

SHATTUCK (F.C.)

SOME REMARKS ON ARSENICAL POISONING,

With Special Reference to its Domestic Sources.

BY

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**SOME REMARKS ON ARSENICAL POISONING,
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DOMESTIC SOURCES.¹**

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ARSENICAL poisoning may be either acute or chronic. Speaking broadly, the manifestations of the acute form vary according to the mode in which the poison influences or enters the system; whether its action is mainly local on the skin or exposed mucous membranes; whether it is taken into the stomach, or reaches in a gaseous form the blood and tissues by inhalation through the lungs. We thus have inflammation of the skin or superficial mucous membranes, intense gastro-intestinal irritation, or symptoms of a very grave but more general character. There is less close relation between the manner of exposure and the character of the leading symptoms in the chronic forms, which include most cases of so-called domestic poisoning; but in these, as we shall see later, all avenues of entrance into the system may be open at once. It is interesting to note that patients who survive the early stages of acute poisoning may later, through absorption into the blood and deposition in the tissues, present symptoms identical with those which may also follow the slow and more or less continuous absorption of far smaller, perhaps of very

¹ The Semi-annual Address before the Philadelphia Pathological Society, April 27, 1893.

small doses. For instance, in a husband and wife who nearly died from arsenic administered once or at most twice in their food by a daughter, who hoped thus to secure an inheritance and render herself more acceptable to a lagging lover, I have seen the development of extreme general neuritis and of pigmentation of the skin resembling, except in its universality, that of Addison's disease. In the husband ninety-three days elapsed before Prof. E. S. Wood failed to detect arsenic in the urine.¹ Such cases form part of the evidence that the metal is stored up in the system and forms albuminoid compounds, from which it is only gradually set free, and they also illustrate the double toxic action of arsenic, its local irritant and its general systemic effects. It may be mentioned that arsenic seems to be stored up in the brain and spinal cord more largely even than in the liver.²

The leading statements which follow admit, I suppose, of no dispute.

A. I. The continued administration of arsenic by the stomach is liable to lead to symptoms of poisoning. These symptoms may be direct—gastro-intestinal irritation; or indirect—*anemia* and debility, dermatitis of different forms, skin-pigmentation, redness of the conjunctiva, puffiness under the eyes, headache, irritation of the upper air-passages, irritation of the kidneys as shown by small traces of albumin, casts, and blood in the urine, and peripheral neuritis. This list could be made longer, but comprises the more frequent manifestations. In some respects the neuritis is one of the most interesting of these. With regard to it I recall reading,

¹ The husband is still, after a year's interval, a paralytic and in the poor-house, I am told.

² Poncy and Livon: *Journal de Pharmacologie et Chimie*, October, 1879, p. 344. Scolosoboff: *Bulletin de la Société de Chimie de Paris*, xxiv, No. 3. Gautier: *Annales d'Hygiène*, January, 1876, p. 136.

but cannot now remember where, the statement of Seguin, that in his very large experience he has never seen neuritis follow the medicinal use of arsenic. In my more limited experience I have seen at least two such cases. One was that of a young woman successfully treated for chorea with large doses of Fowler's solution, which were well borne as far as the digestive organs were concerned, but she developed a marked and widespread paralysis of both motion and sensation from which recovery was slow. The other was also in a young woman, treated by me last autumn for leukemia with Fowler's solution, gradually increased to fourteen drops thrice daily, and maintained for some weeks at that level. She developed a mild but unquestionable neuritis, and also the characteristic brown discoloration of the skin. One post-choreic case of arsenical neuritis has been observed at the Boston Children's Hospital.

2. Medical literature contains reports of a fair number of cases of poisoning by arseniuretted hydrogen, although Professor Chandler¹ says: "I never knew a case except those mentioned in the books many years ago—Galen, for instance, who put his nose to it and is said to have been killed by it—and I have never heard of one." These cases are chiefly acute and mostly rapidly fatal. The possibility that chronic non-fatal cases of poisoning originating in this way may be pretty common will be touched upon later.

3. Arsenical stockings, veils, and other articles which are liable to be closely applied to the human skin, have often been held responsible for toxic symptoms—general from absorption of the drug, as well as local from its irritant effect. A well-known Boston physician had two attacks of sore fingers. He consulted Dr. J. C. White, who asked him whether he had anything to do with arsenic. He could think of nothing except some play-

¹ Appendix to No. 417, House of Representatives, Massachusetts, 1886.

ing cards which he had used. These were found to be loaded with arsenic, were discarded, and he has not had any similar trouble since. Reports of general poisoning from the use of arsenical pastes, lotions, and ointments are also to be found. Dr. Stillé cites a number in his work on *Therapeutics and Materia Medica*.

B. The great difference between different persons in susceptibility to arsenical poisoning must be admitted; but the influence of idiosyncrasy does not seem to be greater here than in the case of lead, alcohol, tobacco, and many other toxic agents. It is highly probable that habituation also plays a part. Here we naturally think of the Styrian peasants so often brought up in this connection. It seems to be a fact that some of them gradually acquire the power of taking, without obvious inconvenience, doses which would prove fatal to virgin soil—six grains, for instance, it is said. But no modern physician, so far as I know, has in very recent times carefully investigated this peasantry to ascertain how many try to become arsenic-eaters and fail in their attempt; how many develop neuritis or other indisputable toxic symptoms. I cannot regard the statement of Marik¹ as conclusive. He bases his opinion that arsenical paralysis is rare in Styria upon conversations with physicians practising in that province, and on a paper of B. Knapp,² written in 1885, when we knew much less about neuritis, especially in its milder forms, than we do now. A degree of neuritis might well pass unnoticed in a peasant, which an artisan, for instance, would find forced upon his attention.

We have all seen patients, to whom we wished to give arsenic for anemia, chorea, or other cause, show intolerance even of the smallest doses given with every precaution. I remember a leukemic boy in my hospital

¹ "Ueber Arsenlähmungen," Wien. klin. Wochenschr., 1891, Nos. 31-40.

² Erg. Hefte zum Centralblatt. f. allg. Gesundheitspflege, 1885.

ward, who bled at the gums and grew worse in every way whenever an arsenical course was instituted, even though only one drop of Fowler's solution thrice daily was given.

C. Arsenic is widespread in civilized countries. It enters as component or impurity into many articles of domestic use. I will not weary you with an attempt to form a complete list; but among these articles may be mentioned wall-papers; cretonnes and other prints; red-striped bed-ticking; Turkey-red cotton; child's paints; the "plated" or "glazed" papers used for kindergartens, for covering paper boxes or wrapping confectionery; some woollen dress goods, hangings, and curtains; black and other stockings; some distemper paints—indeed, anything in which an arsenical anilin pigment is used as a dye. These dyes may contain from 2 per cent. to 3 per cent. of arsenic by weight. Formerly arsenic acid was largely used as an oxidizing agent in the manufacture of fuchsin or magenta, but chromic acid answers equally well. Sodium arsenite is also used as a mordant to fix colors which may be non-arsenical. Silks are rarely arsenical.

D. From these articles or from some other sources in our surroundings, arsenic is absorbed into the system of many persons, as is shown by its detection in the urine of at least 30 per cent. of persons taken at random by J. J. Putnam.¹

We now come to the question as to whether arsenical poisoning arises from the afore-named domestic sources, or, rather, whether it so arises frequently enough to demand the serious consideration of physicians, the guardians of the health of the public, as well as that of their individual patients. The burden of proof certainly rests on those who maintain the affirmative. Let us, therefore, examine the evidence for and against, begin-

¹ Boston Med. and Surg. Journ., 1890, cxxii, p. 421.

ning, as is I think usual in judicial inquiries, with the case for the plaintiff.

Readily-accessible medical literature contains the reports of a large number of cases, many of which came under the observation of highly-trained physicians presumably alive to the dangers of incomplete observation and hasty deduction, and these cases presented symptoms of varying intensity and detail, persisting in spite of what seemed judicious treatment. These symptoms were mainly subjective in some, but usually objective as well, ranging all the way from anemia and debility to extensive peripheral neuritis. For the symptoms, no obvious cause could be discovered in the patients' manner of life, habits, or surroundings. In not a few cases a marked improvement took place on change in locality, perhaps trifling in character, while the symptoms speedily returned on resumption of home-life, without clearer assignable cause than at their first appearance. It was then found that the wall-paper of a room in which the patient slept or passed much time, the Turkey-red lining of a bed-quilt under which he slept, the red-striped bed-ticking covering his pillows or mattress, the chintz coverings of a sofa or of chairs, contained considerable quantities of arsenic. Then arsenic was also found in the urine of the patient, although it had not been given him as a drug or entered his system in Vichy or other arsenical mineral water. The kidneys were in an irritated condition. The arsenically-contaminated material was then removed and replaced by one free from the metal. This was followed by the more or less prompt abatement and disappearance of all symptoms and by restoration to health. In comparatively few of these cases is the history completed by finding the urine non-arsenical after the lapse of some months. If the patient is well, he often passes out of the observation of the physician, who may not care to subject the patient or himself to the

expense of an examination which, from the point of view of the layman, seems unnecessary.

All of the reported cases are not so complete as those just sketched. In many the evidence consists in a certain grouping of symptoms for which it is difficult to account, arsenical surroundings and urine, removal of arsenic from the surroundings, and recovery. I speak of a certain grouping of symptoms. There is no one symptom which is invariably present in cases of supposed arsenical poisoning. We cannot look for a pathognomonic sign here more than elsewhere; but anemia, debility, loss of appetite, frontal headache, perhaps nausea and vomiting, redness of the eyelids, and catarrh of the air-passages or of the intestinal tract, may be so combined as to be highly suggestive that arsenic will be found in the surroundings and also in the system.

If cases like these were isolated, occurred only in one locality, or only in the practice of one physician, one would not attach the same importance to them which one is led to attach when they are seen to occur in Great Britain and the Continental countries, in Maine and Michigan and other States as well as in Massachusetts. In reasoning from cause to effect or from effect to cause, we must often ask ourselves whether the association of result with supposed cause is merely coincidental or otherwise. I think I am alive to the ease with which, especially when public agitation is going on, members of our profession, as well as the laity, may jump at conclusions and connect things which do not belong together. The removal of a supposed injurious influence may well act as a species of mind-cure, and the reference of more or less vague symptoms of ill-health to a definite and removable cause may satisfy the patient and the physician alike. Some of the reported cases of domestic arsenical poisoning are certainly inconclusive, and I have no doubt that many

persons in Boston and vicinity, particularly, have erroneously believed themselves or have been believed to be victims of this kind of poisoning. Some of the cases which have been reported and observed suggest that arsenic may be but one of two or more causes tending to produce ill-health, and that a person already debilitated from some other cause or causes may then be more susceptible to the supposed injurious influence of this poison. Prof. E. S. Wood¹ refers to the case of a young athlete whose convalescence from influenza seemed to his physician, a thoroughly competent man, unreasonably delayed. Arsenic was found in his urine, although the papers, carpets, etc., were free. Eighteen stuffed birds were finally removed from his room and recovery was then rapid.

Allowing full weight to inconclusive cases, and also to all other possible sources of error, it seems to me that there remains enough to make us hesitate, to say the least, before we attribute the whole thing to mere coincidence. The temptation is great to cite cases, but I shall confine myself to a series reported by C. P. Putnam,² and a few of my own which have not been published. When Dr. Putnam went on duty at the Massachusetts Infant Asylum in the spring of 1890, he found the babies looking very pale, without any apparent reason. He then noticed suppurations on the fingers and a slight discharge from the ears. Occasionally a nurse had sores on the fingers. One had an aural discharge, and other skin-eruptions were noticed. Arsenical poisoning was thought of as possible, but there was no wall-paper, no carpets, or other suspicious articles. The health of the inmates of the asylum grew worse. Bronchitis appeared, and two children died from inflamma-

¹ Hearing before Committee of Massachusetts Legislature, 1891, p. 83.

² *Ibid.*, p. 66.

tion and ulceration of the air-passages, involving the pleura.¹ Some blue dresses recently furnished by the asylum to all the nurses fell under suspicion and were found to contain much arsenic. They were discarded and the health of the institution was reëstablished. Much of the arsenic was found to be loose in the cloth. The dresses were therefore thoroughly washed in the winter of 1891 and resumed by the nurses. Very soon afterward both nurses and babies began to have sores on their fingers and other signs similar to those which had appeared before. The dresses were again discarded. The symptoms again disappeared and have not recurred in the past two years. The evidence in my own cases is not as striking, but they serve as fair illustrations of many cases seen by many physicians.

1. W., a clerk in a large dry-goods house, entered my service in the Massachusetts Hospital in the fall of 1891, with poor general health and marked neuritis in all the extremities. It was with much difficulty that he could pick a pin up from the table. Neither alcohol, rheumatism, lead, nor gout could be considered as causative of the neuritis. The physician under whose care he had been, a gentleman well known to me, had given him no arsenic. The bedroom wall-paper, which had been applied for eight years, was highly arsenical, and arsenic was found in his urine. He soon began to improve, was discharged from the hospital, and after a time resumed his work, discarding the arsenical wall-paper. I saw him very recently again, and found his general condition still below par, with some neuritis still present, though not

¹ This statement does not quite correspond with that printed in the report, but is in accordance with information given me recently by Dr. Putnam. In default of a bacteriologic examination of the lungs in the two fatal cases, it must remain an open question as to the part, if any, played by arsenic in the production of the fatal lung-disorder. The other symptoms, however, seem less open to doubtful interpretation.

enough to seriously interfere with his work. An electric examination, which Dr. J. J. Putnam was kind enough to make, confirmed the diagnosis of neuritis. The urine still contains a considerable amount of arsenic, the source of which I have not as yet been able to trace.

2. G., a laster, entered my service January 30, 1893. Investigation showed that no arsenic had been given him before this. Besides pallor and loss of flesh, he had ataxic paralysis of all the extremities, which proved, after thorough study, to be due to peripheral neuritis, and for which the usual causes, as laid down in the books, could not be considered as responsible. I then had the urine examined by Prof. Wood for lead and arsenic. The former was absent, the latter present in large amount. I then secured some of the paper from the bedroom which the man had occupied for two years, and also samples of the leathers on which he worked. The paper was highly arsenical, as was also one of the samples of leather. After entrance to the hospital he grew steadily worse for some weeks, a continuance of the downward tendency present when he first came under observation, and was confined to bed; but he is now greatly improved and steadily gaining in all respects.¹

3. Two vigorous boys, brothers, had been confined to the house in town by colds and chicken-pox shortly after their return from the seashore. From these diseases they had just recovered when they, and also another brother who had been previously well, began to have recurrent attacks of nausea and vomiting. I presently suspected that some kind of poison from without was at work, and had the plumbing, cooking utensils, refrigerators, etc., examined, without finding here any cause for

¹ Repeated examinations of the urine have been made for arsenic by Wood. The amount diminished gradually, and April 24th the arsenic had practically disappeared, eighty-four days after removal from arsenical surroundings.

the illness. The symptoms grew worse. The youngest boy became extremely weak. I then had the wall-paper examined for arsenic, which was found in large quantity in that of the hall, entries, and stairway on every story, and also in that of five chambers. The papers had been on for a number of years. There was *no* arsenic in the paper on the walls of the rooms occupied by the sick children; but I found that they always slept with their windows shut and the doors into the entry open. The boys were at once removed from the house, and the papers were replaced by some free from arsenic. The patients rapidly recovered, and during the three years which have since elapsed have never had any recurrence of such symptoms. The urine of one of the boys has been examined for me within a fortnight and found to be free from arsenic. My supposition is that as the entry papers became worn, the arsenic was gradually set free in larger quantities and contaminated the air of their bedrooms, which were constantly in free and uninterrupted communication with the entry.

In none of these cases can the arsenical origin of the symptoms be regarded as absolutely proved; but I should like to call attention to the parallelism between the symptoms and those which are described in the text-books as occurring from contact with or ingestion of the drug. A few such cases may be only suggestive; but when they are multiplied manifold, as can easily be done by anyone who cares to consult the literature, the evidence furnished by them seems to me to be such as is worthy of serious consideration.

It may be mentioned that a number of European governments recognize arsenic as a source of danger in articles of domestic use.

Let us now consider the objections which can be raised—the case for the defence. In so doing I shall say what I think can be said to meet those objections, just as I called attention to some weak points in the argument for the plaintiff.

First, there is the alleged immunity of workmen and others whose occupation brings them into close relation with arsenic. A number of wall-paper manufacturers and dealers testified before the Committee of the Massachusetts Legislature of 1891 that during the many years they had been in the business they had never known of any injurious influence being exerted on themselves or their employés from arsenic. A number of such cases are, however, reported. Draper¹ mentions several cases among those employed in wall-paper shops, while cases of poisoning from green tarletan, artificial flowers, and among taxidermists are by no means rare.² E. S. Wood tells me that several workmen have stated to him that they suffer every time they remove an arsenical paper from the walls of a room. It is quite conceivable that workmen should not care to mention their disabilities, if not too great, to their employers, for fear of losing their places. The symptoms in these cases are essentially the same as those often seen in the consumers of arsenical goods. Moreover, the conditions are somewhat different between prolonged nightly exposure to the air of a bedroom, for instance, covered with an arsenical wall-paper, and the exposure to which a clerk in a paper-shop is subjected. The papers are there tightly rolled and stored on shelves. But small portions of the rolls are displayed to customers, and only for a short time. The shop, moreover, must be dry, or the papers would

¹ Third Report Massachusetts State Board of Health, 1872, p. 17.

² E. G. Cutler reports his investigation of a Lowell box-factory. Two cases of illness among the employés seem fairly attributable to the arsenical green and red papers used to cover the boxes. These contained about eight grains of arsenic to the square foot, but were heavily sized. The health of the girls in general was excellent. Much attention was given to the cleanliness and ventilation of the work-room, and other precautions were taken to prevent injury. Seventh Report, Massachusetts Board of Health, 1876, p. 546.

mildew and become unsalable. Arsenical dust is, therefore, the only thing to be dreaded. As far as reports in medical literature go, there certainly seems to be a relative immunity among workmen. Whether this immunity is really as great as it seems is a question which appears to me worth further study. The observance of simple precautions can, undoubtedly, do much to lessen the danger.

Next, we have the fact that far larger quantities of arsenic in solution—*i. e.*, in a condition ready for immediate absorption—can be and constantly are given medicinally by the mouth with impunity or only transitory gastro-intestinal disturbance than it is conceivable should, save in very rare instances, enter the system from domestic sources. Chemists of considerable experience in the examination of urine for arsenic recognize this fact, and I have repeatedly known the report to be made that the amount was so large that it must, in part at least, have been taken somehow by the stomach. Elimination after ingestion is slow. In a patient of mine to whom twenty-seven drops of Fowler's solution were given during three days, arsenic was detected in the urine by Wood until the fifty-eighth day. In another, who received sixty-nine drops in seven days, eighty-two days were required for elimination. But the conditions of gastric administration and exposure to arsenical papers or goods are not identical. There are reasons for believing, as will appear more fully later, that some gaseous form of arsenical compound may be set free in consequence of the growth of certain moulds, and that in this form and inhaled the poison may be more active than when it enters the system exclusively through the stomach. But whether arsenic is given off as a dust or gas, the duration of the exposure is generally quite different; that is, it is likely to be far longer in the domestic cases. In either case habituation may, but does not necessarily, ensue.

This leads us to the next objection, that arsenic is found in the urine of many persons who are quite free from indications of subjective or objective disease. J. J. Putnam has conclusively shown that the same is true of another metal, lead, the toxic influence of which on some persons is admitted by all. If this objection is to have weight with one metal, it would seem to have equal weight with the other. Idiosyncrasy, which includes relative immunity and habituation, must relate to both or neither.

The objection that arsenical poisoning of domestic origin occurs only in Boston would be too trivial to notice here were it not that it has been seriously urged, though, it is true, mainly by interested parties. It so happens that the question has received more attention in Boston than perhaps elsewhere in the United States, but the statement that cases are not observed elsewhere argues simply the ignorance of the person making the statement. There are plenty of unrecognized relations between cause and effect, plenty of unclassified conditions which are constantly before our eyes if we could only see them. The general recognition of peripheral neuritis is a very recent matter.

The risk is considered sufficiently great to warrant legislative interference in Sweden, Germany, Russia, Austria, and Denmark. In France no regulation exists, except with reference to articles of food and drink and children's toys, though the government has sent circulars to manufacturers warning them of the penalties to which they are liable if accidents result from the presence of poisonous substances in their goods. In England there is no law, but there has been considerable agitation on the subject, especially by the National Health Society and the London *Lancet*.¹ The very agitation has, however, been followed, as it is stated, by a marked

¹ 1892, ii, 43.

diminution in the amount of arsenic contained in articles for domestic use. An abstract of the laws on this subject will be found in the report of the Massachusetts Board of Health for 1885, in an article from the pen of E. S. Wood, entitled "Arsenic as a Domestic Poison." This abstract is taken from the English National Health Society's report for 1883.

I have tried to ascertain what changes, if any, have been made in these laws since 1885, and am indebted to Vorban¹ for most of the statements here immediately following. The Swedish laws, the most stringent and precise, remain the same since 1883. The maximum amount of arsenic permissible in wall-papers, materials for artificial flowers, and some other articles, is about one-fourteenth of a grain to the square yard; in textile stuffs and yarns and other specified articles one-seventh of a grain to the square yard. The process to be used in the chemical determination is carefully defined. The German law of 1882 was found to be too stringent in that it absolutely prohibited arsenic in wall-papers and articles of apparel. The metal is so widespread and the means for its detection are so delicate that minute traces can be found, oftentimes in spite of the best faith and most painstaking care on the part of the manufacturer. The law of 1887, which went into effect May 1, 1888, allows a maximum of two and a half grains to the square yard, provided that the arsenic is in a form insoluble in water. An exception is also made in favor of colors which do not contain the arsenic as a constituent part, but simply as an impurity; and this at the most in a quantity unavoidable in the ordinary methods of manufacture. Obviously, then, exceptions might afford opportunities for dispute and a loophole for a dishonest manufacturer. The Chancellor of the Empire is authorized to issue directions as to the process to be used in the detection and estimation of the amount of the metal.

¹ Inaugural Dissertation, Dorpat, 1889.

The Russian general law of 1876 seems to be still in force. It allows a maximum of from one-seventh to one-eighth of a grain of arsenic to the square yard in wall-papers. There are some local regulations, as in Riga and Dorpat. In the latter place the maximum is fixed at one-fifteenth of a grain per square yard in wall-paper and one-thirtieth of a grain in cloth.

In this country, Massachusetts takes the lead in the agitation on the subject. The ball was opened by Dr. Draper in 1872, and four unsuccessful attempts have been made to secure legislation. The act of 1891 prohibits arsenic in confectionery and children's toys, and authorizes the Board of Health to expend a sum not exceeding one thousand dollars on "such investigations and inquiries as they deem necessary as to the existence of arsenic in any paper, fabric, or other article offered for sale or exchange." The outcome of this is the report of Prof. W. B. Hills,¹ with regard to the conclusions of which I shall speak later.

Recognition of the danger which may exist of domestic arsenical poisoning is found in the reports of Boards of Health of Michigan for 1873, California for 1874, Rhode Island for 1878, Connecticut for 1879, Pennsylvania for 1887, New York for 1888, and Maine for 1889, as well as in those of Massachusetts for 1872, 1889, and 1892. In the year 1874 the Committee on Poisons of the Michigan State Board of Health prepared one hundred books of specimens of poisonous papers bought from first-class dealers in various cities, and placed these books in public libraries. The book was entitled *Shadows from the Walls of Death, or Arsenical Wall-papers*. This title was followed by a quotation from Leviticus, 14th chapter: "And behold, if the plague be in the walls of the house, with hollow strakes, greenish or reddish, . . . Then the priest shall go out of the house to the door of the house, and shut up the house seven days. . . ."

¹ Report of Massachusetts State Board of Health for 1892.

And he shall cause the house to be scraped within round about, and they shall pour out the dust that they scrape off without the city into an unclean place." I find the plague referred to is leprosy. One lady is said to have been poisoned by examining this book.

In the report of the State Board of Health for Pennsylvania for 1887, in the report of the Committee on Adulterations, Poisons, etc., it is stated that but little work has been done during the year for lack of funds and by reason of the expensiveness of chemical investigation, although "in the manufacture of certain foods employed in our households, wall-papers, textile fabrics, dye stuffs, etc., we shall find abundant scope for the operation of the Board's conserving energies." The only State besides Massachusetts in the laws of which wall-paper is mentioned in connection with poisonous pigments, as far as I can find, is New Hampshire, and here the matter is left in such a way that it can have no direct practical result.

We see, then, that the positive evidence is strong and comes from many sources. It seems to me far stronger than the negative evidence which I have tried to present fairly. It would certainly appear to be undesirable that the public should be exposed to an influence which there is so much reason to believe to be injurious, especially when such exposure is quite unnecessary. In proof that it is unnecessary I will call only three witnesses.

Prof. W. B. Hills reports in 1892 to the State Board of Health of Massachusetts, that in the last ten years decided improvement has taken place in the wall-papers sold in the State. About 3 per cent. of the papers manufactured to-day contain more than one-tenth of a grain of arsenic to the square yard, against, approximately, 30 per cent. ten years ago. Between 60 per cent. and 70 per cent. of the papers sold in the State are free from arsenic. About 90 per cent. contain less than from one-twentieth to one-tenth of a grain per square yard, a

amount which can be harmful to probably very few people. Prof. Hill states that arsenic is not essential to the production of the colors, and that those which were formerly arsenical can now be made without that metal. An absolutely exact comparison between the examinations made from 1879 to 1881 and from 1889 to 1891 is impossible, for the reason that during the latter period the so-called Marsh-Berzelius test was used, while in the earlier period the original Marsh test was followed. The modified method is much more delicate than the Marsh test and detects quantities of arsenic which escape the latter. A still more striking improvement is shown in the "glazed" and "plated" papers used in kindergartens, book and pamphlet covers, to wrap lozenges, etc. The use of Paris green is much less common in tickets, show-cards, and the like than it was ten years ago.

Mr. Henry Saltonstall, the treasurer of the Pacific Mills, one of the largest cotton mills in the world, testified before the Legislative Committee of 1891,¹ with authority to speak for four of the six print works in Massachusetts, as follows: "I wish to say in behalf of them (the print works) that not only are we averse to a law restricting the use of arsenic, but we welcome such a law. . . . We would be glad to have a reasonable and fair law which should prohibit the use of arsenic by any mills inside the State or factories outside the State which have their goods for sale here. . . . I don't dare to say what would be the danger-limit, but I think if one-fiftieth of a grain of soluble arsenic were allowed per square yard we could come down to this limit in textile fabrics or furniture." The proposed law, which failed to pass, allowed one-twentieth of a grain per square yard, not distinguishing between the soluble and insoluble forms. This is strong testimony to show that there is no necessity for the use of dangerous quantities

¹ Hearing before the Legislative Committee on Public Health, 1891, pp. 38 and 41.

of arsenic, coming, as it does, from a most competent general chemist, and also from a very large manufacturer, who has presumably consulted with his own chemists before he committed himself.

Mr. Jones, student-assistant in the chemical laboratory of the Harvard Medical School, showed me an old sample of green tartan which contained one-half its weight of arsenic. He tells me he has bought samples recently and failed to find any arsenic in them. Until very lately many of the red-striped bed-tickings contained much arsenic, but they, too, show the effect of agitation on the subject. In connection with the preparation of this paper I meant to experiment on myself. Professor Wood kindly examined my urine and failed to find arsenic. I then tried to buy arsenical bed-ticking to cover my pillow, taking from Wood a sample which was largely impregnated. Both pieces which were bought for me proved to be non-arsenical, so I was unable to complete my experiment and find out whether my urine became arsenical after sleeping on this pillow-covering.

We are next led to the question as to what amount of arsenic is allowable, a question which nobody seems prepared to answer absolutely. It is, however, probable that an amount not exceeding, say, one-fifteenth of a grain to the square yard, irrespective of solubility and form, may be regarded as practically innocuous. In the German experience we find one explanation for the difficulty in framing a law which will work no injustice to manufacturers or harm to consumers. The best tests are so delicate, and the presence of minute traces of arsenic so general in one form or another that absolute prohibition is really impracticable. A satisfactory law must, like the Swedish, not only fix the maximum allowable amount, but must also prescribe the method of chemical analysis. It is probably not practicable to distinguish, legally, between soluble and insoluble arsenic.

Some manufacturers and dealers argue that the diminution in the amount of arsenic contained in papers and fabrics during recent years shows in itself that no law is necessary. But this diminution cannot be attributed to anything except the agitation of the subject, a continuance of which demands considerable public spirit on the part of the agitators, whose ranks are not generally largely recruited from among the moneyed class. It is, moreover, doubtful whether the benefits of the agitation in Massachusetts extend widely beyond the State. Arsenical goods are, in the main, unsalable there; but no questions are asked in most parts of the country. If purchasers ask no questions, even in Massachusetts, they are liable to receive dangerous goods.

The question is interesting and also important, as to the manner of introduction of arsenic into the system from domestic sources. When the arsenical material comes into close contact with the skin, whether broken or unbroken, as in stockings or in arsenical caustic paste, the avenue of entrance is plain. When absorption takes place from a distance, as in the case of wall-papers, the arsenic is set free either in the form of dust or in a gaseous state. In the former case it is swallowed and inhaled; in the latter, inhaled alone. There can be no question that arsenical dust is detached from papers, fabrics, water-colors, sometimes from curtains or carpets. The dust which has settled on ledges, etc., in rooms containing arsenical papers has been analyzed and found impregnated with the metal. The ease with which the poison is detached varies, of course, much with the character and surface of the paper and material. Some papers grow much more dangerous with age as they become worn; others are highly dangerous from the start. Covering an arsenical with a non-arsenical paper does not necessarily render the former innocuous. Varnishing an arsenical paper renders it safer, certainly for a time, but does not secure safety. Arsenic is sometimes used

as a preservative for the paste which fastens the paper to the wall.

I think it was Fleck¹ who, about twenty years ago, first supported by scientific evidence the suggestion which had been previously made that a gaseous form of arsenic may, with the aid of moisture and in the presence of organic substances, be set free from arsenical pigments. Hamberg² detected the metal in the atmosphere of rooms with arsenical papers. The nature and manner of production of this gas has been studied by Husemann,³ Selmi,⁴ and very recently by Gosio.⁵ The work of the latter is not very readily accessible, and I therefore venture to abstract a portion of his conclusions.

It is proved beyond question that arsenical gases can be developed by the growth of moulds in contact with arsenical chemical compounds. Only a few moulds possess this property. While many moulds can live and grow in the presence of arsenical compounds, only four have thus far been proved to possess the power of setting free arsenical gas: *mucor mucedo*, *aspergillus glaucus*, *aspergillus virens*, and *penicillium brevicaulis* (the most important).

The conditions which favor the production of arsenical gas by these moulds are, first, those which favor in general the life of the fungus, abundance of oxygen, moisture, nutritious material, and suitable dosage of arsenic. Secondly, those which depend on the facility of the transformation of the arsenic. Thus arsenic acid, and the arseniates and arsenites of sodium and potassium are more easily transformed than the arsenite of copper. Third, the presence of carbohydrates (starch pastes).

1 *Zeitschrift f. Biologie*, 1872, viii, 444; et seq.

2 *Schmidt's Jahrb.*, 1875, Bd. clxv, 240.

3 *Virchow-Hirsch's Jahresb.*, 1881, S. 413.

4 *Schmidt's Jahrb.*, 1875, Bd. clxviii, S. 60.

5 *Monograph*, Ministry of the Interior, Scientific Laboratories of the Board of Health, Rome, 1892.

These moulds can, however, decompose arsenite of copper from papers even when they grow in the paste or glue fastening them to the wall. In the case of *mucedo*, at least, the quantity of arseniuretted hydrogen evolved is small in comparison with another more important compound, probably the union of the metal with organic alcohol or aldehydic radicals.

These conclusions are the result of work up to May, 1892. Its further prosecution is promised. They are quite confirmatory of the English reports which suggest that arsenical wall-papers exert a more deleterious action during moist than during dry weather, and they throw important light on one method of domestic poisoning.

The main, if not the sole avenue of elimination of arsenic which has got into the circulation in one way or another is the kidneys. It is a practical point worthy of note that we do not as yet know any direct means to further the elimination. The treatment of chronic arsenical poisoning resolves itself into, first, stopping further absorption; second, general hygiene; and third, the treatment of such symptoms as may require it. Active catarrhal symptoms are likely to subside pretty quickly on the removal of the toxic agent. Neuritis is to be treated by massage and electricity, just as when due to other causes.

The prognosis is good, as regards both life and recovery. Fatal cases are rare, and recovery is relatively quick, unless neuritis is extensive or very advanced, or the arsenical poisoning is only one of a combination of causes producing ill health.

The method of detection used by all the gentlemen connected with the chemical department of the Harvard Medical School is the Marsh-Berzelius test, which is sufficiently delicate and easy of application. In determining the length of time necessary for the elimination of arsenic, Wood has used the method of Sanger.¹

¹ Boston Medical and Surgical Journal, April 27, 1893.

The conclusions I feel justified in drawing from the foregoing considerations, which I have endeavored to strip of unnecessary detail, are the following :

1. There is overwhelming evidence to show that many arsenical articles which enter into common domestic use are dangerous to health.

2. That while it is impracticable to demand absolute freedom from arsenic in these articles, the presence of injurious quantities of the metal is quite unnecessary.

3. That, therefore, carefully framed legislative restriction, if possible uniform throughout the States, is desirable.

4. That it is the duty of the medical profession everywhere to study the question, and to lend its powerful aid in forming public opinion and otherwise securing such legislation.

I wish to take this opportunity of expressing my indebtedness to Drs. E. S. Wood and J. J. Putnam and to Dr. J. L. Morse for indispensable assistance in searching the literature.

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