in this series.

7. In the inert reaction the amount of injected dust remained approximately the same in the peritoneal cavity throughout the various periods, but the nodules became more flattened and fine particles of dust were carried over rather extensive areas in the peritoneum by phagocytes.

8. Calcite, limestone, precipitated calcium carbonate, gypsum, and cement exhibited an absorption reaction.

9. Quartz, chat, and flint produced a proliferative reaction.

10. Soapstone, carborundum, jeweler's rouge, anthracite coal, bituminous coal, and precipitator ash were inert in reaction.

CONCLUSIONS

The tissue of the peritoneal cavity responds actively to a dust introduced as a foreign body, and this response is of such a character that it may be used as a basis for the classification of industrial dusts from a physiological standpoint. In this report, dusts of uniform chemical composition or those definitely known to produce or not to produce silicosis were used, and for this group the reaction occurring in the peritoneal cavity was uniform and constant for each dust. It seems probable, in view of the nature of the reactions, that dusts of mixed chemical composition will produce responses similar to those found in this series of dusts.

Tests of longer duration are now in progress to determine the ultimate fate of the dust in the peritoneal cavity; yet for purposes of obtaining a definite response to any dust 90 days appears to be a sufficient time interval between injection and examination.

ACKNOWLEDGMENT

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(6) Roller, P. S.: Ind
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SULPHUR DIO

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By C. L. Wi

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REFERENCES

(1) Kettle, E. H.: Jour. Path. & Bact., 35: 395–405 (May 1932).
(2) Kettle, E. H., and Hilton, R.: Lancet, 1: 5675: 1190–1192 (June 4, 1932).
(3) Policard and Rollet: Bull. d'hist., 8: 53–58 (February 1931).
(4) Policard and Mouriquand: Bull. d'hist. appl. à physiol. et pathol., 7: 193–199 (June 1930).
(5) Sayers, R. R.: Health Hazards in the Mining Industry. U.S. Bureau of Mines Report of Investigation, no. 2660 (December 1924).
(6) Roller, P. S.: Indust. and Eng. Chem. 4: 341 ff. (July 15, 1932).
(7) Bloomfield, J. J.: Pub. Health Rep., 48: 961–968 (Aug. 11, 1933).

SULPHUR DIOXIDE FOR THE FUMIGATION OF SHIPS*

METHODS OF USE AND PROSPECTS OF IMPROVEMENT

By C. L. Williams, *Senior Surgeon, United States Public Health Service*

Sulphur dioxide has been used for many years in the United States for the disinfection of ships. The discovery that germs were causes of disease and that they could be destroyed by fumigation became the basis of its employment for this purpose in the latter part of the past century. While the procedure was utilized against all of the quarantinable diseases, it was employed most particularly against yellow fever—before the discovery that this disease is transmitted by the mosquito, in the hope of destroying the virus, and, after this discovery, for the purpose of destroying the vector.

Fumigation with sulphur was the principal method utilized on ships in the United States until 1914, when hydrocyanic acid was introduced as a practical ship fumigant. Before the appearance of the cyanide gases, a relatively brief competition was set up by funnel gases—that is, a mixture of carbon dioxide and carbon monoxide; but the apparatus proved too cumbersome for general use, and its failure to destroy fleas was considered a disadvantage for antiplague measures.

While today in the United States hydrocyanic acid has largely replaced sulphur, the latter is still in use at many of the smaller quarantine stations, where it is economically impracticable to maintain fumigation crews trained to use the more hazardous cyanide. About 30 percent of ship fumigations are performed with sulphur.

In the use of sulphur dioxide, the United States Public Health Service has never seriously departed from the method of producing this substance by burning sulphur, and has employed this method in two ways: One has been to burn the sulphur, in small lots, in iron pots placed inside the spaces to be fumigated; the other, to burn it in a specially constructed furnace, from which it was blown through large tubes into the ship. For a time sulphur furnaces were very

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