REPORT OF THE DIRECTOR
of the Saranac Laboratory for the Study of Tuberculosis
1940

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AS NEVER in our history the whole nation is giving thought to the importance of industrial production. We are realizing that without alert and healthy workmen, mere money, machines and factories cannot produce the materials of war that are so urgently needed. Conscious of the dangers to health and life that have attended so many employments in the past, we are resolved that they shall no longer be tolerated. The industrial physicians and engineers who are directly responsible for the health of workmen and who actually control the hazards of industry will find intense satisfaction in being a part of this stirring, collective movement. We, who experiment in laboratories to discover principles of health control must be content with a less direct and active participation. We hope that in the urgency of the moment our needs will not be forgotten for we know that there is more for us to do.

It is common to hear it said that enough knowledge is now at hand to prevent the diseases caused by exposure to industrial dusts and that the only unsolved problems in the field are ones of education and application. In a broad sense this is true for if there were no dust there could be no disease. But to eliminate all dust from every industry would be unnecessarily costly. Many of our state codes recognize this fact and permit higher concentrations of dusts that are not dangerous than would be safe where the materials handled contain significant quantities of quartz.

No expense is too great to eliminate a definite and recognized hazard to health but many kinds of dust, which are objectionable solely because they are nuisances, can be reduced to agreeable concentrations at comparatively small cost. We are uncovering evidence which seems to indicate that a silicosis hazard does not always exist where a rock of high free silica content is being worked. The nature of the processing sometimes determines whether the quartz particles will be dispersed into the air in such form that they produce disease. The quartz must be fractured to an exceedingly fine state of subdivision and the surfaces of the particles must be clean to produce the disease, silicosis. The presence of other mineral particles in the same air-borne

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suspension with fine quartz may cause flocculation, rapid settling and a great reduction in the hazard. These observations do not mean that the danger signal of a high quartz content in a raw material can be disregarded but it does suggest that conditions in particular locations might be examined critically before applying the expensive measures necessary to control a silica hazard. If the men who have worked for a lifetime in such an industry show no evidence of silicosis and suffer no disability, it is a fair assumption that some mechanism, peculiar to that particular plant, is operating to neutralize the usual effect of the quartz. It would be much less expensive to discover the mechanism and exempt the management from maintaining the expensive refinements of dust control. On demonstration of the absence of hazard, the particular dust could be classified as a nuisance and as such its concentration would only have to be kept down to levels where it was not uncomfortable.

The widespread use of roentgenology in industry is responsible for an alarming tendency to build a pathology of shadows that is unsupported by any basis of anatomy. Since shadows are cast on the film by anything which interferes with the passage of the x-rays through the lungs, it is entirely conceivable that collections of dust particles, particularly those of high atomic weight, might themselves be responsible for some of the abnormal conditions that are described as pneumoconioses. But unless these shadows are associated with alterations of function it serves little purpose to stigmatize the condition as a disease. A demonstration of the nature of the underlying pathological condition would serve to orient our thinking and allay tendencies to hysteria. The industrial hygienist has a large opportunity in the collection of material for correlating the shadow patterns produced by different forms of inhaled dusts with pathological anatomy.

Finally, we still have much to learn of the relationships between inhaled dust and infection. The particular case of tuberculosis in silicotic subjects is fairly well documented although the mechanisms responsible for altered susceptibility are barely comprehended. It is definitely known that minerals other than free silica have little or no effect upon susceptibility to tuberculosis but their influence upon non-tuberculous infections is only partially understood.

Recently there has been a tendency to criticize the results of the experimental approach to the problem of pneumoconiosis on the grounds that the lesions in animals do not duplicate in many details the corresponding changes observed in human subjects. In defense of the program carried on for so many years at the Saranac Laboratory it may be claimed that the same objec-

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tion applies to practically every other disease that has been "reproduced" in experimental animals. The exact anatomical form of the human disease process may not be duplicated but if it is composed of the same elements as those observed in man and if the reaction is specific for the particular irritant under investigation, the use of this method would appear to be justified. The experimental pathologist is attempting to formulate principles governing the development of disease. In the case of pneumoconiosis his animals are often exposed to dusts of pure minerals or to mixtures of known composition. Most human beings, on the other hand, who die after a life time of employment in dusty industries have inhaled many kinds of mineral particles. It seems more or less obvious that these different substances, acting over such long periods of time, should have modified the picture produced by the major irritant. At this laboratory every attempt has been made to correlate the findings in animals with those produced in human beings by different kinds of dust. Where no autopsies on the latter are available the pathological picture in the animal serves only as a temporary guide for the interpretation of the human roentgenogram; its major function is to indicate the nature and severity of the pulmonary reaction.

The laboratory's research program embraces many phases of these unsolved problems. Work progresses upon the effects of associated minerals in modifying the action of quartz upon the living body. Each year's work brings a better understanding of the mechanisms, like atmospheric flocculation, that tend to reduce the amount of inhalable silica in an atmosphere of "mixed dust" (see reprint of paper by Mr. L. H. Berkelhamer bound with this report). Evidences of neutralization by chemical or physical coating of quartz grains have been discovered in another industrial dust that has been considered hazardous solely on the basis of free silica content. Thus explanations are being found for the paradoxical absence of silicotic reaction in men who have spent a lifetime in places where mixed dusts of high free silica content have prevailed.

A study of the solubility of asbestos is beginning to shed light on the puzzling variations in response of different species of animals and even of different organs in the same animal. Except under very particular conditions the fine fibres of this unusual mineral apparently fail to maintain their characteristic brittleness which enables them to act as a mechanical irritant to the human lung. It is anticipated that in another year a long series of experiments will have been concluded which demonstrate the pathogenesis of asbestosis.

Experiments upon the influence of silicosis in modifying susceptibility to

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many of the common types of pneumococci are still in progress. By using albino rats instead of rabbits it has been possible to increase the size of the groups and produce results of greater statistical significance. It is still too early to prophecy the outcome. Infection with fuso-spirochaetal organisms has also been tried in silicotic animals with the view of discovering whether these organisms may not be responsible for some of the apparently non-tuberculous conglomerate silicosis in man.

The influence of pre-existing scar tissue in localizing inhaled dust is being adequately demonstrated by electrocauterization of the lungs of animals some weeks before dust exposure.

Work on the subject of individual susceptibility to silica dust has progressed during the past year. It has been demonstrated that rabbits are particularly satisfactory subjects because under apparently identical conditions of exposure they exhibit marked variation in capacity to react. Analysis has demonstrated that at death their lungs contain quantities of quartz which are proportional to the amount of silicosis. It remains to discover whether the non-reacting rabbits simply inhaled less than their fellows or whether after it had entered their lungs the quartz was removed more effectively. Since the lymphatic system is a major mechanism for pulmonary drainage, the nodes at the root of their lungs should contain excessive amounts of silica if such is the case. The appropriate analyses are now in progress. There is also evidence suggesting that the tissues of some individuals are more sensitive to silica than others. To establish this point a group of 100 guinea pigs has been injected with a measured dose of carefully graded quartz particles, barely sufficient to produce specific reaction. At the end of one year all of them will be killed and the amount of silicotic fibrosis will be compared with the quantity of silica in their organs. Empirical attempts to discover whether dietary factors influence capacity to react to quartz have yielded little information. With diets deficient in vitamin C and with supplementary feeding of brewer's yeast, which contains most of the vitamins of the B complex, the production of silicotic fibrosis has not been affected It is hoped that some phase of this study of individual susceptibility will disclose factors that can be identified in human beings and used for their protection in job placement.

An experiment just completed seems to settle a question that has been raised as to the significance of lymph stasis in silicosis. Most investigators have felt that the fibrosis in the lymph nodes at the root of the lungs, one of the early manifestations of silicosis, must interfere with the free flow of lymph out of these organs and the consequent elimination of subsequently inhaled

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dust. This assumption was questioned when it was noted that silicotic nodes became involved in cases of lobar pneumonia and pulmonary cancer. To test the competence of the lymphatics in various stages of silicosis, groups of normal and silicotic guinea pigs were made to inhale iron dust over a period of one year. Their nodes carefully dissected away from the lung tissue, were then analyzed for iron. It was found that more iron had always drained into the nodes of the normal controls and that the longer the preliminary exposure to quartz the less iron came through. However the lymphatic obstruction was never complete as after two and one-half years preliminary quartz exposure the nodes still contained one-eighth the amount of iron found in the normal controls.

The apparent lack of pulmonary damage from exposure to glass wool dust is being demonstrated by an inhalation experiment. For over a year animals have now been exposed to as high a concentration of this material as could be maintained, with no serious effect upon their lungs. The dust has been produced by breaking into short lengths the finest textile glass that is made but none of the fibres that are floating in the air can be found in the lungs of exposed animals. Their tendency, unlike that of asbestos, to form felt-like masses upon any object with which they come in contact probably prevents their inhalation. Slight amounts of chronic inflamation, similar to those observed with other harmless dusts, have resulted from accumulated particulate debris. These very fine, non-fibrous particles are the by-product of the violent beating used to break up the material.

Still another study involves the establishment of standards for the quantities of *free* silica in normal and silicotic lungs. Most normal human beings inhale some from street dust and other sources and the quantity detectable in the lungs increases with advancing years. Average figures have been published from time to time but they are based upon small numbers of cases, too often with little information as to conditions of exposure. The chief objection to the existing standards, however, is the fact that only *total* silica values have been reported without reference to the proportion that may have existed in free state. Such figures have little significance as they may represent both quartz and silica combined in the form of silicates. The latter, except in the case of asbestos, are probably of little or no hygienic importance: it is the quartz that in a great majority of cases constitutes the measure of a dust hazard. Until the present time few laboratories were equipped to make this important differentiation, for chemical methods of analysis are quite inadequate. However, we now have an x-ray diffraction apparatus, generously loaned by the General Electric Company, with which the desired

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objective is readily obtainable. We have started to reanalyse portions of more than 50 normal lungs and well over 100 silicotic ones on which chemical data have already been obtained.

This same apparatus is proving to be invaluable in most other departments of our work. By its use it is possible to identify the quartz, not detected in previous chemical analysis, in the lungs of certain cases of obvious silicosis which from the occupational history would have to be attributed to the action of other minerals. The x-ray method has permitted more accurate analyses of rocks and dusts containing both free and combined silica; it has demonstrated alterations in the structure of mineral particles kept in contact with body fluids and in many other ways it has become an essential tool.

The field division of the laboratory, under Mr. Cummings' direction, continues its work in the iron ore mines of the Lake Superior district and in the state of New York. A control program is also in effect in a West Virginia coal mine and in a limestone quarry. Surveys of dust hazards have also been made in several other industries. The effectiveness of this service will unquestionably be augmented by a new member on our staff. Mr. Edward C. J. Urban, formerly Industrial Hygiene Engineer of the Vermont State Department of Health joined us in May and is now stationed in northern Michigan. His interest in ventilation and the investigations that he is carrying on in various iron mines are important in the solution of the never-ending problem of underground dust control. With his assistance Mr. Cummings is able to exercise the necessary supervision of these field studies and at the same time carry on his work in the University of Colorado

Mr. Richard Libby, who has been with the laboratory for many years, first as histological technician and then as x-ray technician has left our organization. The director wishes to express his appreciation of the meticulous care which Mr. Libby has exercised in his work at the Ishpeming Hospital and deeply regrets that we shall no longer have the benefit of his unusual technical ability. Mr. Melvin Berg has also resigned and our thanks are due him for his willing cooperation in the field studies. Their places have been filled by Mr. Hugo Luistari and Mr. E. Clayton Quinn.

The demand for unprecedented quantities of iron ore created by the preparedness program has made it difficult to find time for the routine periodic examination of all miners. But for the cooperative spirit of our field staff and their willingness to work at any time of day or night it would have been impossible to complete all the examinations this year. The community programs of tuberculosis control carried on in collaboration with the mining companies are beginning to show results. Placement of men with evidence

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of old infections or reaction due to a lifetime of dust exposure continues to be a major feature of our service.

Diagnostic Work

As noted in the accompanying table 6,814 examinations have been made by the diagnostic department. The list indicates that we perform the usual kinds of diagnostic laboratory tests. Among the miscellaneous examinations there were many special tests of medico-legal significance. The fact that 61 pneumococcus type tests were performed indicates that the physicians of the community have accepted this procedure as a regular adjunct of treatment. Likewise the Ascheim-Zondek test for pregnancy is now a routine procedure. The 44 bacteriological examinations of water were made as a part of sanitary surveys in various private camps in the vicinity. Orthotolidine tests are made daily upon the municipal water to control the efficacy of the chlorination apparatus. The surgical pathological examinations are made under contract with the Saranac Lake General Hospital which submits material from every case in which tissue is removed.

There has been an unusual number of requests for post mortem examinations which have kept Dr. Vorwald and his assistants extremely busy. The total number of autopsies was 74; of these 15 were performed by order of the coronors in Saranac Lake and vicinity. Eleven cases involved a diagnosis of silicosis. In addition 13 more lungs were sent to the laboratory by other physicians for analysis, diagnosis and opinion on the influence of occupational exposure to dust. The proposal for a registry of such cases to be sponsored by a national medical society was not considered feasible but even the amount of material now being received taxes the facilities of the laboratory to complete the required analyses within a short period of time.

The director once again expresses his appreciation to all the members of his staff who so faithfully carry on their work. Like others in charge of private institutions he is concerned that the limitations of his budget have made it impossible to grant salary increases as often as they are deserved. Were the laboratory dependent only upon income from endowment it could not carry on the extensive program that it does. The support of our many friends in industry, whose names appear in the list of contributors, continues to make research possible. Finally the director acknowledges his debt to his board of trustees whose sympathetic cooperation is most appreciated.

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