FOURTH ANNUAL REPORT

OF THE

STATE BOARD

OF

HEALTH, LUNACY, AND CHARITY

OF MASSACHUSETTS.

1883.

SUPPLEMENT

CONTAINING THE

REPORT AND PAPERS ON PUBLIC HEALTH.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
No. 18 POST OFFICE SQUARE.
1883.

MEMBERS OF THE BOARD.

1882-1883.

THOMAS TALBOT, *Chairman*	OF NORTH BILLERICA.
CHARLES F. DONNELLY	OF BOSTON.
EDWARD HITCHCOCK, M.D.	OF AMHERST.
ROBERT T. DAVIS, M.D.	OF FALL RIVER.
EZRA PARMENTER, M.D.	OF EAST CAMBRIDGE.
JOHN C. HOADLEY, C.E.	OF LAWRENCE.
GEORGE P. CARTER	OF CAMBRIDGEPORT.
CLARA T. LEONARD	OF SPRINGFIELD.
ALFRED HOSMER, M.D.	OF WATERTOWN.
JOHN FALLON	OF LAWRENCE.
HENRY P. WALCOTT, M.D.	OF CAMBRIDGE.
ALBERT A. HAGGETT	OF LOWELL.
REUBEN NOBLE	OF WESTFIELD.
EDGAR E. DEAN, M.D.	OF BROCKTON.

[Names of *past* members in Italic capitals; of present members, in Roman capitals.]

COMMITTEE ON HEALTH.

HENRY P. WALCOTT, M.D., *Chairman.*

ROBERT T. DAVIS, M.D. THOMAS TALBOT.

JOHN FALLON. EDGAR E. DEAN, M.D.

Health Officer.

SAMUEL W. ABBOTT, M.D., OF WAKEFIELD

CONTENTS.

		PAGE
1.	General Report	ix
2.	The Adulteration of Food	1
3.	Our Eyes and our Industries	87
4.	Leprosy in its Relations to Public Health	119
5.	Reports of the Water Boards, Commissioners and Companies of Massachusetts	141
6.	The Sewerage of Nahant	225
7.	Alphabetical Index	249

GENERAL REPORT.

The Adulteration of Food and Drugs.

This subject received the attention of the State Board of Health in its earlier reports, and brief articles were published relating to it in the third and fourth annual reports of 1872 and 1873.

A new interest has been awakened in the subject by the action of the National Board of Trade, through whose committee of experts a general bill was prepared "to prevent the adulteration of food and drugs." This bill, substantially in the form recommended, has been enacted by the States of New York, Massachusetts and Michigan. The act as passed will be found on a later page of this report.

While the extent of food adulteration may have been overestimated by some, there can be no doubt that the milk supply, especially of our large cities, is very seriously adulterated, — a fact which materially affects the health and vitality of the infant population.

In consequence of the importance of maintaining the purity of this indispensable article of food, an amendment was enacted to the Law of 1882, increasing the appropriation granted for the execution of the act, and requiring the Board to make an annual report of prosecutions, with an itemized account of expenditures.

The first paper in the Report, prepared by Prof. S. P. Sharples, treats of the most important branch of this subject, the "adulteration of food." He affirms that the extent of adulteration has been overestimated, especially as relates to such products as are injurious to health, by far the greater number being such as are simply fraudulent in a commercial sense.

British and other authorities are quoted in support of this opinion.

The principal adulterations appear to be those of milk, of wine, spirits and beer, and of certain groceries, chiefly spices. This paper also treats of the knowledge required by an analyst, — of the mode of collecting samples, of the treatment of samples after collection, of the interpretation of the results of analysis, and the sources of error on the part of analysts; of the classification of adulterations into such as are injurious to health, the fraudulent and the accidental.

The principal articles liable to adulteration are then treated *seriatim*, special notice being made of the analysis and the adulterations of butter, of milk, of sugar, and of wines, together with a brief description of the apparatus requisite for analysis.

Our Eyes and our Industries.

The importance of good eyesight to all classes of people cannot be overestimated. Dr. Jeffries, in his paper, "Our Eyes and our Industries," sets forth some of the causes which tend to produce defective eyesight among the scholars in our schools, who are to fill the ranks of our professional men, educators, artisans and mechanics.

Want of light or its proper management, or poorly adapted school furniture, are fruitful causes of eye disease. So also are the use of poor paper and type in the making of school text-books.

A *résumé*, with quotations from Dr. Javal's "Physiology of Reading," are given, — a very valuable work, and one which clearly illustrates the importance attached to the minutest characteristics and qualifications of good type for the printing of school text-books.

The peculiar shapes, the terminations, the thickness, the height and the size of types are illustrated, as well as the distances between letters, the leading of lines and the length of lines, and their effect upon vision.

Special notice is also made of the subjects of school hours; of the proper selection of glasses under professional guidance; of special causes of impaired vision among artisans, such as dust, dirt, foul air, want of attention to light, and position at work; of the dangers of wood-cutting as affecting the vision; and also of the education of the color-sense in the young.

Leprosy.

The occasional occurrence of isolated cases of Leprosy in the United States, together with groups of cases among people who have immigrated from countries where the disease is more or less prevalent, has awakened considerable interest among health authorities. From the stand-point of public health, this disease cannot longer be ignored in the United States. The immigration to our ports of Norwegians in considerable numbers renders the importation of an occasional leper something more than a mere possibility, especially of such as may be in the early and unrecognizable stages of the disease. Cases have occasionally appeared among the Scandinavian settlements of the North-western States. The same danger is also true regarding the Pacific coast, with reference to immigration from Asiatic ports and the Hawaiian and other Pacific islands.

Dr. White, in a timely article recently published, urges the prohibition of leper immigration, and the restraint of existing cases in isolated hospitals at suitable places.

During the past season the leper settlement at Tracadie (New Brunswick), was visited by some members of the American Dermatological Association. Soon after their return, a report of their visit was made at the annual meeting of the association in August, 1883, and the following general conclusions were presented:—

1. Leprosy is a constitutional disease, and in certain cases appears to be hereditary.
2. It is undoubtedly contagious by inoculation.
3. There is no reason for believing that it is transmitted in any other way.
4. Under certain conditions, a person may have leprosy and run no risk of transmitting the disease to others of the same household or community.
5. It is not so liable to be transmitted to others as is syphilis in its early stages. There is no relation between the two diseases.

6. Leprosy is usually a fatal disease; its average duration being from ten to fifteen years.

7. In rare instances there is a tendency to recovery after the disease has existed for many years.

8. There is no valid reason for pronouncing the disease incurable.

9. Judicious treatment usually improves the condition of the patient, and often causes a disappearance of the symptoms.

10. There is ground for the hope that an improved method of treatment will in time effect the cure of leprosy; or, at least, that it will arrest and control the disease.

Triennial Reports of Water Companies and Water Boards.

In compliance with an act of the legislature of 1879, requiring all water companies and water boards to make reports to the State Board of Health, Lunacy and Charity once in three years, beginning with 1879, circulars were addressed to those companies and boards which were doing business at that time, and requesting replies from them. The result of the inquiry was unsatisfactory, and the replies were so few in number as to be deemed unworthy of publication.

At the expiration of three years, circulars have again been addressed to all boards known to be in operation January 1, 1883, with the result of obtaining replies from nearly all. The required compilation and revision of these returns shows that the form required by the statutes may be modified to advantage by the omission of certain questions requiring a repetition of similar replies, by the combination of others, and also by the omission of irrelevant matter, such as the statistics relating to the stocking of ponds with fish.

A uniform table should also be required for water analysis, upon a plan approved by the Board, for the sake of convenience in the comparison of waters of the State with each other, as well as with those of other States and countries.

The Sewerage of Nahant.

An unusual prevalence of typhoid fever in Nahant in 1881 awakened its people to the necessity of investigating the causes of the trouble, and, if possible, of providing a remedy therefor. Mr. Bowditch has already given in a paper entitled the "Sanitary Aspects of Nahant," some statements as to the condition of the town at that time.

Believing that an examination of the drinking-water might contribute to the desired object, an analysis of the water of one hundred and ninety wells and cisterns used for drinking purposes was made. Of this number, seventy-nine were classed as good or desirable in variable degrees, and one hundred and eleven were considered to be suspicious or bad.

In summing up the cases of typhoid, he says: "Some of these cases were 'imported' from other towns; others occurred where the drinking-water is quite undesirable or bad; still others, where the surroundings seem particularly favorable for the propagation of zymotic diseases. In fact, there is but one case out of nearly eighty that cannot be accounted for by filthy surroundings, bad drinking-water, or importation."

With these facts in view, the following remedies were proposed: —

First. To advise a system of pipe sewers sufficient for the present use and future growth of the town.

Second. So far as possible to cleanse the wells and cisterns, and put them in better condition than they were in the summer of 1881.

Third. To obtain a purer supply of ice.

Fourth. To be certain that the cans of milkmen are rinsed with pure water.

Fifth. To deliver drinking-water of known purity to every householder who expresses a willingness to use it to the exclusion of other supplies, and at least at those houses where typhoid existed last year, to insist on its use as far as possible.

The two first propositions have been carried out. The sewers have been constructed, and with what results the paper of Mr. Bowditch will show. The plan adopted is the separate plan, excluding all storm water, this being thought to be best adapted to a town and community like that of Nahant. This beautiful resort is not only provided with a most thorough and perfect system of sewerage, but also presents a commendable example of what may be termed a correct sanitary sequence, such as is not often adopted; viz., that of constructing the proper channels for its effluent water before introducing the water.

Another question presented in this paper is one of much interest to sanitarians, the "Recovery of soils from pollution." Thus far this important topic has been much neglected in America; but we trust this paper will awaken an interest in it which shall result in a thorough investigation of the subject.

Commercial Fertilizers or Artificial Manures.

The manufacture of chemical fertilizers or artificial manures has increased rapidly within the past twenty-five years, and assumed an important place among the industries of the State.

The U. S. Census Report, 1880, gives the following figures relating to the manufacture of commercial fertilizers in Massachusetts:

Number of establishments	21
Capital invested	$1,738,150
Number of hands employed	570
Value of products	$2,164,680

The value of such works in contributing to the agricultural resources of the State cannot be questioned, and their maintenance should be encouraged as a useful and valuable industry. At the same time the processes of manufacture should be so guarded and restricted as to render them as inoffensive as possible to their surroundings, by the choice of a suitable location of the works, and also by the adoption of such measures as shall remove as much as possible all offensive odor from the works resulting from the storage and handling of crude materials, the processes of manufacture, and the final disposition of the manufactured fertilizer.

These points have already been referred to in previous reports of this Board, and the measures therein suggested have been complied with by several of the larger establishments in Massachusetts with manifest success. Water-towers, condensing shafts, and the destruction of offensive gases by fire have been employed in a satisfactory manner, and similar measures should be required of all establishments of the same sort, for, wherever the work is carried on in the neighborhood of dwellings, complaints are likely to become frequent from parties to whom the odors evolved may prove offensive.

The act which concerns such trades and occupations provides that the State Board of Health, Lunacy and Charity may order the persons or corporations to cease and desist from such business, "if, in their judgment, the public health or the public comfort and convenience shall require." It is not necessary to measure the degree of offensiveness of noxious trades by the standard of the robust laboring man, especially if he is an employé in a factory of this sort.

A charge of nuisance to public health is tenable when a considerable number of persons, whether invalids, persons of a delicate organization, or even such as are in perfect health, are so affected that their lives are rendered uncomfortable.

An eminent authority, John Simon, when testifying before the Royal Commission on Noxious Vapors, said: "I think the expression 'injurious to the public health' has been used in a sense to impose upon the person who is charged with the duty of protecting health an obligation to prove that some named disease, such as typhoid fever, is produced by those vapors. I do not think we are bound, when it is a question of sanitary injury, to show injury of that circumscribed kind. To be free from bodily discomfort is a condition of health. If a man gets up with a headache, *pro tanto* he is not in good health. If a man gets up unable to eat his breakfast, *pro tanto* he is not in good health. States of languor, states of nausea, states of oppressed breathing, though not in themselves definite diseases, are *pro tanto* states of unhealth. When a man is living in an atmosphere which keeps him constantly below par, as many trade nuisances do, that is an injury to health, though not consisting in what at present passes under one nosological title. And though, as regards many of these chemical vapors, I have no doubt but that people resident in them do at length, in many cases, get fairly inured to them, there are people in considerable number to whom they continue constantly troublesome. For instance, every population includes a certain proportion who have sensitive *bronchi*, and such sensitive people are frequently very much troubled with any acid vapor, as causing them distress, although not producing any separate disease. I think that those who are fighting for the interests of the public health may rightfully claim of the legislature that any such pollution of the common air as makes a common nuisance, either in acidity, or in stink, or in dust, shall be deemed a nuisance injurious to health."

Sir John Morris, an owner of extensive fertilizing works at Wolverhampton, testified in reply to an inquiry before the same commission in 1877: "I feel no hesitation in saying that the trade can be conducted and ought to be conducted on a principle which will prevent the great complaints which are made when the trade is carelessly conducted. The process of converting unskilfully managed works into works which are supplied with all the best appliances (for correcting nuisance) is no more expensive than the public have a right to expect and the manufacturers are bound to adopt."

The extent and number of such works in Massachusetts, and the frequent complaints which arise from the careless and neglectful management of some of them, suggest the necessity of special legislation which shall require all establishments of this nature to modify their processes of manufacture, and their modes of storage of crude and of manufactured goods, under proper supervision, and such supervision should not be intrusted to the sole control of local authorities.

STATUTES OF 1882 AND 1883

Relating to the Adulteration of Food and Drugs.

[Chap. 263.]

An Act relating to the Adulteration of Food and Drugs.

Be it enacted, etc., as follows:

Sect. 1. No person shall, within this Commonwealth, manufacture for sale, offer for sale or sell any drug or article of food which is adulterated within the meaning of this act.

Sect. 2. The term "drug" as used in this act shall include all medicines for internal or external use, antiseptics, disinfectants and cosmetics. The term "food" as used herein shall include all articles used for food or drink by man.

Sect. 3. An article shall be deemed to be adulterated within the meaning of this act, —

(*a*.) In the case of drugs, — (1.) If, when sold under or by a name recognized in the United States Pharmacopœia, it differs from the standard of strength, quality or purity laid down therein; (2.) If, when sold under or by a name not recognized in the United States Pharmacopœia, but which is found in some other pharmacopœia, or other standard work on *materia medica*, it differs materially from the standard of strength, quality or purity laid down in such work; (3.) If its strength or purity falls below the professed standard under which it is sold:

(*b*.) In the case of food, — (1.) If any substance or substances have been mixed with it so as to reduce, or lower, or injuriously affect its quality or strength; (2.) If any inferior or cheaper substance or substances have been substituted wholly or in part for it; (3.) If any valuable constituent has been wholly or in part abstracted from it; (4.) If it is an imitation of, or is sold under the name of, another article; (5.) If it consists wholly or in part of a diseased, decomposed, putrid or rotten animal or vegetable substance, whether manufactured or not; or, in the case of milk, if it is the produce of a diseased animal; (6.) If it is colored, coated, polished or powdered, whereby damage is concealed, or if it is made to appear better or of greater value than it really is; (7.) If it contains any added poisonous ingredient, or any ingredient which may render it injurious to the health of a person consuming it.

The state board of health, lunacy and charity may from time to time declare certain articles or preparations to be exempt from the provisions of this act; and the provisions hereof shall not apply to mixtures or compounds recognized as ordinary articles of food, provided that the same are not injurious to health, and are distinctly labelled as mixtures or compounds.

Sect. 4. The state board of health, lunacy and charity shall prepare and publish from time to time lists of the articles, mixtures or compounds declared to be exempt from the provisions of this act, in accordance with the preceding section. The said board shall also from time to time fix the limits of variability permissible in any article of food, or any drug, or compound, the standard of which is not established by any national pharmacopœia.

Sect. 5. The state board of health, lunacy and charity shall take cognizance of the interests of the public health relating to the sale of drugs and food and the adulteration of the same, and shall make all necessary investigations and inquiries in reference thereto, and for these purposes may appoint inspectors, analysts and chemists, who shall be subject to its supervision and removal.

Within thirty days after the passage of this act the said board shall adopt such measures as it may deem necessary to facilitate the enforcement hereof, and shall prepare rules and regulations with regard to the proper methods of collecting and examining drugs and articles of food. Said board may expend annually an amount not exceeding three thousand dollars for the purpose of carrying out the provisions of this act.

Sect. 6. Every person offering or exposing for sale, or delivering to a purchaser, any drug or article of food included in the provisions of this act, shall furnish to any analyst or other officer or agent appointed hereunder, who shall apply to him for the purpose and shall tender him the value of the same, a sample sufficient for the purpose of the analysis of any such drug or article of food which is in his possession.

Sect. 7. Whoever hinders, obstructs, or in any way interferes with any inspector, analyst, or other officer appointed hereunder, in the performance of his duty, and whoever violates any of the provisions of this act, shall be punished by a fine not exceeding fifty dollars for the first offence, and not exceeding one hundred dollars for each subsequent offence.

Sect. 8. This act shall take effect at the expiration of ninety days after its passage. [*Approved May 26, 1882.*

[Chap. 263.]

An Act to amend an Act relating to the Adulteration of Food and Drugs.

Be it enacted, etc., as follows:

Sect. 1. Section five of chapter two hundred and sixty-three of the acts of the year eighteen hundred and eighty-two is hereby amended by striking ont the word "three" in the thirteenth line, and inserting the word "five" in place thereof: *provided, however*, that two-fifths of said amount shall be annually expended for the enforcements of the laws against the adulteration of milk.

Sect. 2. The board of health, lunacy and charity shall report annually to the legislature the number of prosecutions made under said chapter, and an itemized account of all money expended in carrying out the provisions thereof.

Sect. 3. This act shall take effect upon its passage.

[*Approved June 28, 1883.*

The foregoing act of 1882 (chap. 263) relating to the adulteration of food and drugs, together with the amendment of 1883, relative to the adulteration of milk, are already noticed in an earlier portion of this report. The proceedings of the Board in compliance with the provisions of this act will be published in the Annual Report of the ensuing year.

The Metric System.

LENGTH.

1 Myriameter . .	Mm.	(10,000 m.)	= 6.2137 miles.
1 Kilometer . . .	Km.	(1,000 m.)	= 0 62137 mile.
1 Hectometer . .	Hm.	(100 m.)	= 328.0833 feet.
1 Decameter . .	Dm.	(10 m.)	= 393.7 inches.
1 Meter	m.	(1 m.)	= 39.37 inches.
1 Decimeter . .	dm.	(0.1 m.)	= 3.937 inches.
1 Centimeter . .	cm.	(0.01 m.)	= 0.3937 inch.
1 Millimeter . .	mm.	(0.001 m.)	= 0.03937 inch.

SURFACE.

1 Hectare . . .	Ha.	(10,000 sq. m.)	= 2.471 acres.
1 Are	a.	(100 sq. m.)	= 119.6 square yards.
1 Centare . . .	ca.	(1 sq. m.)	= 1.550 square inches.

CAPACITY.

1 Kiloliter or Stère .	Kl. or st.	(1,000 l.)	= 1.308 cubic yards	= 264.17 gallons
1 Hectoliter . .	Hl.	(100 l.]	= 2 bush. and 3.35 pecks	= 26.417 gallons.
1 Decaliter . . .	Dl.	(10 l.)	= 9.08 quarts	= 2.6417 gallons.
1 Liter	l.	(1 l.)	= 0.908 quart	= 1.0567 qts. (1.761 imperial pints.)
1 Deciliter . . .	dl.	(0.1 l.)	= 6.1022 cubic inches	= 0.845 gill.
1 Centiliter . . .	cl.	(0.01 l.	= 0.61022 cubic inch	= 0.338 fluid ounce.
1 Millimeter . .	ml.	(0.001 l.)	= 0.061 cubic inch	= 0.27 fluid drachm.

WEIGHT.

1 Millier or Tonneau,	M. or T.	(1,000 Kg.)	= 1 Kl. or 1 Cu. m.	= 2204.6 pounds (avoirdupois.)
1 Quintal . . .	Q.	(100 Kg.)	= 1 Hl. or 0.1 Cu. m.	= 220.46 pounds.
1 Myriagram . .	Mg.	(10 Kg.	= 1 Dl. or 10 Cu. dm.	= 22.046 pounds.
1 Kilogram . . .	Kg.	(1,000 g.)	= 1 l. or 1 Cu. dm.	= 2.2046 pounds.
1 Hectogram . .	Hg.	(100 g.)	= 1 dl. or 0.1 Cu. dm.	= 3.5274 ounces.
1 Decagram . .	Dg.	(10 g.)	= 1 cl. or 10 Cu. cm.	= 0.3527 ounce.
1 Gram	g.	(1 g.)	= 1 ml. or 1 Cu. cm.	= 15.432 grains.
1 Decigram . . .	dg,	(0.1 g.)	= 0 1 ml. or 0.1 Cu. cm.	= 1.5432 grains.
1 Centigram . .	cg.	(0.01 g.)	= 0.01 ml. or 10 Cu. mm.	= 0.1543 grain.
1 Milligram . .	mg.	(0.001 g.)	= 0.001 ml. or 1 Cu. mm.	= 0.0154 grain.

One kilogram is equal to a weight represented by one liter of distilled water at 4° C. In the centigrade scale 0 (32° + F.) is the freezing point; 100° + (212° + F.) is the boiling-point. Five degrees C. corresponds to nine degrees F.

All measures in the metric system are derived from the meter, and their names express their values. Some of the names in the French system (like our "dime") are not in practical use; e.g., hectometer, decagram, etc.

One inch = 2.5 centimeters nearly; one quart (wine measure = 0.946 liter; one pound Troy = 0.373 kilogram; one acre = 0.4046 hectare.

ADULTERATION OF FOOD.

By S. P. SHARPLES, S.B.

ADULTERATION OF FOOD.

No branch of sanitary science has proved so difficult and troublesome to deal with as that relating to food and its adulterations.

Attacks on the quality of the food furnished in our cities seem, like panics and certain diseases, to be periodic in their character. Every few years some one makes a collection of awful examples, and publishes them for the benefit of the credulous. Then a new law is passed, and things go on very much as before. Until within the last six years no systematic attempt has been made, in either this country or in England, to ascertain the quality of the food-supply, except in regard to the milk furnished in large cities. It will, however, hardly be denied by any one who has made a careful study of the subject, that the character of our food-supplies has steadily improved during the last twenty or thirty years.

The means of transportation all over the world have so greatly increased that many articles which were formerly found only in the houses of the most luxurious are now common to all who wish for them.

But with the increase of wealth and the desire for more luxurious living the supply has sometimes fallen short, either from the limited amount of the article which it is possible to produce, or from the entire or partial failure of the crop, either from natural causes, or war in the country producing the article.

When from any such cause the supply becomes limited, the adulterator steps in to at least keep up the appearance of a supply. A good illustration of this was furnished by Madeira wine. For many years the crop was insufficient for home use: yet the article, or an imitation of it, could always be obtained in the market. Such frauds as this are soon discovered, — generally by a competitor who has been under-sold, — an outcry is raised, and the consequence is that a new law is placed upon the statute-books. I say upon the books, for that is generally all that is done with it: it is rarely enforced.

The statute-books of all nations abound with such laws, most of which become dead as soon as the excitement is over. This arises from two causes, the first of which is ignorant, indiscriminate legislation. A law which condemns equally chromate of lead and flour or rape-seed in mustard is soon looked upon with contempt.

The second cause is too definite or too conservative legislation. There are many laws which condemn specifically certain adulterations. The sophisticator carefully avoids these substances, and substitutes others, perhaps not less dangerous, and continues his trade. For instance, if a law was passed condemning, under heavy penalties, the use of gypsum in any article of food, and the law was enforced, its use would cease; but soon there would be an increased demand for China-clay, which can be furnished as abundantly as gypsum, and almost as cheaply.

Another objection to this specific legislation is, that when an adulteration is once exposed it becomes practically dead, since, if it is known to the whole of the trade, it generally ceases to be profitable. The adulterator's only hope of profit is the secrecy with which he carries on his trade. As soon as his competitors discover what he is doing, they either follow the same line, or denounce him, whichever they think will prove the more profitable; and the adulteration either ceases, or, what amounts to the same, becomes unprofitable.

All criminal or prohibitory legislation necessarily follows the first commission of the act which it is intended to prevent, and therefore specific laws against any particular adulteration (without it is one, like the adulteration of milk with water, that is very easy to perform, difficult to detect, and very profitable) generally fail of their object, since they come too late to be of any benefit: by the time the law is on the statute-book the old adulteration has been forgotten, and a new one has taken its place. A law which declares that "dealers shall not color, stain, coat, face, or otherwise treat any article so as to conceal from the purchaser its real value or quality," is one which it would be impossible to strictly enforce; since, from the apple-woman on the street who polishes her apples with her apron, to the farmer who colors his butter and cheese, every one who has an article for sale is interested in making it appear as well as possible. In passing laws against adulteration, legislators have generally managed to leave some loophole through which the guilty may escape; and by the time this is mended another is discovered. The "prejudice to buyer" section of the English law is an example: this gave the inspectors much trouble until it was modified.

A careful examination of the English laws upon the subject of adulteration, which have been passed and repealed during the last hundred years, will serve to fully illustrate what should be done, as well as what should be avoided, in such legislation, since England has legislated more upon this subject than any other country.

A law upon this subject should be simple, easily understood, and general in its application; and it should not attempt to control all commercial frauds, but only such as are detrimental to health. Moreover it must have some one especially appointed to carry out its provisions: a prohibitory law in which no one has a special interest soon falls into neglect.

Massachusetts has at present upon her statute-book an abundance of laws upon this subject; but, with one or two exceptions, they are practically dead, since there has never been any systematic attempt to enforce them.

The trouble with many of these laws has been this: that a law, which from the very nature of it is expensive to enforce, has been left without any money for such enforcement. In cases where the law has provided for the appointment of local inspectors, these inspectors have either not been appointed, or the place has been given as a reward for political services; and, when the officer has tried to do his duty, he has very soon found out that he must make his investigations at his own expense, since the local authorities either can not or will not provide the means for carrying on such investigations, which in many cases must be without tangible results.

Under laws relating to adulteration there has gradually grown up a class of experts, who have made a careful study of the subject, and who have written many valuable monographs upon special branches of adulteration, and a few general works. Below, I have first given some general observations upon the subject, appended to a list of adulterated articles and the methods used in the analysis of some of the more common articles of food; these are followed by a list of the more useful apparatus for the food-chemist, and the bibliography of the subject.

Extent of Adulteration. — From a general acquaintance with the subject for the last fifteen years, and a close examination of all the available literature of the subject, I have been led to the belief, that, outside of the single article of milk, that injurious adulteration is by no means common. Fraudulent adulteration is but little more common than injurious adulteration.

Various attempts have been made in Europe to investigate the extent to which adulteration is carried; but no one, so far as I have been able to find out, has made a thorough examination of the adulteration practised on a single article of food; and indeed from the very nature of the subject this would be almost impossible, since such an examination must include the entire supply, and not merely occasional samples obtained here and there.

The English Society of Public Analysts have perhaps done more towards such an investigation than any other body of men; and, thanks to their journal "The Analyst," these reports are accessible.

"The Analyst" reports as follows on the doings of the Society of Public Analysts since its organization.

	Districts.	Samples Examined.	Samples Adulterated.	Per cent Adulterated.
1875–6 . . .	109	15,989	2,895	18 10
1877 . . .	127	11,943	2,371	17.70
1878 . . .	168	15,107	2,505	16.58
1879 . . .	212	17,574	3,032	17 25
1880 . . .	237	17,919	3,132	17.47

In 1875–76 only one hundred and nine districts reported while in 1880 two hundred and thirty-seven districts reported: yet the two hundred and thirty-seven reporters only examined about two thousand more articles than the one hundred and nine did in 1875–76.

The classified list of these adulterations is also interesting.

	Number. 1879.	Number. 1880.	Per Cent. 1879.	Per Cent. 1880.
Milk	6,036	7,251	36.1	40.40
Butter	969	892	5.7	4 97
Groceries	4,197	3,845	25.0	21.48
Drugs	615	390	3.6	2 17
Wines, beer, and spirits	1,615	2,220	9.7	12 36
Bread and flour	1,471	1,326	8 7	7.40
Water	1,240	1,604	7.5	9.04
Sundries	629	391	3.7	2.18
	16,772	17,919	100.0	100.00

Of the whole number of samples found to be adulterated,

	PERCENTAGE.
Milk	50.98
Butter	5.73
Groceries	12 90
Drugs	2.52
Wines, spirits, and beer	15.18
Bread and flour	2.68
Waters	9.18
Sundries	.83

Or, taking each class separately, there were found in each of the years as given below the following percentages of the total number of samples which were adulterated: —

	1877.	1878.	1879.	1880.
Milk	26.07	18 38	22 06	22.00
Butter	12.48	13.23	13 93	20.08
Groceries	13 00	12 89	11.73	10.43
Drugs	23.82	35.77	26.66	20.26
Wines, spirits, and beer	47.00	29.31	28.30	21.31
Bread and flour	6 84	2.97	4 62	6.33
Water	21.63	14.98	21.45	17 73
Sundries	–	–	10.17	6.66

In remarking upon the first of the above tables, Mr Wigner says, —

"Once more, therefore, 1880 follows 1879 in showing an increase in the percentage of adulteration. Since no reason for this is apparent," etc.

Percentages are sometimes delusive, as will be seen if instead of percentages we take the number of samples, all the analysts examined in each year, and divide it by the number of analysts; and also treat the number of samples said to be adulterated in the same way.

	No. Samples to each Analyst.	No. adulterated.
1875-6	146+	26+
1877	94+	18+
1878	89+	14+
1879	82+	14+
1880	75+	13+

The percentage of adulteration should show a steady increase, and not a decrease, if the work is skilfully done. The inspectors would be very stupid, if they did not soon learn enough about the character of the articles examined, to be able to tell without much examination whether it was worth while to take an article for analysis.

Now, putting the articles in the order in which they were found to be adulterated in 1879, we will take the increase or decrease in the number of samples examined.

	1879.	1880.	
Wine, spirits, and beer	1,615	2,220	+605
Drugs	613	390	−223
Milk	6,036	7,251	+1,215
Butter	969	892	−77
Groceries	4,197	3,895	−302
Bread and flour	1,471	1,326	−125

This shows the curious fact, that, with drugs standing second on the list for 1879, yet there were two hundred and twenty-three fewer samples purchased, while the rest of the list closely follows the percentage of adulterations found;

that is, when an article was found to be much adulterated an increased number of samples was bought the next year.

The increase or decrease in percentages bought was as below: —

Wine, spirits, and beer	+37.46
Drugs	−36.38
Milk	+20.13
Butter	− 7.95
Groceries	− 7.19
Bread and flour	− 8.50

Thus wine, spirits and beer, and milk were found to be promising subjects for investigation, and an increased number of samples were bought; while butter, groceries, bread, and flour had not yielded well, and the number fell off. A certain number of samples will always be complained of by outside parties: hence, if the purchase of the article is stopped, the percentage of adulteration will increase. Since if one hundred articles are examined, and twenty of them prove to be adulterated, this will be twenty per cent, while if but fifty are examined, this fifty being a selected fifty, and fifteen of the samples are adulterated, then the percentage of adulteration will be thirty instead of twenty, although there has been an actual decrease of five adulterated samples.

Of the falling-off in drug samples it might not be very hard to give an explanation. In looking over the numbers of "The Analyst," it will be found that many of the prosecutions were for such things as the use of gypsum in violet-powder instead of starch, the sale of carbonic-acid water as soda-water, the sale of precipitated sulphur containing sulphate of lime, and of cream of tartar containing tartrate of lime. These had all become trade customs, and were most of them mere misuse of names. When prosecutions were commenced, the practice was soon stopped.

In this country, unfortunately, we have but little data to go by for making an estimate of the amount of adulteration.

In 1874 the late John M. Merrick examined one hundred and nineteen samples of groceries for the City Board of Health of Boston, and found, out of the one hundred and nineteen, twenty-three samples that might fairly be called adulterated, some eight or ten of them dangerously so. This is 19.33 per cent.

These were in most cases selected samples, and did not by any means, except in the case of the sugars, represent the state of the market.

Professor H. B. Hill, in 1872–73, made a number of examinations of articles of food for the State Board of Health of Massachusetts: of these he found about half more or less adulterated, many of them injuriously so. No action was taken on his report.

In 1879 Mrs. Richards examined three hundred and sixty-one samples of groceries.

She examined twenty-five samples of flour: these were all found to be free from adulteration.

Seventy-five samples of sugar, which were found to be pure.

Ninety-three samples of bicarbonate of soda, of which twenty-five were found to contain too much sulphate of soda and salt.

Of one hundred and sixty samples of cream of tartar, one hundred and eight were found to be unadulterated.

Or, 22.25 per cent of all the articles examined were found to be adulterated. But in the above list seventeen samples of acid phosphate of lime are counted as adulterated cream of tartar: omitting these we have the percentage of adulteration 17.90. In this, with the exception of alum in the baking-powders, no injurious adulteration was found.

It would have been well to have given the names of the baking powders which were found to contain alum, since nothing hurts the sale of such articles so much as a full publication of the names under which they are sold.

The researches, however, established the fact, that has often been asserted, that New York was the headquarters for adulterated cream of tartar.

In 1880 Dr. Leeds made a report to the New Jersey State Board of Health on the purity of the articles of food as found in that State.

But he does not state the number of samples examined, or the number found adulterated: he simply comes to the conclusion that there has been much sensational writing on the matter.

Occasional investigations have been made in other parts of the country; but no systematic investigation has yet been made in this country, such as is being carried on in England.

In order to do any good work of this kind, it requires some system like that adopted in New York.

Knowledge required. — The food analyst must be a chemist of thorough practical as well as scientific training. He must, as far as possible, be acquainted not only with pure articles which he is expected to analyze, but must have also a knowledge of the various processes through which articles of food pass in preparing them for the market or table. He must also be a man of good judgment, who is not easily led astray by public clamor. He must be very careful, in passing his judgment on an article, that he does not condemn as adulterations those things which are present only as accidental impurities. A chemist, a few years ago, made much trouble for himself by a mere slip of the pen in describing a baking-powder as follows: —

"Analysis showed it to be a mixture of tartrate of potash and carbonate of soda, containing 3.40 per cent of insoluble matter; from this amount of impurity, and the color of the solution, it may be inferred that argols was used in its composition, and not refined cream of tartar, especially as lime was found present."

The analyst was correct in this, that the powder in question was made from argols; but he did not make the statement that he should have made, that refined argols differ from cream of tartar only in color. He was wrong in his nomenclature: he should have said bi-tartrate of potash, and bi-carbonate of soda. And he overlooked the principal cause of the dirty color of the solution, which was due to a small amount of ground hops, added to give a flavor to the bread similar to that imparted by good hop-yeast. The lime is found equally in cream of tartar and argols.

The consequence was, that he was forced to back down from what he had said by the manufacturers, and to acknowledge that the powder that he had undertaken to condemn was equal to any in the market.

The report that he had made was quite a good one, but its value was destroyed by this single blunder, by which he did considerable harm to a firm who were doing a perfectly honest and legitimate business. Besides being a chemist, the analyst must be well acquainted with the practical use of the microscope, as this instrument will enable him to detect many adulterations which it would be almost impossible to find without it.

He should also be quite fully acquainted with the laws on the subject, and the way in which they have been interpreted by the courts, since he will often be placed in positions in which he will have to instruct the prosecuting lawyer in regard to the particular offence committed.

Obtaining Samples. — This is often a matter of some difficulty. In England, and to a very small extent in this country, officers have been appointed whose special duty is to inspect provisions. The inspector of milk and vinegar, and the inspector of meat, in this State, may be referred to as examples.

These officers, unless they act discreetly, are the cause of much ill-feeling. Sumptuary laws have rarely been popular, and as a general rule the people are much more apt to side with the offender than with the officer; it being an axiom almost with most people, that while other grocery-men, milkmen, and butchers may sell adulterated articles, their particular man always supplies them with the best of every thing, and if he did not they would cease trading with him at once. To say that their milkman has been adulterating the milk he brings them, is a reflection on their own good judgment: when, therefore, the officer applies to them to assist him in exposing the fraud, they generally refuse, and side with the milkman or grocer, certain that they at least, if they tell him that the officer is on the lookout for him, will be well treated.

In some cases the law has authorized the officer to take samples for analysis; but this proceeding without the consent of the dealer is unconstitutional, since no man can be deprived of his property without due course of law. The question has also been raised as to whether mere possession with intent to sell constitutes an offence punishable by law. Possession without intent to sell is clearly no offence, and the officer who seizes samples is always liable to be met with the statement that the dealer knew the article was adulterated, and did not intend to sell it.

Very frequently the officer will be given leave by the dealer to take and examine such samples as he wishes, with the statement that he, the dealer, does not know whether they are pure or not; and with the request that he will let him know the character of the articles, promising at the same time to stop the sale if the goods are not genuine. If the officer takes the articles, and finds that they are all right, and so reports, his report is at once used as an advertisement, to the detriment of the dealer's competitors. If they are not right, the dealer keeps quiet about it, and the officer is put in the position that he must either say nothing, or make complaint against a man who has been trying to assist him in enforcing the law, and who has done all he could in furnishing evidence against himself.

Another method still remains to be considered: that is the purchase of samples.

The difficulty in this case is, that in most cases there is no fund for this purpose. The laws in this State providing for the appointment and payment of officers make no provision for the purchase of samples. While merchants may, and do frequently, combine together for the purpose of having certain kinds of goods inspected for their own mutual benefit, they, as a general rule, are opposed to having such inspection forced upon them. They regard it at the best as but a necessary evil; and in most cases it soon becomes inoperative, since the great law of demand and supply is superior to any system of inspection. When the supply is in excess of the demand, adulteration is not practised, or only to a slight extent. On a short market, any thing can be sold that bears the slightest appearance of an approach to the genuine article.

As a general rule, the inspector must have some grounds on which to found a case before he proceeds to procure samples. In the case of milk, for instance, if he finds one man is underselling the rest of his competitors, he must pay particular attention to that man. If he can obtain a sample of his milk directly from him by purchase, it is perhaps best to do so; although in most cases it will be better to obtain the sample through a third party, asking the third party to make a note of the time of purchase, and any other particulars he may deem necessary. The inspector soon becomes known to the men whom he is after, and, if he calls for an article, is furnished with the best. Milk-inspectors are frequently systematically watched and avoided.

In procuring a sample, care should be taken that it is done in such a manner as to fix the fact in the mind of the seller. It is generally sufficient to ask that a bill be given of the same. This serves two purposes: it establishes the fact of the sale, and, so far as it is designated, the character of the article sold.

In a recent case of the sale of adulterated olive-oil, it was claimed that the article was not sold as pure olive oil. But the bill of sale was produced in court; and, as it called for "olive-oil," the judge very properly ruled that olive-oil meant olive-oil, and not a mixture of olive-oil and cotton-seed oil.

Treatment of Sample. — After the sample has been received by the analyst, if it is of such a nature that it can be preserved, it should be divided into two portions. One of these should be placed in a white glass bottle, and properly marked and sealed, in order that it may be shown in court if the case happens to come up. This division and marking should be done in the presence of the inspector who has procured the sample, and he should retain this sealed sample in his possession. The portion retained by the analyst is to be used for analysis. This portion should never be allowed out of his possession for an instant until he has finished his work upon it. And it is best always to keep such samples under lock and key at all times when he is not actually at work upon them.

If the analyst is not perfectly familiar with the article in question, he should procure several samples known to be genuine, and compare the suspected article at every step with these. In general, it is not sufficient to procure a single genuine sample, but several must be obtained, coming from different localities, so that the accidental variations in examples may be, so far as is possible, eliminated. For instance, there is one brand of cream of tartar at present on the market which contains 99 per cent and over of pure cream of tartar, while the average commercial article does not contain over 92 or 93 per cent. If the 99 per cent article was selected for comparison, the other samples would be pronounced adulterated.

But the fact is, that, in the ordinary methods of preparation, 94 per cent is about as pure as it can be prepared; and the very pure article containing over 99 per cent was, until recently, a by-product from the manufacture of chloric acid — the chloric acid being set free by the addition of tartaric acid to chlorate of potassa.

The analyst should also consult whatever books he can obtain in regard to the article in question; bearing in mind, however, that books cannot be used in court, except on cross-examination, and that one case cited from personal experience is worth twenty from the books.

Interpretation of the Results of Analysis. — This is often extremely difficult, for it requires not only a full knowledge of the value of the various determinations made, but also a knowledge of the state of the market, the processes used in the manufacture of the article in question, and a careful discrimination between accidental impurities and foreign substances that cannot be accounted for in any manner except that they must have been intentionally added.

As an instance only, a little while ago some one published a statement that pickles were put up in hydrochloric instead of acetic acid or vinegar; and gave as a proof of it, that several samples of vinegar from pickles, when tested with nitrate of silver, gave a heavy precipitate of chloride of silver. The fact of the precipitate was perfectly correct, only the conclusion was wrong. If he had turned to the first cook-book that he could find, he would have found that nearly all receipts for pickles contain common salt or chloride of sodium as one of the ingredients; and in addition to this many substances are treated with strong brine before they are placed in the vinegar.

It is well also for the analyst to inquire if the adulteration is injurious to health; for the addition to food of an article injurious to health is a much graver offence than the ordinary fraudulent adulterations, such as are commonly found in commerce, which generally consist of inert substances.

The analyst should never allow his zeal to mislead him. His position is a responsible one, and it is his duty to avoid giving needless alarm by asserting that he has found adulteration in articles before he is absolutely certain that he is correct.

In cases which are likely to come into court, it is better to err on the side of too great caution, than to bring a case on insufficient evidence; for one case lost in court by careless management or insufficient evidence will do him and the cause more harm than ten cases gained will benefit them.

The courts soon recognize the officer who comes into court well prepared, and who presents his cases in such a clear manner as to leave no doubts as to his knowledge of the subject.

Classifications of Adulterations. — Adulterations of food may be conveniently divided into three classes, — deleterious, fraudulent, and accidental.

Deleterious adulterations are fortunately the rarest. They are such as are directly injurious to health. Examples: copper in pickles, red lead in cayenne-pepper, arsenical or other metallic colors in confectionery, and water in milk — the latter by diminishing the food value of the milk, and so starving the children who are fed upon it.

In this class must also be placed all sophistications of drugs and medicines, since the physician depends greatly upon the purity of these in regulating the size of the dose: if not of full strength, they do not produce the desired effect, and thus become negatively injurious.

This is the class of adulterations in which the health officers should be particularly interested; and, in endeavoring to frame laws against adulteration, particular attention should be directed to this division in order that it may be accurately and comprehensively defined.

A case was recently lost in Massachusetts because it could not be proved that candy was an article of food in the ordinary acceptation of the term, and, although it was shown that it contained chromate of lead, the defendant was allowed to escape. The law was afterwards amended so as to cover all such cases.

Much trouble in securing convictions for adulteration has arisen from the confusion existing in regard to the nature of the adulteration practised; many persons putting all adulterations without exception into this class.

When asked in court to show how the adulteration was injurious to health, they have been unable to do so, and the case has been lost. This class is the only one in which the adulteration should be regarded as a criminal offence. The aggrieved party in other cases has a sufficient remedy in a civil suit for damages.

Fraudulent Adulterations. — These are such as are either not at all or very indirectly injurious to health, but which are a fraud upon the pocket of the consumer. These adulterations are by far the most common. Many of them have been sanctioned by long usage; and it is generally plead in extenuation of the whole class, that no one is harmed by them, since the buyer, as a general rule, knows what he is purchasing.

To this class belong such articles as package-coffee, which is generally a compound which contains no coffee; salad-oil, which is frequently free from olive-oil, consisting mainly of cotton-seed oil; mustard diluted with flour and colored with turmeric; the mixture of inferior grades of goods with higher grades of the same material, the mixture being represented as being pure and of full strength; the mixture of corn-sirup or glucose with cane-sirup, the mixture being sold as pure cane-sirup; the sale of oleo-margarine or suet-butter as genuine butter; and the adulteration of spices with various inert substances.

These were all frauds in their inception; but, sanctioned by long usage, they have become extremely difficult to deal with.

The health officer may, and should, expose them, so far as he can; but he will find that he can do but little with them in the courts, the law holding, that, when the nature of the article is well known to both buyer and seller, no fraud is committed.

The English statute attempts to meet this case by declaring that every package of such mixed goods shall bear upon it the distinct statement that the article is mixed.

Accidental Adulterations. — This class consists of such substances as are accidentally present in articles of food; i.e., which have not been intentionally added, but which are present, either because they are natural to the article, or because they have been accidentally incorporated in it during the process of manufacture.

This class of substances frequently causes considerable trouble to the health officer; and their presence requires him to possess a thorough knowledge of the process of manufacture or production of the article in question, in order that he may be able to decide whether they are accidentally present or have been intentionally added, or are the result of some manipulation which has been necessary to the proper preparation of the article.

In case these accidental impurities are of such a nature that they are likely to be injurious to health, the article should at once be condemned, and means taken to prevent its doing harm; though in this case it would be hardly just to hold the vender liable to a further degree than is involved in the loss of his property.

To this class belongs the grit occasionally found in flour ground with newly-dressed millstones. Fragments of lead are also occasionally found in flour from the lead used in repairing the millstones.

Another adulteration of this kind is common in wheat, and has caused the millers much trouble. It is the presence of small fragments of iron in the wheat. These come from the wire bands now so extensively used in the West for binding the grain by the so-called self-binders. The removal of these by electro-magnets has shown that these were not the only fragments of iron present; as the magnets not only gather up these fragments, but many fragments of iron coming from the machinery used in threshing and otherwise preparing the wheat for market.

In the same category may be placed the sand found in raw sugars, and the dirt and sand occasionally found in milk. A case recently occurred in this vicinity in which the cows had been bedded with dry sand. During the milking some of the sand dropped into the milk, and occasioned considerable annoyance, as it was found almost impossible to strain it out, and the milkman's business suffered in consequence.

Of the same nature is the dust found in the so-called "overland" teas. This dust is merely powdered tea, which is produced by the constant jarring to which the tea is subjected during its long railroad ride from San Francisco to the East. The tea is pure; but the presence of the dust has more than once served to condemn a fair grade of tea.

Another instance of the same kind was recently observed. In examining a number of samples of Cayenne-pepper the ash was found to be red, and one or two per cent too high; and it was suspected that the pepper was colored with oxide of iron. On examination, however, it was found that the unground pods, in some cases, gave the same color and amount of ash, and that the oxide of iron was probably derived from adhering soil of a ferruginous character. A small amount of tartrate of calcium in cream-of-tartar may serve as another example.

Hassall, in his "Food: its Adulterations, and Methods for their Detection," gives a long list of articles found by himself and others in food. Some of these are hardly likely to occur at the present time; others seem to have been copied from one book to another, without comment or inquiry as to the probability of their occurrence.

A table similar to Hassall's, but with the classification modified according to the above principles, is given below: —

Articles liable to be Adulterated.

Articles.	Deleterious Adulterations.	Fraudulent Adulterations.	Accidental Adulteration.
Arrow-root . .	. . . . . .	Other starches.	
Brandy . . .	. . . . . .	Water, burnt sugar.	
Bread . . .	Alum, cupric sulphate.	Flours other than wheat, inferior flour, potatoes.	Ashes from oven, grit from mill.
Butter . . .	Copper . . .	Water, other fats, excess of salt, starch.	Curd.
Canned vegetables and meat.	Copper, lead .	Excess of water .	Damaged meat.
Cheese . . .	Mercury in the rind.	Oleomargarine.	
Candy and confectionery.	Poisonous colors, artificial essences.	Grape-sugar . .	Flour.
Coffee . . .	. . . . . .	Chiccory, peas, rye, beans, acorns, chefus-nuts, almond or other nut shells, burnt sugar, inferior coffee, dandelion-root.	
Cocoa and chocolate.	Ferric oxide and coloring matters.	Animal fats, starch, flour, and sugar.	
Cayenne-pepper .	Red lead . .	Ground rice, flour, ship-bread, corn-meal.	Oxide of iron.
Flour . . .	Alum . . .	Ground rice . .	Grit and sand.
Ginger . . .	. . . . . .	Turmeric, cayenne pepper, mustard, inferior ginger.	
Gin	Alum, salt, spirits of turpentine.	Water, sugar.	
Honey . . .	. . . . . .	Glucose, cane-sugar.	Pollen of various plants.
Isinglass . .	. . . . . .	Gelatine.	
Lard . . .	Caustic lime, alum.	Starch, stearine, salt.	

Articles liable to be Adulterated. — Continued.

Articles.	Deleterious Adulterations.	Fraudulent Adulterations.	Accidental Adulteration.
Mustard . . .	Chromate of lead, lead.	Yellow lakes, flour, turmeric, cayenne.	
Milk . . .	Water . . .	Burnt sugar, annotto.	Sand, dirt.
Meat . . .	Infested with parasites.	. . . . . .	Tainted.
Horse-radish . .	. . . . . .	Turnip.	
Fruit-jellies . .	Aniline colors, artificial essences.	Gelatine, apple-jelly.	
Oatmeal . . .	. . . . . .	Barley . . .	Old and wormy.
Pickles . . .	Copper, alum.		
Preserves . .	Aniline colors .	Apples, pumpkins, molasses.	
Pepper . . .	. . . . . .	Flour, ship-bread,	Sand.
Sago . . .	. . . . . .	Potato-starch.	
Rum . . .	Cayenne pepper, artificial essences.	Water, burnt sugar.	
Sugar . . .	Tin, lead, gypsum.	Rice-flour . .	Iron, sand, insects dead and alive.
Spices . . .	. . . . . .	Flour, starch, ship-bread, peanut-shells.	
Cloves . . .	. . . . . .	Arrow-root.	
Cinnamon . .	. . . . . .	Spent bark.	
Pimento . . .	. . . . . .	Ship-bread.	
Tea . . .	. . . . . .	Foreign leaves, spent tea, plumbago, gum, indigo, Prussian blue, China-clay, soap-stone, gypsum, magnetic iron ore.	
Vinegar . . .	Sulphuric, hydrochloric, and pyroligneous acids.	Burnt sugar, water.	
Wine . . .	Aniline colors, crude brandy.	Water . . .	Sulphate of potassa.

The above list is a formidable one, but fortunately the majority of articles sold in our markets are not adulterated with any injurious substances; and in giving the list I do not wish to be understood as saying that these adulterations are frequent or even common. But many of them have been met with recently, either in this country or England; and the health officer would do well to be on his guard against the entire list.

Arrow-Root. — The only substances which are likely to be used in the adulteration of this article are "terra-alba," which may be China-clay or gypsum, and other starches.

The former may be easily detected by igniting five grams of the arrow-root, and weighing the ash. The ash of a pure sample of arrow-root should not exceed a few tenths of a per cent. If the ash is larger than this, it should be examined for gypsum and silicate of alumina in the usual way.

Other starches are detected by the microscope, a pure arrow-root being used for comparison. The most common adulteration is potato-starch.

It may be observed in this connection that arrow-root is the starch of several different plants, and care must be taken in comparisons that the arrow-root from the same plant is used as a standard.

Brandy.— This when genuine is the dilute alcohol distilled from wine. As sold, however, it is rarely genuine, being in almost every case tampered with in some manner.

When it is the product of the grape it is frequently made from the fermented husk or marc left after the wine is pressed: this yields an article which is very much inferior to the genuine. A large portion of that found in the market is made from so-called neutral spirits, which are merely alcohol which has been rectified by passing over wood-charcoal. These neutral spirits are colored with burnt sugar or caramel (known to the trade as "French color"), and flavored with oil of cognac; a little catechu is then added, so as to imitate the taste of the "wood;" and finally a little simple sirup, or in some cases glycerine, so as to take off the rough edge, and impart a smooth taste. In this country the spirits used are generally free from any objectionable ingredient, as the alcohol made from corn-whiskey is generally very pure. The foreign or British brandy made from potato-whiskey is more objectionable, since it is apt to be poorly rectified, and to contain considerable fusel oil.

No proof has been advanced, however, that these manufactured articles are any more deleterious than the genuine brandy. The essences and other materials used in the manufacture are such close imitations of the extracts found in the true article, that it is extremely difficult to detect them; and all that can be done is to see that the article is free from excess of fusel oil. The most ready test for quality in a brandy is to observe the taste and aroma; and also to evaporate a small quantity on the hand, and observe the taste and odor of the substance which remains after the alcohol has evaporated. Good brandy should evaporate completely, and leave no disagreeable odor on the hand. If it leaves the hand moist and sticky, either sugar or glycerine has been added.

It is a good plan to evaporate 50 cc. in a platinum dish, and weigh the residue. The residue can then be tested by tasting for cayenne-pepper, sugar, glycerine, or other impurities. Brandies as found in the market generally leave a decided residue, which, however, rarely amounts to over one per cent. The brandy should also be tested for alcoholic strength; this can be done with sufficient accuracy in most cases by taking the specific gravity directly without distillation. If, however, it contains much over one per cent of sugar, it should be first distilled, and the specific gravity of the distillate determined.

Good brandy generally contains from 56 to 60 per cent of alcohol.

Whiskey is examined in the same manner as brandy.

Bread. — The chief complaint in regard to bread is that the loaves sold are light in weight.

The law in this State requires that a loaf of bread shall weigh thirty-two ounces. As a matter of fact, it is rarely found that bread holds out in weight. Some samples weighed in Boston a few years ago weighed from nineteen to thirty ounces. That weighing nineteen ounces was the best; and the baker claimed that, as he used the best flour, he was entitled to make a light-weight loaf. The law does not regulate the price of the loaf, but it does the size.

The bread sold in the poorer class of shops is apt to be dark in color, sour, and consequently heavy.

The most common adulteration is by means of potatoes. When flour is high, and potatoes low, bakers use potato-yeast to a considerable extent. There is nothing injurious in this use of potatoes, except that the bread is thus enabled to hold more moisture, and the consumer buys a little more water.

The controversy on the use of alum in bread is very old, and still continues in England.

Accum in 1820 mentions its use in London, but gives but very imperfect means for its detection.

Mitchell, in 1848, says that in ten samples of bread examned by him the amount of alum varied from 34½ grains to 116 grains to the four-pound loaf. This would give from 8⅝ to 29 grains to the pound, or in per-cents from .0123 to .0414 per cent.

He gives the following process for its detection, or rather for the detection and estimation of the alumina: "Digest the finely divided bread for an hour or two in distilled water, strain through a linen rag, and wash the residual bread with a little more distilled water. Mix the washings with the first strained liquid, and filter through paper, to obtain a bright solution, which evaporate nearly to dryness; re-dissolve in a little water, and filter; add to the solution caustic ammonia; alumina will fall, which collect and weigh;" and adds, "every 100 grains of alumina corresponds to about 467 grains of alum." This last figure is incorrect; it should be 448.1 grains. The process is not accurate, since there is no guaranty that you can extract all the alum from the flour by this means. Some of the alumina by the action of the heat, and of the ash of the flour is no doubt rendered insoluble.

Hassal, in his first edition, London, 1851, says, "First char one thousand grains of the flour or bread, then boil in a flask with four drachms of nitric acid, four of hydrochloric acid, and four of water; evaporate to dryness; when cold add one ounce of distilled water, and boil for a few minutes; while boiling dilute with two ounces of liquid potassæ, and boil again for a few minutes; then filter, neutralize with hydrochloric acid, and precipitate with ammonia. The precipitated alumina should be washed, dried, ignited in a platinum dish, and weighed."

He then gives a list of twenty-eight samples of bread which he claims were adulterated with alum, but gives no quantitative results. In his second edition he describes the same process, and refers to the process employed by Mitchell as utterly fallacious.

Perhaps the doctor, by the time he wrote his third edition, came to the conclusion that the method employed by himself was "utterly fallacious" also; for, while still referring to the twenty-eight samples of bread in which alum was detected in 1851, in 1875 he gives the following method: "The bread is ignited, then boiled in a platinum basin with some strong hydrochloric acid, and evaporated to dryness to render insoluble any silica which might have been in solution. The dried mass is moistened and heated with a few drops of strong hydrochloric acid; 50 cc. of water are then added, and the solution which contains the alumina as chloride of aluminum is filtered. The filtrate is rendered strongly alkaline by a solution of *pure* potash. The potash precipitates the phosphates of lime and magnesia, while the alumina is kept in solution. The alkaline solution is boiled, and after filtration is slightly acidulated with pure hydrochloric acid, and then ammonia is added until the solution is decidedly alkaline. If any precipitate is thrown down, this consists of alumina, more or less combined with phosphoric acid." Then follow directions for separating the phosphoric acid from the alumina, so as to get the true weight of the alumina.

It will be observed that since 1857 the doctor has discovered that the ash of bread may contain soluble silica, and that the precipitate which he described as alumina may consist of phosphate of alumina.

He goes on to say that the best way to estimate the alumina is to add a few drops of phosphate of soda before precipitating with ammonia.

This last method will undoubtedly give the amount of alumina in bread. In practice, however, I prefer to use the method proposed by Messrs. Dupee & Wanklyn, which avoids the use of potash, which it is difficult to obtain pure. The ash is prepared in the same way as for the above method. After the separation of the silica a few drops of phosphate of soda are added to the solution, then ammonia in excess. The precipitate, which always forms, consists of phosphates of lime, magnesia, iron, and alumina. An excess of acetic acid is now added, and the liquid is brought to a boil. The lime and magnesia phosphates are soluble in acetic acid, while the phosphates of iron and alumina are insoluble. The precipitate is filtered off, ignited, and weighed. If it contain much iron this is estimated volumetrically, being first reduced by zinc.

Bread free from alum will give a precipitate of from .005 to .013 per cent. This larger amount should therefore be subtracted from the weight of the phosphate found, and the remainder multiplied by 3.733 gives the per cent of ammonia alum in the bread; or, if potash alum is used, then the factor should be 4.481.

Example: a certain bread gave .120 per cent of phosphate of alumina.

$.120 - .013 = .107$ per cent of phosphate of alumina.

.107 × 3.733 = .399 per cent of alum used; or, a two-pound loaf would contain 54.86 grains of alum.

Dr. Dupee, in "The Analyst," vol. iv., 1879, gives the amount of alumina he has found in ten samples of flour. He also gives the amounts of silica found. His table is given in number of grains of alumina in four pounds of the flour. Reducing these to per-cents we find that his lowest amount was .0021 per cent, while his highest result was .0133 per cent, corresponding to .005 per cent and .0316 per cent of phosphate of alumina respectively; which corresponds to about from 1.05 grains to 6.636 grains in the four-pound loaf, or, calculated as ammonia alum, from 3.95 to 25.86 grains of alum in the four-pound loaf, if we allow that the four-pound loaf contains three pounds of flour.

In 1878 I examined a number of samples of bread from the vicinity of Boston, to see if alum could be detected in them. The largest result expressed in phosphate of alumina was .013 per cent. This was far within the limits that alumina might exist in the bread, from other sources than alum. Professor Leeds, in a report to the State Board of Health of New Jersey, says he found in three loaves a weight of alumina corresponding to 8, 15½, and 23 grains respectively, of alum. This, it will be seen, is still within the limits of alumina found by Dr. Dupee in pure flour.

Some of the fancy crackers and ginger-snaps in the market are said to contain considerable alum.

If the ash of bread or crackers rises above two per cent, it should be examined for mineral impurities.

It has been claimed that bread is adulterated with sulphate of copper; and Dr. E. Waller found in many samples of bread he examined minute traces of copper, but upon further examination came to the conclusion that the minute amounts found might be derived from the vessels used in cooking, or from the materials used in making the bread. He found that potatoes, white and yellow Indian meal, all contained minute traces of copper.

Butter. — In this country, until recently, butter has been free from adulteration, though occasionally a sample has been met with containing starch.

The most common impurities met with in genuine butter are excess of water and salt. Good butter when freshly cut should not show any cavities containing discolored water, and should not, on analysis, give over nine to twelve per cent of water. Fresh butter should not contain more than three per cent of salt. Salt butter may contain as high as one ounce to the pound ; any amount above this should be considered an adulteration. Butter poorly prepared is apt to contain a little curd, and some buttermilk. A butter that is intended for storage for winter use should be free from both these substances, since they serve to render it rancid much sooner than it would be in their absence. They may be detected by examination of the butter with the microscope, or by melting the butter in a test-tube at a gentle heat, and allowing it to stand for some time in a place heated to about 110° Fahrenheit, when the buttermilk, water, and curd will settle and form a layer under the fat.

The *amount* of water may be determined by drying two or three grains of the butter over the water-bath in a flat platinum dish, for two or three hours.

The amount of curd may be ascertained by dissolving the dry fat in benzine, and weighing the residue on a dried filter. This is ignited, and the amount of ash determined and subtracted from the total weight of the residue on the filter: this gives the weight of the curd. The ash may be all reckoned as salt. The analysis of some of the brands of butter sold in the Boston market gave the following results : —

	Fat.	Water.	Curd.	Ash.
Alderney	87.78	9.44	2.02	.76
"	87.89	9 94	2.68	1.49
"	86.95	9.52	1.65	1.88
Common bakers'	87.14	9.88	1.90	1.08

If the amount of matter insoluble in benzine is large, it should be examined by the microscope, and by testing with iodine, for starch. It is said that soapstone or steatite in the form of a fine powder has been used for adulterating butter. If this is used to any extent it may be readily detected by dissolving the ash in water, when it would remain insoluble.

The presence of other fats than butter fat is sometimes suspected, but no very satisfactory tests have yet been found for the same. Most of the tests given in the books proceed on the assumption that some special fat is used, and directions are given to test butter by its melting-point flavor and odor; on heating, all of these tests may in certain cases mislead.

The closest imitation of butter yet made is undoubtedly the oleo-margarine of M. Mégé. This, when properly made, agrees with butter in its melting-point. It is a little deficient in flavor, but not more so than many samples of butter. If carelessly made it may contain traces of membrane, which are represented by the curd found in common butter. It may also show crystals of the stearates, but old butter frequently does the same; and butter that has been melted always shows crystals. The most satisfactory test proposed for the presence of foreign fats in butter is the determination of the amount of soluble fatty acids in the sample. Butter contains, besides the stearate, oleate, and palmate of glycerine, about six or seven per cent of the butyrate of glycerine. The acids of the first three bodies are insoluble in water, while the acid of the butyrate is soluble.

Pure butter fat should yield about 88 per cent of insoluble acids, and 6 per cent of soluble acids; while all the other fats give about 94 to 95 per cent of insoluble acids.

The examination is made by first melting the butter, and allowing it to settle while in the melted state. About three or four grams of the pure fat are taken and saponified with a concentrated solution of potash. It will be found advantageous to use alcoholic potash for this purpose. When the saponification is completed, the soap is evaporated until the alcohol is driven off; it is then dissolved in water, and decomposed by dilute hydrochloric or sulphuric acids.

The fatty acids are then thoroughtly washed with boiling water: this is most conveniently done at first by decantation; the water being poured on to the fat which is placed on a separatory funnel, or in a beaker: in the latter case the water is removed from under the fats by means of a pipette. When the fatty acids have been well washed, they are transferred to a weighed filter, the filter having been previously wet with water. After the fatty acids have been completely transferred to the filter, it is placed on a watch-glass, and dried at 100° C. until it ceases to lose weight.

If the operation is carefully carried out, it gives good results.

Butter intended for the Boston market is very generally colored; this is done sometimes with carrot-juice, but most commonly with some preparation of annatto. The color for this purpose is made by heating the annatto seed with caustic soda or potash. The seed produces a much brighter color than that obtained from the cake. An oil color has been recently introduced into the market, which is made from cotton seed, or some other neutral oil, colored with annatto and turmeric: this color is preferred by many, since it does not color the buttermilk. The use of these various colors in butter is a fraud in so far as it is an endeavor to make pleasing to the eye an otherwise uninviting article. But it is a fraud which is sanctioned by long usage, and which is not only harmless, but adds to the comfort and pleasure of the user.

The legislature of New York showed a keen appreciation of this point when they passed a law last winter forbidding the use of any coloring matter in oleo-margarine, well knowing that if it was not colored no one would use it as butter. The bill was vetoed by the governor as conflicting with patent-rights, but was again passed with a clause exempting patented articles.

The use of substitutes for butter seems to be steadily on the increase in this country. When good butter is at from forty to fifty cents per pound, it has passed beyond the means of persons in moderate circumstances, and they have the choice of three things, — to do without, to use poor butter, or to use some substitute.

It was, according to Mégé-Mouriez, a demand such as this which led him to investigate the manufacture of a palatable substitute for butter from the fat of animals slaughtered for food. By his investigations he was led to believe that the only difference between butter and beef-fat was that the latter contained an excess of stearine. He also came to the conclusion that the taste and smell of ordinary tallow was largely due to the want of care in its manipulation. He therefore prescribed the following method of procedure: —

The caul fat was to be taken as fresh as possible, and to be thoroughly washed, then chopped fine and rendered with a dilute solution of acid phosphate of lime, and the stomach of a pig or sheep at a temperature not exceeding animal heat. (This heat has been gradually raised in re-issues of his patent, until, at the present time, it reads, "at a heat not exceeding 125° F." It is not possible to do good work at a temperature below 116° F.) After the fat is completely liberated by this process, it is then allowed to stand until the membrane settles; it is then drawn off into coolers, and allowed to granulate and to cool to a temperature of about 80° F. The fat is then placed in cotton-cloth press-bags, and submitted to a powerful press, the press-room being maintained at an even temperature of 80° F. The oleo-margarine thus produced is free from any disagreeable taste or odor. It is in fact a pure tallow oil, suitable for use as an article of food; in this state it makes an excellent substitute for lard.

To manufacture this into an imitation butter, it is mixed with a fiftieth part of mammary tissue (which is the udder of the cow minced fine), a hundredth part of bi-carbonate of soda, a fiftieth part of curds of milk, and some coloring matter, and agitated at animal heat for three hours; it is allowed to settle and cool, "when the butter will be good and capable of being preserved."

Such was the process as originally proposed by M. Mégé. The process as now followed is much more simple, and omits some of the objectionable features of the Mégé process.

In the first place, the fat which is received warm from the slaughter-house is sorted over, and all bloody pieces thrown out; it is then at once placed in cold fresh water, where it is thoroughly washed. From this water, which not only washes it, but serves to cool it, it is at once taken to hashing-machines, similar to the ordinary sausage-cutters, where it is cut into fine pieces. From these machines it falls at once into the rendering-tanks, where it is rendered at a heat varying from 160° to 200° F.; the object being to separate, as quickly as possible, the fat from the membrane. No "gastric juice" or phosphate of lime is used. After the fat is well cooked a quantity of salt is added: this serves to separate the membrane more completely. After standing a few minutes the fat is then run off into barrels or other vessels, where it is allowed to settle, and is crystallized. When it has cooled to about 95° to 100° F., it is pressed in the usual manner.

After pressing, the oil is churned with sour milk, or buttermilk, some genuine butter being frequently added; it is colored properly, and then run into ice-water, or pounded ice, so as to prevent its crystallization; after this operation it is worked as ordinary butter.

When well made it is a very fair imitation of genuine butter; being inferior to the best butter, but much superior to the low grades of butter too commonly found in the market.

So far as its influence on health is concerned, I can see no objection to its use.

Its sale as genuine butter is a commercial fraud, and as such very properly condemned by the law.

As to its prohibition by law, the same law which prohibited it should also prohibit the sale of lard and tallow, and, more especially, all low-grade butters, which are far more injurious to health than a good sweet article of oleomargarine.

A great deal has been said in regard to the poor grade of fats from which the oleo-margarine is made. Any one making such assertions in regard to the fats is simply ignorant of the whole subject. When a fat has become in the least tainted it can no longer be used for this purpose, as it is impossible to remove the odor from the fat after it has once acquired it.

Canned Vegetables and Meat. — Frequent cases have been reported of late years of sickness arising from canned meats; the cause seems mainly due to improper methods of canning, or to the use of meat that was tainted before it was canned. Unfortunately we can do nothing in this case by inspection of the meat, for it generally appears to be all right.

An examination of the outside of the can is the only guide we can have in the purchase of this class of articles. The heads should be slightly concave. This shows that they were hot when sealed, and that the seal has remained unbroken. If the heads are convex, it shows that decomposition has commenced in the can.

Sometimes, through careless soldering, or the use of terne-plate in making the cans, the article preserved becomes contaminated with lead. As this, at most, exists only in small quantities, its detection is often a matter of difficulty.

The best method of proceeding is to destroy the organic matter, either with aqua-regia or chlorhydric acid and chlorate of potassium, then pass hydrogen sulphide through the dilute solution, filter and examine the precipitate in the usual manner for tin and lead.

Copper is also occasionally found in these goods. It may be detected by the same means as are used for tin and lead.

Copper is to be particularly looked for in canned vegetables and pickles, which were formerly very generally colored with this metal. French peas are, in particular, to be looked upon with suspicion. Another fraud practised in these goods is light weight, and the addition of too much water, or sirup, to the contents.

Cheese. — This product consists essentially of the butter and caseine of milk. The cheese generally used in this country is the product of the milk of the cow.

Cheese is made by coagulating the milk by means of rennet, or more rarely by the use of acetic acid. Whichever method is used, the milk soon separates into two distinct parts, — the curd, which consists of caseine and butter; and the whey, which is a solution of milk-sugar, and the salts of the milk containing some albumen.

The whey is separated from the cheese by proper means, and then the curd is pressed and allowed to ripen. The various grades of cheese found in the market depend on the methods of treatment used in their manufacture, for their peculiar flavor and consistency.

It is a curious fact that the very flavor which is prized in cheese renders butter unfit to be eaten. All yellow cheeses found in the market are colored, fashion in this case as well as in butter demanding that the cheese shall not be white. The same materials are used for coloring that are used in the case of butter.

Recently it is said that oleo-margarine, lard, and cotton-seed oil have been substituted, to some extent, for the genuine butter fats that should be present in cheese. The method of doing this is to allow the milk to stand for twelve hours, then skim off the cream that has arisen, warm the skim-milk to about 100° F., add the oil or melted oleo-margarine, then thoroughly mix, and proceed in the usual way. The detection of this fraud is extremely difficult, if not impossible. The most promising way of detecting it is to dissolve the fats out of the cheese with ether or benzine, and then to make an analysis of them in the same manner as is used in the examination of butter.

The analysis of cheese is made by taking two or three grams shaved in thin slices, drying it on the water-bath until it ceases to lose weight, then boiling it with benzine until the fat is extracted, and weighing the residue. The residue is ignited, and the ash determined. The composition of good American cheese, according to Blyth, is about as follows: —

Water	22.59 to 31.80 per cent.
Fat	35.41 to 28.70
Caseine	37.20 to 36.00
Ash	4.80 to 3.50

Skim-milk cheese will show much less fat, and a larger proportion of caseine.

Sage-cheese is colored with chlorophyl, and flavored with sage. It is customary to color only a portion of the curd, and then to mix this through the mass so as to give it a handsome mottled appearance. This cannot be regarded as an adulteration, as it comes under the head of those harmless operations which are done to please the eye or suit the taste of the consumer.

Cases have occurred in which the cheese has undergone a peculiar fermentation which renders it poisonous: whole families have been seized with violent pains and vomitings after eating such cheese. This peculiar condition seems, however, to be of rare occurrence.

Something analogous has been observed in certain cases in ice-cream which has been kept too long before being used, and also in milk.

The rind of cheese is frequently washed with arsenical or mercurial washes to protect it from the flies. It is always safest, therefore, never to eat the rind.

Neuchatel cheese is simply the unripened curd from which ordinary cheese is made.

Candy and Confectionery. — No article of food is so liable to be injuriously adulterated as candy, and all kinds of confectionery. Even the perfectly white candy, which is free from injurious coloring matters, is frequently flavored with fusel-oil (essence of banana), oil of bitter almonds, or essence de mirabane (nitro-benzole), prussic acid in various forms known as almond flavor, and various other essences and extracts which are poisonous in their nature, and which are used in large excess by the makers in order to give a strong flavor to the article. Various pigments of a poisonous nature have been found in candies by different investigators from time to time: these. fortunately, seem to be becoming more rare of late years, since public attention has been directed to this subject.

A long list of such colors may be found in Hassall, or in the Proceedings of the American Pharmaceutical Association for 1878.

The vegetable colors can frequently be identified by dyeing pieces of mordanted cotton cloth with them in a bath slightly acidified with acetic acid.

The aniline colors are easily identified by dyeing unmordanted wool in a neutral or slightly acid bath. Mineral colors must be sought for by the usual methods of qualitative analysis. In order to identify coloring matters, Bolley's Manual may be studied with advantage.

Glucose is largely used in all grades of candy, in the highest-priced as well as the cheapest. Candy containing glucose should be carefully examined for free sulphuric acid and for excess of lime or sulphate of lime, since the glucose of the market sometimes contains an excess of these bodies. The glucose itself is harmless: it is only the impurities that are to be feared. "Terra-alba," which may be either gypsum or China-clay, is frequently found in certain kinds of cheap candy, such as conversation-lozenges. They are to be sought for in such candies as have a very white, opaque appearance. Flour is sometimes classed as an adulterant; it is very apt to be present, as it is used for various purposes in the manufacture of candy. It is harmless, and less injurious than the sugar. Its use, even in excessive quantities, can only be condemned on the ground that it is a fraud so far as it is used as a make-weight. The frosting on cake, being of the same nature as candy, is subject to the same adulterations and frauds.

The polariscope is the best means for the detection of glucose in candy. (See Sugar.)

Very frequently papers colored with Paris green, or the aceto-arsenite of copper, have been used as a covering for rolls of lozenges, and such papers are almost universally used to make the leaves with which cake is ornamented. Such a practice cannot be too strongly condemned.

Coffee. — This article is rarely, if ever, injuriously adulterated. The fraudulent adulterations, however, are numerous. The sophistications commence with the whole berry, which is polished and variously manipulated so as to deceive the consumer as to quality. The berry itself has been imitated, according to some authors, though this story seems about on a par with wooden hams and nutmegs.

There was a patent granted in England some thirty years ago, for compressing chiccory into shapes resembling coffee-berries; but any one who could be deceived by such imitation must be very innocent.

The berry is sometimes weighted after roasting, by subjecting it to a current of steam while it is still warm.

On the other hand, the so-called package-coffee rarely contains any coffee. Many coffee-drinkers are satisfied if they have some warm drink with their meals. If this drink is dark-colored, and tastes bitter, so much the better.

The delicate aroma of good coffee is utterly unknown to them, or, if known, is not valued sufficiently to take any exertions to obtain it. Their idea of the strong coffee is that it is a very dark-colored, bitter liquid.

The preparation of a cup of good coffee is exceedingly easy, yet how rarely is it seen!

Coffee is best prepared for the table by percolation, and it should never be boiled. Mr. Allen, of the Oriental Tea Company of Boston, has devised a neat piece of apparatus for this purpose. It consists of a large tin can, which is filled with water: inside of this the coffee-pot proper sits, so that it does not come in direct contact with the heat, but is surrounded by boiling water. Inside of this pot is a third funnel-shaped vessel or percolator, with a lid. The lower end of this vessel is closed with a stout piece of cloth tied over it. The ground coffee is placed in this vessel, it is then filled with boiling water, and the whole apparatus is set on the stove. At the end of fifteen minutes the whole of the water has percolated through the coffee, and you have in the pot a clear bright decoction, containing all the valuable part of the coffee, and also retaining all the aroma.

To obtain a good cup of coffee, it is of course necessary to start with good materials.

So-called essence of coffee consists mainly of burnt molasses. Package coffees are composed largely of peas, chiccory, and rye roasted and ground. A small nut of unknown origin, called "chefus-nut," is occasionally to be met with. Castana-nut shells have also been used. Almond-shells treated with molasses, and then roasted to convert the molasses into caramel, make a fair imitation.

The best method of detecting these articles is to become thoroughly familiar with the appearance of genuine ground coffee under the microscope, — low powers being used such as two and three inch objectives, — and then to compare the suspected articles with the genuine.

Throwing the suspected article on cold water, and stirring it around so as to separate and wet each particle, will frequently serve to detect the adulteration.

Pure coffee swims much longer than any of the ordinary adulterations, and only colors the water slightly and but slowly.

Chiccory sinks, and colors the water rapidly; peas sink, and color it only slightly; rye colors rather more than coffee, and sinks more quickly.

Chiccory is largely used by hotels and restaurants to give the dark color and bitter taste to the solution, and so satisfy their customers, who think that color is an indication of strength.

The grains of ground coffee are hard, and crumble between the teeth; ground chiccory is softer, and does not crumble. Peas and rye are easily recognized by the naked eye, from the shape of the fragments.

Cocoa and Chocolate. — The chief adulterations in these are starch and foreign fats, and oxide of iron in various forms as a coloring material.

Sugar, starch, and flavoring materials are legitimate in chocolate, since it is a manufactured article, and is understood to be such. The oxide of iron can be readily detected in the ash; the flour or starch, by first extracting the fat with benzine or ether, then treating the residue with cold water to dissolve out sugar, and examining the insoluble portions by means of the microscope for starch grains, and testing for them by means of tincture of iodine.

The foreign fats are detected by evaporating the benzine used in dissolving them, and then determining the melting point of the fat. This, however, will only serve to detect tallow. The cocoa fat has a melting point of 35° C., while tallow melts about 8° or 10° higher.

This difference in melting point, however, disappears when a properly prepared specimen of tallow-oil or oleo-margarine is used for the adulteration.

Wanklyn recommends that the ash be determined, and says that genuine cocoa should yield about 3.40 per cent of ash. For the examination of mixed cocoas and chocolates he makes a cold aqueous solution, and then determines by evaporation the amount of soluble matter in it, and ignites the residue, and determines the ash. A genuine cocoa gave him, —

	PER CENT.
Dry extract	8.92
Ash	2.16

While a mixed cocoa gave, —

Dry extract	46.04
Ash	1.04

It is said that when the fat is extracted from cocoa, and exposed to the air, it will remain sweet a long time if genuine; while if it contains foreign fats it will speedily become rancid.

Flour. — This is extensively sophisticated in England and Europe, but observers have almost uniformly reported it to be free from adulteration in this country. The most trouble found with it is from its being made from a poor quality of wheat, or improperly ground and stored.

Flour having these defects makes dark-colored, heavy bread.

Occasionally a sample of flour is met with which has been adulterated with rice or Indian meal; but such samples are not at all common.

Both of these adulterations can be readily detected by careful washing with water: the rice and corn flours, being heavier, sink to the bottom, when the flour and water may be poured off, and the residue be examined by the microscope. Alum may be detected by shaking up the flour with chloroform. The flour, being lighter than the chloroform, swims at the top; while the alum and other mineral impurities sink, and may be examined by the microscope. If not detected, or as confirmatory, the residue may be dissolved in hot water, and tested for sulphuric acid and alumina.

Genuine flour yields from ½ per cent to 2 per cent of ash; if it exceeds the latter amount, mineral adulterations may be suspected and searched for.

The flour-dealers test flour by kneading up a little of it with water, and observing the toughness of the dough.

Ginger. — This article is generally sold of two grades, — the pure and the so-called "yellow ginger." The latter is mixed with about half its weight of turmeric, and is used for coloring and flavoring gingerbread.

Very frequently other kinds of ginger are sold for pure African ginger; and it is adulterated by flour, and strengthened by mustard and cayenne-pepper.

The appearance of ginger under the microscope is very characteristic.

Honey. — This is frequently adulterated with glucose. The fact that it is sold in the comb is no guaranty of its purity, since the bees themselves are employed to store the glucose in the cells. And it has been stated that this fraud has been carried a step further, and that the bees have been furnished with ready-made cells of paraffine, which they proceed to fill with glucose, and then seal over with genuine wax.

The wax may be examined by melting it over water so as to free it completely from honey, and then determining its specific gravity and melting point. Genuine beeswax melts at about 142° to 144° F., and has a specific gravity of from .958 to .960, water being 1.000.

Glucose, or starch-sugar, is best detected with the polariscope. The normal weight of honey — 16.26 or 26.048 grammes of the honey, according to the instrument — is weighed out and dissolved in water, and made up to one hundred cubic centimetres. This solution is filtered and polarized. Genuine honey always polarizes to the left, or in the opposite direction to cane-sugar. According to Dr. J. C. Brown, the polarization is from —3 to —5½ at 15° C. I have found in three samples, two of which were extracted from the comb by myself, a polarization of —10° to —11° at 20° C.

According to Dr. Brown, the water in honey lost on drying at 100° C. varies from 15.5 to 19.8 per cent.

Any adulteration with starch glucose would be shown by the polarization being positive instead of negative.

Cane-sugar is shown by polarizing to the right: on inversion with acid in the usual way, the polarization becomes left-handed. Genuine honey has almost no cane-sugar in it, and is only changed three or four degrees by inversion.

Lard. — Lard should melt to a clear fat without sputtering, should dissolve completely in benzine, and should be free from any burnt odor or taste. It is frequently adulterated with alum and lime-water to improve its color and to add to its weight. Pure lard should contain only the kidney fat of the hog. Much of that sold in the market contains fat from all parts of the animal. It is sometimes adulterated with starch; this is easily detected by examining the residue, insoluble in benzine, with iodine and with the microscope.

If the lard is intended for export to Southern ports, it is hardened with stearine, thus raising its melting point.

Mustard. — This is sometimes colored with chromate of lead to give it a bright color: the presence of the metal may be detected by the ordinary tests for lead. It is also colored with turmeric, which may be detected by the microscope, and by turning brown when treated with an alkali. It is weighted with sulphate of lime, which is shown by increased weight of ash, and also by the usual tests for sulphate of lime. Genuine mustard yields about six per cent of ash. Some authors have recommended that the amount of oil in mustard be determined. Blyth says genuine mustard contains from 33 to 36 per cent of oil. Many manufacturers, however, press out as much of the oil as possible after the seed is crushed, alleging that it keeps better, and makes a finer article for table use.

This, of course, would render any comparison of the amounts of oil with that contained in the genuine article worthless.

The lime lake of Persian berries is sometimes used as a coloring re-agent. The best method of detecting this is to slightly acidify the mustard stirred up with water, and to dye some wool with it. Pure mustard will give only a faint tinge to the wool, while the Persian berries give a decided yellow.

Mustard sold ready mixed for the table is never simple mustard and vinegar, but always contains more or less flour, and is frequently colored with turmeric. It is not worth while to spend much time over articles of this description, except to ascertain whether any poisonous ingredients are contained in them.

Cayenne-Pepper. — This is said by Hassall to be colored with red lead, but recent observers have failed to find it. It is sophisticated with rice-flour, salt, and ship-bread. These may all be detected with the microscope. The ash is found to sometimes contain one or two per cent of oxide of iron: this is evidently an accidental impurity, since the unground pods are frequently colored in the same way. The ash of cayenne varies from four to seven per cent.

Horse-Radish. — Much of the grated horse-radish that is sold consists largely of turnip. Turnips cost much less than the genuine horse-radish, and the mixture is more palatable.

Fruit-Jellies. — Many of these are what they purport to be only in name, being made from apple-jelly colored and flavored to suit the name. Gelatine is said to be the basis of some of them.

The coloring matters used are sometimes quite objectionable, and this is true of most of the flavors used.

The safest course to pursue in regard to them is not to use them unless the source from which they come is known, and known to be trustworthy.

They should always be carefully examined for copper, since they are sometimes contaminated with this metal derived from the vessel in which they are cooked.

Milk. — This substance is perhaps the most important article of food entering into daily use, since it forms the entire or almost the entire food of children at an age at which they are little able to withstand any tampering with their nourishment. Milk analyses may be divided into two classes, — first, the very elaborate analyses that were made some twenty or thirty years ago, and which gave the exact composition of the milk with full analyses of the ash, dividing the albuminoids in the milk into caseine and albumen, and giving the composition of the butter fats. Such an analysis as this, while interesting from a scientific point of view, has but little practical importance.

The second class of analyses were those instituted by Wanklyn, in which the endeavor was made to determine sharply some of the most important constituents of the milk, and, from these determinations, to judge whether the milk was adulterated or not. In this method of analysis the endeavor is rather to make certain determinations that can be quickly and easily made, and which can be made with such accuracy that there can be no reasonable doubt in regard to them, than to make a full and exhaustive analysis. The determinations usually made are the following: cream, specific gravity, total solids, fat, sugar, ash, and caseine; the latter is generally found by difference, and includes the albumen.

The English public analysts have adopted the following as the method of analysis to be followed in cases of suspected adulteration: —

The specific gravity is first taken, then about five grams of the milk are evaporated to dryness on the water-bath. The fat is carefully extracted from the residue, and weighed. The residue is then ignited. The standards adopted by them are about the following: —

Specific gravity	1.030
Ash	.70
Solids not fat	9.00
Fat	2.50
Total solids	11.150
Water	88.50

On this basis they report, and ask for conviction on, as low as seven or eight per cent of added water; in other words, a milk that would give the following analysis would be reported as containing eight per cent of added water: —

Specific gravity	1.028
Ash	.64
Solids not fat	8.28
Fat	2.76
Total solids	11.04
Water	88.96

The society seems to be convinced that no conviction should be asked for without the determination of all the above ingredients.

A few years ago many of the members of the Society of Analysts seemed disposed to deny that milk ever fell below the standard as given above; in other words, that the poorest milk given by a cow was equal to this standard. Driven from this ground by numerous examples of so-called "abnormal" milk, they then took refuge in the statement, that, while milk in individual cases did fall below the standard, yet the milk of a herd of cows, as a whole, never did fall below the standard; and they further made the statement that the milk sold in cities was always mixed milk, and should therefore always be above the standard.

While it may well be insisted upon that milk falling below the standard is very poor milk, it is nevertheless true that milk from healthy cows, and even from a herd of cows, may fall below this standard. The following analysis is of the mixed milk of several cows which were milked in my presence, at Waltham, Mass., in September, 1877. The pasturage was rather short, and the cows were fed largely on fodder-corn. This substance tends to increase the volume of the milk without increasing the absolute amount of solids. The milk is therefore equivalent to a normal milk watered.

	PER CENT BY VOLUME.
Cream	10
Specific gravity	1.026

All per-cents below are grams in a hundred grams of the milk.

Sugar	3.86
Caseine	3.31
Ash	.60
Solids not fat	7.77
Fat	3.07
Total solids	10.84
Water	89.16
	100.00

Judged by the English standard, the above milk contained 13.66 per cent of added water.

The law as at present in Massachusetts calls for thirteen per cent of total solids, and pays no attention to any other fact in regard to the milk. This, like all other attempts to measure the purity of milk by a single standard, is open to grave objections. Since 1874 the writer has made analyses of about seventy samples of milk known to be pure; of these, fourteen have contained less than thirteen per cent of solids. The lowest of these is the one quoted above: according to this, twenty per cent of the milk given by cows in this vicinity is adulterated when drawn from the cows! The endeavor has been made to obtain, as far as possible, milk which would fully represent the average milk of the State.

The statement that the milk sold is always mixed milk, from whole herds, is hardly borne out by the facts. A can, as a general rule, will not contain milk from more than two or three cows; a very common practice being to milk into a pail until it is full, and then to strain into a cooler, and from this run into a can; not more than one or two cans-full being in the cooler at once.

The cans used in the Boston market contain only two gallons. Of course this argument has much more force where, as in New York and Philadelphia, forty and sixty quart cans are used.

The New York City Board of Health relies almost entirely on the specific gravity of the milk, and its general appearance; and the New Jersey State Inspector of Milk seems to use the same means for the detection of fraud.

This, as well as all other single determinations, is liable to mislead. The sample of milk quoted above, by this method of examination, would contain about ten per cent of added water.

In order that no injustice should be done to either the consumer or the milk-dealer, an analysis, as full at least as that required by the English Society of Analysts, should be made; and in my own practice I always prefer to make an additional determination. The sugar is determined either by the polariscope or by precipitation with copper.

It is much better to be perfectly sure of your case, than to go into court half prepared.

The additional determinations required to make a comparatively full analysis of the milk occupy but little time.

A sugar determination can be made with the polariscope inside of ten minutes. The determination of the "total solids" will generally enable a chemist to decide whether it is worth while to go any further. If he finds that these are about 12 or 12.5 per cent, and the specific gravity is all right, and iodine gives no re-action for starch, it will in general only be wasted time carrying the analysis further; although the determination of the fat can so easily be made, occupying at the outside not over ten minutes working time, that it is well to make it, and so set at rest all questions in regard to the milk.

· *Analysis of Milk: Specific Gravity.* — This is determined by an ordinary glass hydrometer, or by means of the specific-gravity bottle.

The hydrometers in use are graduated according to various plans. The one which has been found most convenient is a simple spindle about fifteen centimetres in length. The stem of this is graduated from 0° to 40°, 0° representing pure water, while 40° represents the specific gravity of 1.040. This range is wide enough for any sample of milk that may be met with; the instrument is so short that it may be readily carried in the coat-pocket; and it floats in an ordinary quart-measure, and thus saves the trouble of carrying a glass jar or other special vessel. Any milk that indicates above 33° or below 29° is open to suspicion; the former being probably skimmed, and the latter watered.

The advantage of this instrument over certain others in common use is, that there is no assumption of a standard on the instrument itself. It merely gives a statement of facts in regard to the milk.

The New York Board of Health instrument assumes that 1.029 is the specific gravity of pure milk; and the space between zero and this mark is divided into 100°. On this instrument 1° represents 1° of milk in the sample. Thus a sample testing 75° would, according to this instrument, contain 75° of milk and 25° of water. This instrument has enclosed in the cylinder a piece of black paper. The inspector, by dipping the instrument into the milk and allowing it to flow off gradually over the black surface, is able to judge, to some extent, as to whether the milk is a rich or poor one.

The Orange-county lactometer, which is a favorite among the milkmen, is graduated into 25°: 0° represents water, while 25° represents specific gravity 1.040. On this instrument pure milk by the New York standard of 1.029 is 18.5°; or, by the standard of 1.030, 19°. The specific gravities corresponding to the markings of the instrument are as below: —

0° = 1.0000	7° = 1.0112	14° = 1.0224	21° = 1.0336
1° = 1.0016	8° = 1.0128	15° = 1.0240	22° = 1.0352
2° = 1.0032	9° = 1.0144	16° = 1.0256	23° = 1.0368
3° = 1.0048	10° = 1.0160	17° = 1.0272	24° = 1 0384
4° = 1.0064	11° = 1.0176	18° = 1.0280	25° = 1.0400
5° = 1 0080	12° = 1.0192	19° = 1.0304	
6° = 1.0096	13° = 1.0208	20° = 1.0320	

Skimmed milk will stand at 21° or 22° on this instrument.

The objection to the use of the lactometer as the sole test for milk is that very rich or warm milk will stand as low as watered milk. Further, skimmed milk to which eight or ten per cent of water has been added shows just as well with this instrument as pure milk. As a preliminary test to enable the inspector to judge as to whether it will be better to go further with his test, it is extremely valuable. If the milk appears well, and stands at a specific gravity of 1.029 to 1.032, it is generally of no use to make any further examination. If, however, it stands above 1.032, it will generally be found to be skim-milk. If below 1.029, it is either very rich or watered milk. If very rich, the inspector can generally judge of the fact by its appearance. When the specific gravity of the milk is taken, care should be taken to have the temperature of the milk as near 60° F. as possible, since a milk at other temperatures may give a test that is several degrees out of the way.

Creamometer. — This consists of a glass jar or tube about 25 mm. in diameter and 250 mm. deep. This is graduated from 0 to 100, the 0 mark being at the top of the jar. The 100-c.c. mixing jars, such as are to be had of any dealer in chemical apparatus, answer every purpose. A sample of the milk to be tested is to be poured into the jar until the upper surface of the milk corresponds to the zero mark. The jar is then to be set in a cool place for twenty-four hours, at the end of which time the cream is to be read off. This test is not very reliable, as it is influenced by the amount of agitation which the milk has previously undergone, by the breed of the cow, and by various other circumstances. It is well to make it, however, as a check on other observations.

The richness of a milk may also be judged to some extent by its opacity. Several instruments have been devised for measuring this. One of the most simple consists of a small vessel with parallel glass sides. A given amount of water is placed in this, and then the milk is added drop by drop until the flame of a candle can no longer be seen through the liquid. From the quantity of milk necessary to produce this opacity, its richness is determined, this being in inverse proportion to the quantity of milk used. The black bulb or black paper of the New-York lactometer is another way of judging of the richness from the opacity. The richer the milk, the more of it will adhere to the instrument, and so the more completely hide the paper.

Recently Fesser of Munich has devised a new form of lactoscope. This consists of a glass cylinder with a contraction at the lower end. In this contraction is placed a small cylinder of white glass with a number of sharply-marked black lines upon it. The upper part of the cylinder is graduated in percentages of fat.

Four cubic centimetres of milk are put into the instrument with a small pipette. Water is gradually added until the black marks on the white cylinder are just visible; the reading is then taken. The objection to this instrument, as well as the last one, is that the opacity of a milk depends not only on the amount of fat contained in a milk, but also on the size of the globules of fat. The size of the globules varies not only with the breed of the cow, but also with the individual cow. If, however, the breed of cow remains constant, I am inclined to think the instrument will work quite well.

Our American milk is, however, generally the product of grade cows, and a single herd will often contain representatives of half a dozen different breeds. In actual work with the instrument, I have not been able to come nearer than half of one per cent to the actual fat contents of a milk, and the variation is sometimes wider.

Lefeldt has proposed the use of a centrifugal machine for the purpose of testing the amount of cream in a milk. This machine consists of a wheel of about half a metre in diameter mounted so that it can be revolved rapidly in a vertical plane. To this instrument glass tubes of about 16 cm. long and 1.5 cm. wide are attached in such a manner that they are parallel to a radius of the wheel. These tubes are graduated into a hundred parts, are closed at the bottom and open at the top, which when in use is closed with a good cork. They are placed on the wheel with the corked end pointing towards the centre of the wheel, while the other end is at the rim. The glasses filled with milk are placed upon the wheel; it is then revolved at the rate of six hundred turns per minute for twenty minutes, at the end of which time it is stopped with the glasses in a vertical position. On account of the difference of specific gravity, the cream will be found at the end of the tube nearest the centre of the wheel, and the amount may be read off at once on the graduation of the tube. The same objection holds against this machine as against other methods of determining the cream; that is, the amount of cream does not vary directly with the amount of fat.

Total Solids. — The next point to be determined is the amount of total solids. For this purpose various plans have been proposed; such as, adding the milk to a known weight of dry sand sustained on a paper filter, as proposed by Von Baumhauer, using a plate of plaster-of-Paris to absorb the milk, and other such devices. Wanklyn pointed out in his monograph that all such devices were useless provided only 5 c.c. of the milk to be tested were dried. If more than this quantity is taken, it is found troublesome to dry. Wanklyn dries the milk over a water-bath kept vigorously boiling for three hours. I prefer to follow the plan given below.

Five c.c. of milk are measured into a small flat platinum dish of known weight; the milk and dish are then weighed together; the weight is noted, and then the dish is placed on a water-bath, and the milk evaporated to dryness *without* stirring.

This will take about an hour. The dish is then to be placed in an oven, heated to 100° C. for half an hour longer, when it is taken out and weighed.

The increase in weight above the weight of the dish gives the weight of the total solids. On examination, the milk will be found to have dried in two separate layers, an upper thin skin and a lower one which is honeycombed in appearance. Parallel determinations made in this way on the same milk will not differ more than two or three hundredths of one per cent.

Fat. — The fat or butter in the milk is determined by pouring petroleum-benzine of specific gravity 70° B. or less, over the residue, and allowing it to stand an hour. At the end of this time, the benzine is carefully poured off, taking care that none of the upper film is lost, and replaced by a fresh quantity. This is allowed to stand half an hour, and is then poured off as before. The dish is finally rinsed out with a fresh portion of benzine, and is then placed in the drying-oven at 100° C. for half an hour, and again weighed. The loss of weight from the last weighing gives the amount of fat in the sample.

The dish is then placed over a Bunsen burner, and ignited at a low heat until the ash becomes white. It is again weighed; and the difference between this weight and the weight of the dish gives the weight of the ash.

The above determinations give all the data necessary for judging whether the milk is adulterated with water; but as a matter of precaution I prefer to determine also the amount of sugar in the milk.

This when a polariscope is readily obtainable is a very easy matter.

65.36 grams of milk are weighed for the Ventzke-Scheibler, or 41 grams for the Soleil-Duboscq, or other saccharimeters in which the normal weight is 16.19 grams for cane-sugar. To this is added 5 c.c. of basic acetate of lead solution, such as is used in clarifying ordinary sugars; the milk having previously been placed in a 100 c.c. flask. It is then shaken vigorously for a few moments, allowed to stand for five minutes, and the flask is filled to the 100 mark with water, again shaken, and immediately filtered. The filtrate is as clear as water when the operation has been properly performed. The solution is placed in the 20 cm. tube; and the reading of the instrument, divided by two, gives at once the per-cent of sugar in the milk.

The milk-sugar may also be determined by the use of Fehling's solution of copper. The operation is conducted as follows: —

Twenty-five c.c. of the milk are precipitated with a few drops of acetic acid. The milk is best warmed to 40° C. before precipitating. It is then cooled and filtered; the filter being well washed with cold water, the filtrate is made up to 500 c.c. If the milk is not cooled below the melting point of the fat before filtering, the fat will clog the filter, and give much trouble.

A solution of tartrate of copper in caustic soda is used for titration of the sugar: it is made as follows: —

34.65 grams of pure crystallized sulphate of copper are dissolved in 200 c.c. of distilled water; 175 grams of Rochelle salt are dissolved in 480 c.c. of a solution of pure caustic soda (specific gravity 1.14); the two solutions are mixed, and made up to one litre. Each c.c. of the solution equals .0067 grams of milk-sugar.

This solution does not keep well: it should therefore be freshly prepared whenever wanted for use. To make the analysis, take 10 c.c. of this solution, and place it in a porcelain dish with 40 c.c. of water, then heat to boiling, and add the whey from a buret so long as a blue color is seen in the dish, the contents of which must be kept continually boiling.

It has been found in practice best not to rely too much on the blue color, but, when the point of saturation is nearly reached, to take out a few drops with a pipette, filter on a very small filter, and test the filtrate, previously acidulated with acetic acid, with a few drops of ferrocyanide of potassium, which will give a brown color so long as any copper remains in the liquid. When the point of saturation is found it is noted, and a second trial is made to check the first, a fresh 10 c.c. of the copper solution being used. The two should agree very closely, not differing over a few tenths of a cubic centimetre.

Ten c.c. of the copper solution is equivalent to .067 grams of milk-sugar. The whey used to reduce it contains therefore .067 grams of milk-sugar.

In order to find out how many grams of milk-sugar the 25 c.c. taken contains, we have the following formula: —

$$\frac{500 \times .067}{\text{Number of c.c. of whey used}} = \left\{ \begin{array}{l} \text{weight of sugar in 25 c.c.} \\ \text{of the milk.} \end{array} \right.$$

To find the weight in 100 c.c. this is multiplied by 4. Or, 100 grams of the milk contain this weight divided by the specific gravity of the milk.

In order to save the trouble of going through with this calculation each time, the following table has been constructed in which the weight of sugar corresponding to each cubic centimetre of whey from 10 to 109 is given. It will take from 27 to 33 c.c. of ordinary whey to precipitate the copper in 10 c.c. of the standard solution.

Cubic Centimetre of Whey used.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
10	13.40	12.17	11 17	10 30	9.57	8.92	8.38	7.91	7.44	7.05
20	6.70	6.39	6.09	5 83	5 58	5 36	5 15	4 96	4.78	4.62
30	4.46	4.32	4.19	4 06	3 94	3 83	3 72	3 62	3.53	3.44
40	3.35	3.27	3.19	3 11	3 04	2 98	2 91	2.85	2 79	2 74
50	2.68	2.63	2.58	2.53	2.48	2.44	2.39	2 35	2 31	2 27
60	2.23	2.19	2.16	2.13	2 09	2.06	2.03	2.00	1 97	1.94
70	1.91	1.88	1.86	1.84	1 81	1.79	1.76	1 74	1.72	1 69
80	1.67	1 65	1.63	1.61	1.59	1.57	1.56	1.54	1 52	1 51
90	1.49	1.47	1 47	1.44	1.43	1.41	1 39	1 38	1.37	1 35
100	1.34	1.32	1.31	1.30	1.29	1.27	1 26	1.25	1.24	1.23

Of course this table can only be used when the directions given above are followed; that is, when 25 c.c. of the milk are taken for a test, and the whey is made up to 500 c.c., and 10 c.c. of the standard copper solution are used.

After the analysis is made, it is necessary to make comparisons between it and the analysis of what we regard as a standard milk.

For this purpose we may make the following calculations: —

1st, Calculate the amount of pure milk from the total solids.

2d, Calculate the amount of pure milk from the solids not fat.

3d, Calculate the amount of pure milk from the sugar.

4th, Calculate the amount of pure milk from the specific gravity.

Take, for example, the actual analysis of a watered milk, which was made by the writer; and in this connection I would call attention to the *form* in which the analysis was made.

This may seem a matter of trivial importance; but, if one has many analyses to compare, it will be found to be a great convenience if they are all stated in the same form. In fact, if any number above ten or fifteen samples are to be examined, it will be well to have printed blanks, which can be filled in with the figures as found by analysis. The milk-inspector of the city of Boston has for years furnished such blanks to the chemists employed by him.

The form which I prefer is that given below. It will be observed that this not only contains the analysis of the milk in question, but printed in a parallel column the analysis of a standard milk.

CERTIFICATE OF ANALYSIS.

Boston, Aug. 20, 1881.

This is to certify that I have examined a sample of milk received from and marked with the following results:—

	Sample.	Average Milk.
Specific gravity	1 021	1.030
Cream	7	9
Sugar	3.45	4.40
Caseine and albumen	2.785	4.30
Ash	0.475	.60
Solids, not fat	6 71	9.30
Fat	2.31	3.20
Total solids	9.02	12.50
Water	90.98	87.50
	100.00	100.00

This sample contains, —

Pure milk of average quality	72.10
Added water	27.90
	100.00

Signed,

——— ———, *Chemist.*

In this State this analysis must be sworn to.

In order to calculate the amount of added water in the above sample we have the following proportions: —

From the total solids,

$$12.5 : 9.02 :: 100 : 72.16.$$

From the solids not fat,

$$9.30 : 6.71 :: 100 : 72.10.$$

From the sugar,

$$4.40 : 3.45 :: 100 : 78.4.$$

From the specific gravity,

$$30 : 21 :: 100 : 70.00.$$

When 12.5 is used as the standard of total solids in a milk, a very simple way of finding the amount of pure milk in a sample is to multiply the total solids found by 8.

Thus in the above milk, $9.02 \times 8 = 72.16$. Subtracting this from 100, gives the amount of added water, or 27.84 per cent.

Considering all the above tests there can be but little doubt that this milk was watered with at least 25 parts of added water to every 75 parts of milk; or, in other words, to every three cans of milk there was added one can of water. The above is rather an extreme case, as the milk-men here are generally satisfied with one can of water added to four of milk, or 20 per cent of added water.

The inspector should be on the look-out for other adulterations of milk than water; but he will find them rare, with the exception of a little burnt sugar or caramel or annatto added to color milk that is too pale, either from improper feeding or the too plentiful use of the skimmer and pump.

Skim-Milk. — There seems to exist in this community a strong prejudice against skimmed milk: yet in the city of Philadelphia skim-milk was formerly, and for all I know is at present, as regular an article of commerce as whole milk. Then it was sold at one or two cents a quart lower than whole milk.

Skim-milk has exactly the same composition as whole milk, with the single exception that it is deficient in fat, as the following analysis will show.

The first analysis was made of a sample of milk that was skimmed by pouring a quart of cream from the top of the can after it had stood for twelve hours. The second was a sample from Mr. Burnet's farm, which was skimmed by the use of the centrifugal machine; it is remarkable for its almost entire freedom from fat. This latter article has been sold very extensively at a reduced rate in Boston, and has been eagerly bought by the poorer classes. As will be seen by its composition, it is a valuable article of food.

	No. 1.	No. 2.
Specific gravity	1.034	1.034
Sugar	4 31	5.20
Caseine and albumen	4.75	4.41
Ash	.79	.70
Solids, not fat	9.85	10 31
Fat	1.34	.46
Total solids	11.19	10 77
Water	88 81	89 23
	100.00	100.00

This is much too valuable an article to be condemned as unfit for food. But the inspector should be empowered to mark the vessels in such a way that they would plainly indicate what their contents were. And the milkman might be very properly fined for not having his milk in vessels which were so marked. The law in this State as it now stands is sufficient on this head; this declares that all cans containing skim-milk shall be plainly marked with the fact. Care should be taken, in interpreting the results of an analysis, not to confound skim-milk and watered milk.

For instance: in a recent case the analysis of a milk was about as follows: —

Solids not fat	9	per cent.
Fat	2	"
Total solids	11	per cent.
Water	89	"
	100	

The chemist properly returned it to the inspector as skimmed milk; but the inspector, anxious for a case, had the indictment drawn up for selling milk to which fifteen and thirty-nine hundredths per cent of water had been added.

The case was not defended before the police court, so the accused was convicted; but, upon appeal to the Superior Court, the judge very properly charged the jury that, since milk generally had but little over nine per cent of solids not fat, and since skimming was not alleged, they must acquit the defendant.

Buttermilk. — This is not an article of commerce to any extent in this State, but is for sale to a limited extent as a beverage. It has a composition closely approaching skim-milk. It, however, contains a little free acid produced by the oxidation of the sugar during the churning of the milk.

A sample recently analyzed gave the following results: —

Sugar	4.25
Caseine, etc.	4.47
Ash	.91
Solids not fat	9.63
Fat	1.41
Total solids	11.04
Water	88.96
	100.00

Cream, as sold in this market, is generally the toppings of milk-cans. The milkman allows his milk to stand perhaps twelve hours, then pours off about a quart from the top of each can. This is sold for cream at an advanced price; the remainder, either alone or mixed with other unskimmed milk, is sold as whole milk to the stores, or on some routes to the regular trade. The composition of good cream is about as follows: —

Specific gravity	.9564
Sugar	3.70
Caseine, etc.	3.31
Ash	.40
Solids not fat	7.41
Fat	43.14
Total solids	50.55
Water	49.45
	100.00

The most common and indeed the only adulteration commonly met with in milk is water.

Many statements are to be met with in regard to various substances that have been met with in milk, some authors asserting that calves' brains are used to adulterate milk. A moment's reflection will show that this must be a very rare adulteration, from the impossibility of obtaining enough brains to make it an object. Yet it is mentioned in all the books, and two authors assert that they have found milk so adulterated. It can be detected by the use of the microscope.

Chalk has also the credit of furnishing a portion of the milk. If it has ever actually been used, I have failed to find any account of its use, although it is commonly mentioned in the text-books.

A very small amount of chalk, not exceeding one-half of one per cent, might possibly have rather a beneficial effect upon the milk by retarding its coagulation.

It is a common practice to add a little lime-water to milk intended for the use of children in warm weather, with, in many cases, a decidedly beneficial result.

Bi-carbonate of soda, and borax, are said to be occasionally added to milk to preserve it.

Quevenue discusses the preservation of milk by bi-carbonate of soda, or common baking-soda, at very considerable length in his "Instruction sur l'Essai et l'Analyse du Lait, par A. Bouchardat et Th. A. Quevenue," Paris, 1879; and concludes that $\frac{1}{2000}$ of bi carbonate may be added to the milk without changing its flavor. This addition, he says, is not authorized by the public officers in France, but is tolerated by them; and he concludes by saying, its use in this limited quantity is beneficial in the heats of summer, when milk undergoes such rapid changes.

It may be recognized in the milk by the increased proportion of ash.

In winter, when milk is apt to be very pale in color, many milkmen are accustomed to color it. The most common article used for this purpose is burnt sugar. A strong solution of this is made in water, and a few drops of this solution are added to the milk. Of late years the milkmen have used Richardson's Perfected Butter Color to some extent for this purpose. This is a decoction of annatoine in very dilute caustic potash. The caustic potash in this case has the same effect in preserving the milk that the bi-carbonate of soda has. So far as health is concerned, both these colors are harmless. They are, however, both fraudulent, but may be classed as coming among those frauds that are demanded by the public.

Milk is so generally tested in common use by its color and general appearance, that a milkman to satisfy his customers is forced to color it when too pale, just as the butter-maker in winter uses some artificial color.

The great objection to the use of color in milk is, that by this means the milkman is enabled to sell to his customers milk that has been partially or wholly skimmed, as whole milk; since by skimming, then watering, he is able to reduce the specific gravity to that of whole milk. The addition then of a little color serves to cover the blueness of the milk, and it looks all right.

Lime-juice. — This article seems to be coming into use as a pleasant acid drink, being more convenient for use and easier kept than lemons.

When of good quality, it is of a pale yellow color, and should contain from six to eight per cent of citric acid, and should yield about four-tenths per cent of ash; it should also be free from sulphuric acid or sulphates.

The specific gravity of lime-juice should be above 1.035.

Meat. — There has been no definite line laid down between good and bad meat. In country towns meat is generally cut up and sold the day after it is killed, while in large cities it is frequently kept in ice-rooms for weeks before being used. Meat which some would consider just ripe, others would at once condemn. It may be laid down, however, as a safe rule to follow, that meat, when once tainted, is not fit food for those who are not accustomed to its use.

The use of veal under four weeks of age is forbidden by law in this State.

Letheby defines good meat as having the following characteristics: —

1. It is neither of a pale pink color nor of a deep purple tint; for the former is a sign of disease, and the latter indicates that the animal has not been slaughtered, but has died with the blood in it, or has suffered from acute fever.

2. It has a marbled appearance, from the ramifications of little veins of fat among the muscles.

3. It should be firm and elastic to the touch, and should scarcely moisten the fingers; and the juice should be distinctly acid, — bad meat being wet and sodden and flabby, with the fat looking like jelly or wet parchment.

4. It should have little or no odor, and what is perceptible should not be disagreeable; for diseased meat has a sickly, cadaverous smell, and sometimes a smell of physic. This is very discoverable when the meat is chopped up and drenched with warm water.

5. It should not run to water, or become very wet, on standing for a day or so; but should, on the contrary, dry upon the surface.

6. When dried at a temperature of 212° or thereabouts, it should not lose more than from 70 to 74 per cent of its weight, whereas bad meat will often lose as much as 80 per cent.

7. It should not shrink or waste much in cooking.

Meat which has commenced to putrefy sometimes occasions serious intestinal disturbances, acting like an active irritant poison, and this though the meat has apparently been well cooked. Instances of this kind of poisoning are not uncommon.

Meat infested with parasites such as *trichina spiralis* is not a safe article of food, although, if properly cooked, it may be eaten without danger. The presence of this and similar parasites can only be detected by the use of the microscope.

In order to prevent meat from being used as food, which has been condemned by the inspector, it should be injected with carbolic acid, or "dead oil," or some similar substance. This may be readily done with a grooved knife which is first plunged into the liquid, and then into the meat.

Oatmeal. — Much of the oatmeal sold in the market is old and rancid, and it is sometimes wormy. Recently English chemists have found samples contain considerable barley.

Freshly ground oatmeal has very little odor; but, when it becomes old and rancid, it has a very decided mouse-like odor.

The best in this market is made from Canadian oats. It should be examined with the microscope for foreign starches.

Buckwheat. — Much of the buckwheat sold in the market is said to be adulterated with wheat middlings. The starch grain of the buckwheat is very small and angular. The wheat starch is comparatively large and round.

Pickles. — These should be examined for sulphuric acid. Mash up, treat with hot water, filter, and test the filtrate with chloride of barium.

If sulphuric acid is found they should also be tested for alum, for it is sometimes used to harden them. Mash a number of them, evaporate to dryness, incinerate, and test the ash for alumina. In pickles free from alum, it should be found only in traces.

Some writers have asserted, as previously mentioned, that hydrochloric acid was used in pickles, since the liquor from them gave a strong re-action for chlorides with nitrate of silver. But most receipts for pickling contain common salt as one of the ingredients; and many pickles are soaked in strong brine before being placed in vinegar.

Neither hydrochloric nor sulphuric acids are poisonous when very dilute.

The most common adulteration, and the one most to be feared, is copper in some form. Many of the pickles in the markets, and most of the imported canned pease, contain copper. In order to detect it, reduce the pickles to a paste in a mortar, then add hot water and a few drops of sulphuric acid, and insert in the mass two clean bright plates of platinum connected with the poles of Bunsen or Grove's battery of two cells. If copper is present it will be deposited on the platinum. It may be removed from the plates with a drop of nitric acid, and be identified in the usual way with ammonia or ferrocyanide of potassium.

Preserved Fruits. — A great deal of very inferior fruit is found every year on the market in the form of "apple-sauce," which is frequently pumpkin boiled in cider. The raspberry-jam offered for sale is frequently sour.

Strawberry jam is often made from the refuse strawberries of the market.

These can only be examined as to their general character. No specific tests can be given.

Pepper. — This is frequently adulterated with roast ship-bread, mustard-husks, and Indian-meal.

These adulterations are best discovered by comparing the sample with one known to be genuine, by aid of the microscope.

Sago is frequently made from potato-starch. It may be detected by the microscope.

Rum. — New-England rum is generally pure, though it is sometimes watered. It should test 50 per cent by weight of alcohol.

Much of the St. Croix and Jamaica rum in the market is merely New-England rum flavored with the genuine article; a common practice being to add ten gallons of the genuine to thirty gallons of New-England.

Rum should leave no disagreeable smell on the hands when evaporated from them. The Jamaica and St. Croix rums have more of the odor of the raw sugar than the New-England: the latter has the odor of sour molasses.

Sugar. — In this market this article is very generally found to be in a pure state. The trade in sugar has undergone a very decided change during the last twenty-five or thirty years. Formerly high-grade sugars were imported from the East Indies and from Cuba, and sold without refining. These sugars were apt to contain more or less clay and sand derived in part from the method used in refining them. At present these sugars are never seen at retail. The refined sugars of various kinds, assisted by the United-States tariff, have driven them out of the market.

The sugars in use most largely at present are: First, loaf sugar, or crushed sugar as it is generally called. This formerly came in conical loaves about eighteen inches in length and six inches in diameter at the lower end. This grade of sugar is now supplied to the market either crushed in irregular fragments, or cut into cubes or forms approximating a cube. This sugar is almost absolutely pure, hardly containing even a trace of moisture.

This sugar has, however, been almost entirely displaced in its turn by granulated sugar. This sugar is of about the same grade as the loaf sugar, although occasional samples are of a shade darker color. It is produced by disturbed crystallization of pure sirups. These, when well granulated, are thrown into a centrifugal machine, which throws out the sirup, retaining the crystals. The crystals are then washed with pure sirup made from granulated sugar, and then dried in a drying machine.

Granulated sugars contain from 99 to 100 per cent of pure crystallizable cane-sugar, and only a trace of invert sugar.

The next grade of sugar to granulated is soft white sugar. This contains a little more invert-sugar and some moisture, but is still a pure, high-grade sugar.

After this the color gradually shades off through very light cream-color to decided yellow, and finally to molasses-sugar, which is produced by boiling down molasses, and which is of quite a deep brown color. Molasses-sugar contains from 82 to 86 per cent of crystallizable cane-sugar, considerable invert-sugar, and some gum and coloring matter. It is at present but rarely, if ever, offered at retail: it generally goes to the refineries to be worked over, and converted into higher grade sugars and sirups, or sugar-house molasses.

Pure cane-sugar is a perfectly white, or, in large crystals, colorless substance. Its crystalline form may be best seen in rock-candy, which is simply pure crystallized cane-sugar; the white appearance of ordinary pure sugar being due to the smallness of the particles, as may be readily shown by crushing rock-candy.

By long boiling, or by heating in presence of an acid, cane-sugar is converted into another kind of sugar, which cannot be crystallized.

This sugar has the property of reducing copper solutions, a property not possessed by cane-sugar; it is always present in all samples of commercial sugars except the pure white hard sugar, varying in amount from one per cent up to as high as fifteen or sixteen per cent.

Very rarely a sample of brown sugar contains a little iron, which the sugar has dissolved from the machinery used in the manufacture. A sample of sugar of this kind gives a black or blue-black color with the tannin of tea or coffee, and has thus occasionally caused needless alarm.

It is frequently charged that sugars are adulterated with corn-sugar or glucose. Sugars thus adulterated have been thrown on the market under the name of "new-process" sugar. There is no evidence that corn-glucose is not as healthy an article of food as cane-sugar; but the mixture of it with cane-sugar, and its sale as cane-sugar, is a fraud, since it has not the sweetening power, pound for pound, that is possessed by cane-sugar.

Corn-sugar, grape-sugar, or glucose, is a body produced by the action of dilute sulphuric acid on corn-starch; or, better, by the action of diastase — which is a nitrogenous principle found in sprouting grain — on corn or other starch.

When starch is boiled for some time with dilute acid, it is first converted into a body that is known as dextrine from its power of rotating a beam of polarized light to the right. Still further heating converts this body into another body rotating to the right, known as maltose. Prolonged boiling of maltose with acid converts it into still another substance known as dextrose or grape-sugar.

If the boiling is stopped at the point when iodine ceases to give a blue color with the starch, the sulphuric acid is neutralized with lime, the resulting sulphate of lime is allowed to settle out, the sirup is clarified with bone-black, and then evaporated until it contains only fifteen to twenty per cent of water, — it produces the article known in commerce as glucose. This is a heavy, sticky, colorless body, having a sweetish taste, and turning a ray of polarized light strongly to the right. If the same amount, or more conveniently if half the amount, of this sirup is weighed out and treated in the same manner as ordinary cane-sugar, it will be found to polarize somewhere between 130° and 150° on the polariscope; 100° representing pure cane-sugar. If, however, the action of the acid has been carried as far as possible on the starch, there is then produced a body comparatively free from dextrine, which may be granulated and treated exactly as granulated sugar. If the process is properly carried out, this product is white, and strongly resembles a low-grade granulated sugar.

On polarization, however, we find that it only polarizes from 65° to 85° on the cane-sugar scale. It is this article which is used for mixing with cane-sugar in the so-called "new-process" sugar.

It has no disagreeable taste when well made, and is probably but little, if any, inferior as a food to cane-sugar; but it has much less sweetening power, and its use is a fraud on the consumer, without a corresponding reduction in the price is made.

The detection of glucose and starch by the methods in common use is considerably complicated by the fact that low-grade sugars, such as it is commonly mixed with, contain invert-sugar, which reduces sodio-tartrate of copper solution even more freely than the corn-sugar.

Casamajor recommends washing the suspected sample with methylic alcohol saturated with grape-sugar or glucose. This will dissolve out the cane and invert sugar, and leave the grape-sugar unacted upon. This will give an approximation to the amount of grape-sugar present.

The best means, however, of detecting the presence of the various compounds which go under the name of starch-sugar is by means of the polariscope.

Clerget found that if cane-sugar was heated with strong hydrochloric acid, it was converted into invert-sugar in a definite manner.

If the sugar before inversion polarized +100°, after inversion it would polarize —44° at 0° C., making a difference in polarization of 144°. And, further, that if other optically active substances such as are found in cane-sugar were present, their polarization was not changed by this treatment if properly carried out.

He found further, that the polarization was much affected by the temperature of the solution, diminishing about half a degree for every degree Centigrade that the temperature is raised. The true amount of cane-sugar in the solution will be given by the following formula, in which S represents the sum or difference of the polarization before and after inversion, the difference if both numbers are positive, or to the right; the sum of one is positive and the other negative; T represents the temperature at which the reading is taken and R represents the true per cent of sugar: —

$$R = \frac{200\ S}{288 - T}.$$

For instance, a certain sugar polarized 88°, after inversion it polarized 6 at 20° C.; the sum of 88 and 6 is 94.

$$\text{Then } \frac{200 \times 94}{288 - 24} = \frac{18800}{264} = 71.21.$$

But a sugar of the grade of this should, if it were pure cane, have polarized about 90°: therefore it contained $\frac{71.21}{90.00}$ 79.12% of cane-sugar and 20.88% of starch-sugar.

If we subtract the per cent of cane-sugar from 88, we will get the reading due to the starch-sugar present in this case, 16.79°. A starch-sugar supposed to be similar to the one used for adulterating this sample gave, on polarization, a reading of 72°. Then, for the amount of starch-sugar present, we have the formula $\frac{16.79}{72} = 23.32\%$, which is a sufficiently close approximation to the other estimation.

Of course, not knowing the exact polarization of the starch-sugar used or of the cane-sugar, we can only make an approximate calculation.

Ordinary starch-sugar is not affected by heating with acid. The polarization of glucose is lowered, however, if the heating is prolonged.

The analysis of sugar is conducted as follows: —

The standard weight, or some multiple of it, is weighed out. (This is different for different instruments, but is always given by the maker of the instrument; 26.048 grams are used for the Ventzke-Soleil, and 16.18 grams for the Soleil-Duboscq and the Laurent and Duboscq shadow instruments.) Two or two and a half times the standard amount is a very convenient amount to work with, since it gives plenty of material. If two and a half times the standard amount is taken, this is dissolved in water, 10 c.c. of the standard acetate of lead solution added, and the solution made up to 250 c.c.; it is then filtered. The tube of the instrument is filled with this filtered liquid, and placed in the instrument; the reading is noted. If adulteration is suspected, 50 c.c. of the filtered solution are placed in a 100-c.c. flask; to this are added 5 c.c. of strong hydrochloric acid. The mixture is then heated to 70° C. on a water-bath; it is allowed to stay at this temperature for a few moments, and then cooled down to the temperature of the air. The volume is then made up to 100 c.c.: this solution is filtered if necessary, then placed in the tube of the instrument, and allowed to stay in the instrument for fifteen or twenty minutes; the temperature is carefully noted by laying a thermometer alongside of the tube. The reading is then taken, and from the two readings the amount of sugar calculated according to the formula given.

Powdered sugar is sometimes adulterated with rice-flour or starch. This is easily detected by its insolubility in cold water, and further identified by treatment with dilute sulphuric acid and tincture of iodine. If starch in any form is present, the characteristic blue color of iodide of starch at once appears.

Very frequently granulated sugar is colored with ultramarine, indigo, or Prussian blue to give it a blue-white shade instead of the natural yellow-white shade. Since this adds nothing to the value of the sugar, and it is a mere fancy, it should be discontinued. The ultra-marine spoils the sugar for certain delicate uses, such as making druggist's sirups. It may be found by dissolving a comparatively large quantity of sugar, say one or two hundred grams, in distilled water, and allowing it to stand for some time: the bluing will settle to the bottom of the vessel.

Molasses and Sirups. — These are solutions of sugar which always contain more or less invert-sugar, and certain gummy matters, caramel, and the salts of the juice of the sugar-cane.

The average sugar-house sirup will analyze about as follows: —

Crystallizable sugar	36.00
Invert sugar	34 00
Gum pectose, etc.	10.00
Ash	4.00
Moisture	16.00
	100.00

Sugar-house sirup is frequently blanched by the action of sulphurous acid gas. When this is the case, it will be shown by the increased amount of sulphates in the ash. Pure sugar-house sirup made from cane contains only traces of sulphates. It frequently contains considerable amounts of iron; this is easiest shown by dropping on the suspected sample a drop of tannin solution, when the characteristic blue color appears.

Of late, sugar-house sirup has been largely used to flavor corn-sirups. This adulteration can be readily detected by the method given under "Sugar," for the detection of grape-sugar in cane-sugars: only in this case it is the high-polarizing article that is used. In one case, for instance, the sample before inversion polarized $+135°$; after inversion, $+129°$; difference, $6°$ at $22°$ Fah.

Then $R = \frac{200 \times 6}{288 - 22} = \frac{1200}{266} = 4.51, \frac{4.51}{36} = 12.58\%$ of sugar-house sirup in the sample.

This would indicate that one part of sugar-house sirup had been mixed with seven parts of glucose.

These results are, as in the case of adulterated cane-sugar, only approximate, since we do not know positively the polarization of the cane-sirup used, or of the glucose, both of which are subject to considerable variations.

The copper test is equally worthless in this connection, since the adulterated sirup reduces little if any more copper than genuine sugar-house sirup.

Sugar is sometimes infested with mites. These are rarely, if ever, found in refined sugars, but are met with in the raw sugar as imported; they may be detected by dissolving the sugar in cold water, and carefully observing the surface of the solution: if they are present they will be seen swimming around actively, and may be further examined with the microscope.

Sand and gravel are frequently met with in raw sugars: these may be easily detected by dissolving the sugar in water, when they remain insoluble.

In this connection I wish to enter a protest against the loose way in which the term "glucose" has been used by certain writers. In four reports which I have seen recently, the authors have stated that they have found glucose in brown sugars; and they have given the amounts, which in no case have risen above eight per cent. Not one of the four has taken the trouble to find out what kind of glucose was present, and the report has been spread abroad in the daily papers that Professor A, B, or C, as the case may be, has examined a number of sugars, and found glucose in them all; whereas the truth is, that they all found invert sugar, and invert sugar only, in all probability. One of these cases I took the trouble to follow up, and found the Professor supposed that all sugars which would reduce copper solutions were glucose, and that you could detect the presence of a glucose in a sirup by its reducing power. This whole business of sugar analysis has grown entirely beyond the ordinary text-books, and is as little known as Greek to the ordinary chemist. It is a business by itself.

In a letter received a few days ago from the author of one of the most recent books on the subject, he acknowledges that he was wrong in the method laid down in his book; and yet the book has been published only six months, and was fully up to the times when published.

Spices. — In order to obtain these pure and of good strength, it is advisable to buy them in the unground state. Ground spices lose strength very rapidly unless kept in air-tight boxes, from the escape of the volatile oil on which their flavors depend.

The microscope furnishes almost the only guide to their purity. It is always well, however, to determine the amount of ash, and compare it with the amount found in genuine samples. The addition of terra-alba raises the amount of ash, while the addition of flour and starches lowers it. Peanut-shells are said to be used to adulterate cassia, while old ship-bread is a frequent component of other spices.

Tea. — Tea is said to be adulterated with leaves other than those of the tea-plant. These are best detected by soaking the leaf, and then spreading it out flat, and comparing it with tea-leaves known to be genuine.

Exhausted tea-leaves are said to be shipped from China to this country. These can best be detected by exhausting a weighed quantity of the tea with hot water, and then evaporating the extract to dryness; it should leave a residue of at least 25 per cent of the weight of the tea. Sand and dirt are frequently found in low-grade teas. The ash of tea should not exceed 6 per cent. Weighted teas frequently contain from 20 to 30 per cent of ash.

The tea should be carefully examined for facing material such as black lead, Prussian blue, indigo, and soap-stone.

Vinegar. — The British law allows an amount of sulphuric acid, free or combined, in vinegar, which shall not exceed one-tenth of one per cent. Any amount above this should be considered an adulteration. Chlorides in quantities of more than one-tenth of one per cent should also be absent. Good vinegar should only give a cloudiness with chloride of barium or nitrate of silver.

Burnt sugar or caramel is sometimes used to color vinegar. As this is done to please the eye, and is not injurious, it can hardly be regarded as adulteration. Good vinegar should contain at least three per cent of acetic acid; any thing below this must be regarded as watered.

A large portion of vinegar used by the pickle-makers is made from whiskey or rum by what is known as the quick process, or percolation over shavings. In order to evade the duty on alcohol the vinegar-makers ferment their own mash, frequently using glucose for the sugar. This is apt to introduce enough sulphates into the vinegar to give a decided precipitate when chloride of barium is added. Vinegar for pickle-makers' use is generally tested by the number of grains of bi-carbonate of soda or potash which one Troy ounce will neutralize; the vinegar being spoken of as so many grains soda or potash test, as the case may be.

The vinegar made by the quick process from alcohol is a much purer article than ordinary cider-vinegar, and is better for pickling purposes. As the law now stands in this State, it is a criminal offence to add acetic acid to cider-vinegar. Pure cider-vinegar is a very variable article; and in poor seasons it is much improved by the addition of sufficient acetic acid to bring its test up to 4 or 4½ per cent of acetic acid.

White wine vinegar is rarely, if ever, made from wine: it is simply the trade name for vinegar made from alcohol.

Professor Hill examined 26 samples of vinegar for the Board of Health in 1872. In 13 of these he found sulphuric acid: the amounts varied from .06 to .40 per cent. Twelve of these were cider-vinegars, and were, with one exception, free from sulphates. This sample contained .12 per cent of sulphuric acid. In 14 samples of wine-vinegar, only two were found free from sulphates.

Mrs. Richards tested a number of samples of vinegar in 1879 for the Board, and reports that no excess of sulphates was found in them.

Dilute sulphuric acid, not exceeding three-tenths of one per cent in strength, can hardly be considered a dangerous adulteration.

It is recommended by most writers on lead-poisoning that the workmen in lead-works be regularly supplied with sulphuric acid lemonade considerably stronger than this. Occasional samples of vinegar made from poorly purified pyroligneous acid have been met with by the writer in the West during the past year, but none have been seen in this market.

In view of the very small amount of vinegar used, and the comparative purity of that found in the markets in this State, it does not seem to be necessary that the present law should be continued on the statute-book, since it gives the cities no discretion in the matter of appointing an inspector of vinegar. The general law is sufficient to cover all cases that can arise.

Wine. — In order to define what is an adulteration in wine, it is first necessary to understand what wine is. Some assume that wine is the pure fermented juice of the grape. But this definition of wine at once excludes a very large and important class of wines.

It would exclude the whole of the ports, sherries, and champagnes, which are rarely, if ever, sent into the market without undergoing some manipulation for the purpose of adding to or modifying their strength, flavor, or keeping-properties.

Sherries and ports are almost invariably plastered and fortified. A "natural" port or sherry should not contain in each litre over 120 to 130 grams of alcohol. The commercial ports and sherries contain, however, from 170 to 190 grams of alcohol in the litre. Of this alcohol at least 50 to 60 grams are added. This is apt to be in the form of brandy of a very poor quality; the brandy used being either potato-whiskey, or brandy made from fermenting the marc of the grapes and then distilling the product.

Again: the ash of pure wine should not contain more than one grain of sulphates to the litre of wine; but the ash of port or sherry generally contains from three to four grains of sulphates to the litre of wine, or, expressed in per cents, from .3 to .4 per cent. Indeed, this amount is so constant in the sherries and ports as sent into the market that it almost furnishes an index of their genuineness. This large increase of sulphates arises from the practice of dusting the grapes with sulphate of lime. The sulphate of lime decomposes the acid tartrate of potassium in the fruit, producing sulphate of potassium in the wine, while the tartrate of calcium is deposited in the lees.

This plastering of wine is excused on various grounds. It is said that it tends to preserve the wine, and that it corrects the acidity of the wine. That it is injurious hardly admits of question; but at present it has to be submitted to, since it is impossible to obtain genuine port or sherry that has not been so treated.

The next sophistication to which wine is submitted during its manufacture is sweetening with sugar. In bad seasons the grapes are poor, and yield a thin acid juice. In order that fermentation may produce enough alcohol to keep the wine, it is customary to add sugar to the must. In this case, the grapes are relied upon to furnish the flavor; the strength comes from the sugar.

Sometimes the flavor is deficient. In order to improve this, the wine-merchant keeps a supply of old high-flavored wines which he adds to the poor wine. It is said that in order to procure any particular brand of sherry all that is necessary is to send a bottle of the required brand to Cadiz.

The following extract from Thudichum and Dupré will explain how this is done: —

PREPARATION OF WINE FOR EXPORT.

"When the proprietor of the store-house receives an order to prepare a certain number of butts of sherry, he mostly receives therewith a limitation of price, and an injunction to send exactly the same quality as that sent on a former occasion. For so small is the knowledge of the public regarding wine, that they suppose it possible to have the same wine all the year round and all their lives; and wine-merchants are unable or unwilling to overcome this prejudice. The makers of sherry therefore always keep samples of their shipments, and, on the receipt of the order, work up to this standard by mixing.

"A sample is first mixed, and the proportion of each ingredient taken is noted. When the new sample is as near the standard as practicable, the great operation is performed. This is done either by vatting (as is frequently done in the London docks on a large scale), or by mixing in detail in the butts themselves.

"The body is first put in, and by it the main value of the wine is determined.

"To this are added the various smaller quantities to impart what body, sweetness, flavor, or color may be needed. Dryness is favored by an addition of amontillado and brandy; lusciousness, by an addition of sweet old wine; soleras, which are used sparingly for such bonification, are sometimes called 'doctors.' Mr. Bernard has given the proportions of ingredients of which a butt of sherry for England was generally made up in 1860: —

1 jar of spirits about 60 over proof,
8 jars of sweet wine or dulce,
7 jars of soleras or mother-wine,
10 jars of dry wine, 1854,
14 jars of dry wine, 1859,
—
40 jars of sherry.

"From the whole of such an operation there results a number of from 20 to 50 or 100 butts of sherry of uniform quality.

"The butts are branded with the particular trade-mark of the maker, numbers and other signs by which the particular quality or shipment is signalized, and shipped off to the destined market.

"From the above it is evident that a proprietor of a warehouse requires to be possessed of a large stock, if he intends to be able constantly to satisfy the curious demands of his customers."

So much for genuine (!) sherry. In some of the imitations sold there is certainly nothing more injurious than in the imported sherry, the only objection being that they are not sherry.

Sometimes fashion demands that sherry shall be dark colored. Caramel is then used to produce the desired tint. If the color is deficient in the case of port and other red wines, elderberry-juice is added to produce the desired shade. In France of late years it is said that magenta has been used to a considerable extent to color clarets.

Champagne is a manufactured wine, having for its basis the juice of a black grape growing in the Champagne district in France. The bottlers of champagne flavor it, fortify it, and sweeten it according to private formulas, so as to imitate as nearly as possible their well-known brands; the main difference between the vintages of various years being in the good or poor quality of the wine they start upon.

Only one thing can be relied upon in regard to champagne, and that is the fact that it is not the *pure* fermented juice of the grape. It is just as much an artificial production as the various cordials found in the market.

So far, only what may pass as reasonably pure wines have been spoken of; that is, wines which come from the places where such wines originate, and which are free from adulteration other than what custom and long usage have sanctioned.

Factitious wines similar to the example given in the case of sherry, which have never even been within the limits of the wine-growing districts, are also to be found in the market in greater abundance than the genuine. It is estimated that the Champagne district in France does not produce more than one-tenth of the amount of champagne consumed; the remainder being manufactured from cider and other wines.

Some of the fictitious champagnes are even superior in flavor, bouquet, and all that is generally held to indicate a good wine, to the genuine article.

Many elaborate analyses of wine have been made; the most complete monograph on the subject being Thudichum and

Dupré's treatise on the origin, nature, and use of wine, in which may be found full directions for making minute analysis of wine, and also such analyses of all the leading wines of the world.

They have collected a mass of information that is simply invaluable to any one who wishes to study the subject.

In ordinary commercial tests only a few determinations are made.

It is well to take the specific gravity of the wine: this is best done in the ordinary specific-gravity flask, which should hold about 100 grams. The alcohol is also determined: this may be done in two different ways, — either by distilling 200 or 300 c.c. of the wine, and collecting and determining the specific gravity of the distillate, having first diluted it until it occupies the same volume as the wine taken; or, by evaporating a known volume of the wine on the water-bath to about one-fourth its volume, diluting to its original volume, and again determining the specific gravity.

The specific gravity of the entire wine, divided by the specific gravity of the de-alcoholized wine, gives the specific gravity of the alcohol contained in the wine. Having the specific gravity, the percentage is readily found by referring to any alcohol tables.

The total solids should also be determined. This may be done by evaporating from 10 to 50 c.c. in a platinum dish. If the wine is very sweet, not more than 10 c.c. should be taken. The residue should be dried at a temperature not exceeding 105° C., and then weighed.

For the same kind of wine this residue is quite constant in weight, not varying generally more than one or two per cent. For instance, in ten samples of sherry, the residue minus the ash varied from 2.260 per cent to 3.575 per cent; and in seven clarets from 1.105 per cent to 1.613 per cent. After weighing the residue it is ignited at as low a red heat as possible, until it becomes white, when it is weighed. The amount of ash is generally quite constant, and is larger in genuine wines than in the manufactured article.

In red wines an examination should also be made of the coloring matters. Very elaborate tables have been given for the detection of various coloring matters. As a general rule, the coloring matters used are harmless, and the only object in detecting them is to show whether the wine has been adulterated or not. The only one that is likely to be harmful is fuchsine or magenta. This is most easily detected by concentrating the wine, and then dyeing a piece of wool with the solution. Cochineal or fuchsine will give a red color on wool if strong; pink, if dilute. The coloring matter of wine does not dye wool without a mordant. A very elaborate table by M. Gautier was published in "The Analyist" for 1877, which may be consulted on this subject.

The amount of sulphates should be determined in the ash.

Beer is examined in the same manner as wine: sulphates here indicate glucose.

Cream of Tartar. — Much of what is found in the market under this name is more or less adulterated. Mrs. Richards, in the last report of the State Board of Health, takes 97 per cent as a standard of purity; that is, in classifying the samples examined, only those which contained less than three per cent of tartrate of lime were considered pure. This, however, is a higher standard than the condition of the market will warrant. All the cream of tartar used in this country is manufactured here, none being imported, the duty being practically a prohibitory one. The chief, if not the only, supply for this market comes from New York. During the last six or seven years I have had frequent occasion to examine the unground crystals. These will average but little over 93 per cent of pure cream of tartar.

The manufacturers will not guarantee them to be over 92 per cent of acid tartrate of potassium.

Alfred H. Allen, in "The Analyst" for 1880, p. 114, discusses the amount of calcium tartrate that is normally present in cream of tartar, and comes to the conclusion that ten per cent is a fair allowance; and he quotes various authors who give the amount as varying from one to twelve per cent. In this market, however, a good article rarely rises above 8 per cent of calcium tartrate; and occasional samples are met with which contain only traces of tartrate of calcium. The purest samples are apt to contain, however, a trace not often amounting to more than one-third of one per cent of sulphate of lime. This is most likely due to the fact that sulphuric acid or acid sulphate of potassium has been used for removing the last traces of tartrate of lime.

The cream of tartar sold here with the name of the grinder and the words "Strictly Pure" upon it is generally a good commercial article, free from adulteration. If sold in packages without the name of the packer, it is rarely to be trusted. In an examination made of the article sold by six of the leading dealers in the city of Boston a few years ago, twelve out of eighteen samples were found to be of good quality. Three made by one firm contained only a slight amount of gypsum; while three other packages by another firm contained about one-third of their weight of gypsum.

The examination most conveniently made is the following: Twenty grams are dissolved in hot water with the addition of a little hydrochloric acid, and the solution is filtered and made up to 200 c.c. 100 c.c. of this solution is taken, and to it ammonia is added in excess, then oxalate of ammonia, and it is allowed to stand an hour or so, and then filtered; the filter is well washed with dilute ammonia-water, and then dried, the filter burnt, and the residue ignited over a good blast-lamp for ten minutes in a platinum crucible. The residue after ignition consists of caustic lime, Ca. O. The second 100 c.c. of the solution is then heated to boiling, and chloride of barium is added to the solution. The precipitate, if any is formed, consists of sulphate of barium. It is collected on a filter, dried, ignited, and weighed. The weight of the precipitate multiplied by .7382 gives the weight of the corresponding amount of gypsum. This multiplied by ten gives the percentage of gypsum in the sample.

The percentage of gypsum multiplied by .3256 gives the amount of lime in the gypsum. This lime is to be subtracted from the lime found in the sample.

The remainder of the lime multiplied by 4.642 gives the amount of tartrate of calcium in the sample.

Example: A certain cream of tartar gave 6.773 per cent of sulphate of baryta, and three per cent of lime.

$6.773 \times .7382 = 5. =$ per cent gypsum.
$5. \times .3256 = 1.628 =$ lime.
$3 - 1.63 = 1.37.$
$1.37 \times 4.642 = 6.36 =$ per cent tartrate of lime.

If the cream of tartar is dirty, and does not dissolve completely in acid, then the amount of residue is estimated.

It is a good plan to ignite five grams of the tartar in a platinum dish, and weigh and titrate the ash. Pure cream of tartar yields 36.79 per cent of ash, while tartrate of calcium yields only 21.54 per cent of ash if it is ignited sufficiently to drive off all the carbonic acid; or 38.46 per cent if ammonia carbonate is added to the ash, and it is only gently ignited. Gypsum gives 79.03 per cent of ash.

The amount of ash as calculated from the analysis, and as found, ought to closely agree; although, if much gypsum is present, it is generally too low, as part of the sulphuric acid is decomposed during the ignition.

If the sample is adulterated with rice-flour or starch, the ash will be low. A few samples were found recently in the market which contained bitartrate of ammonia. The lowness of the ash in this case led to the detection of the ammonia.

The starches are easily detected by tincture of iodine, and may be identified by the microscope.

Occasionally samples of "cream of tartar" are met with which are free from any potassium compounds. A favorite form is, tartaric acid, one-third; gypsum, one-third; and rice-flour, one-third. This has about the same strength as the genuine article.

Sometimes a sample is found which is badly adulterated with alum, or with acid sulphate of soda or salt-cake. These are both easily detected, though a mixture of alum and rice-flour occasionally gives the analyst some trouble.

A cream-of-tartar substitute composed of acid phosphate of lime and potato-starch is sometimes sold as cream of tartar. This, if well made, is unobjectionable, but it should be sold under its proper name.

Bi-carbonate of Soda. — This article is used in connection with cream of tartar for rendering articles made of flour or meal light. It rarely, if ever, is adulterated, although occasionally it is deficient in carbonic acid. Samples have been met with which contained as low as 44 per cent of carbonic acid. A pure article contains 52.38 per cent, while the ordinary commercial article averages about 51 per cent. It generally contains a little sulphate of soda, and traces of common salt and other impurities, derived from the soda-ash from which it is manufactured.

It is sold under two different names in the stores, saleratus and baking-soda, but they are one and the same article. Saleratus is defined in the dictionaries as bi-carbonate of potassium; and this was the salt that was always sold, until about twenty years ago the grocers found out that bi-carbonate of soda was much cheaper.

Baking Powders. — These, as found in the market at present, may be divided into several classes. First, those which contain only cream of tartar and bi-carbonate of soda. These, when freshly made, are the strongest; but they are apt to deteriorate with age, especially if kept in a damp place.

The second class consists of the same mixture to which a certain amount of rice-flour or starch has been added. This class at present is the most popular, since it keeps much better than the first class. If about one per cent of the bi-carbonate of potassa is replaced by carbonate of ammonia, these powders generally give entire satisfaction. The carbonate of ammonia has the advantage that it may be added in slight excess above the amount required to neutralize the cream of tartar, since it is completely volatile, and any excess is dissipated during the baking.

Another class does not contain any cream of tartar: the acid in this is acid phosphate of lime. It is claimed for these powders that they restore to the flour the phosphoric acid which was abstracted when the flour was bolted, since much the largest proportion of the phosphate in the wheat grain is in the husk which is removed as bran.

There exists no serious objection to either of the above powders, provided they are well made and do not contain an excess of fixed alkali.

The same remark does not apply, however, to the powders which depend upon alum to liberate the carbonic acid. These powders make very handsome white bread, and leave less foreign salts in the bread than any others; but it is strongly insisted upon that the hydrate of alumina left in the bread acts injuriously on the system. Much has been written on each side of this question, without any very definite results having been arrived at. In the present stage of the controversy, it is but the part of wisdom to avoid the use of these powders.

Tin-ware. — Much complaint has been made that the cheap tin-ware so abundant in the market is not made from sheet-tin but from terne-plate, and that it has given rise to lead-poisoning.

Terne-plate has not the appearance of good tin-plate, but has the bluish cast characteristic of lead. To test it, scrape off a little of the coating, dissolve in aqua regia, dilute, and pass through the solution a stream of hydric sulphide. The formation of a dark precipitate indicates the presence of lead. The test sometimes given, of putting a drop of nitric acid on the article, then warming until the acid has evaporated, and finally moistening with a drop of solution of potassic iodide, is worthless in unskilled hands. Pure tin gives almost exactly the same shade of color as lead.

Poisonous Glazing or Enamel. — Articles of iron and earthen ware are frequently glazed with an enamel which contains large quantities of lead. This is often in such a state of combination that it is easily soluble in dilute organic acids, such as citric or acetic. To test such ware, boil dilute nitric acid in it, and then test the acid in the usual way for lead and arsenic.

The best makes of iron-ware are free from this objection.

Poisonous Papers. — The most dangerous article that enters into every-day use is paper colored with pigments of which arsenic forms a component part.

This paper is met with in great abundance. The bright green glazed paper boxes used so freely in fancy-goods stores are always covered with paper of this kind. Car and theatre tickets are printed on it, and it is quite freely used as a wall-paper. It has even been met with as a covering for lozenges.

There is no good reason for its use, except that it is cheap. It should be condemned whenever met with.

Arsenic is best tested for by means of Marsh's test. Generally dropping a fragment of the paper into the flask is sufficient to give the re-action.

Six square inches of the paper should not give any trace of arsenic.

Apparatus required. — The following list of apparatus is almost indispensable. The outfit will cost from eight to nine hundred dollars if bought in this country. From one-quarter to one-third the price may be saved by importing directly from England or Germany.

Microscope. — The second-class stands of the best makers, such as Zentmeyer's Army Hospital, made in Philadelphia; the Investigator microscope of Bausch and Lomb, Rochester, N.Y.; the Student's stand made by Tolles of Boston; or the stands made by Bullock of Chicago, or Sidle of Lancaster, Penn., — will answer every purpose. The large stands of the above makers are elegant as articles of luxury, but for every-day use in the laboratory the smaller stands are to be preferred. To the above list may be added the Economic, Ideal, and National stands, made by R. and J. Beck, London and Philadelphia; and Crouch's Student and Premier stands.

These stands should be provided with two good eye-pieces and at least two good objectives: the one-fourth and one inch are to be preferred. The instrument should have the society screw, so that any objective of modern make can be used. Any of the stands above mentioned will be found good enough to carry any objective up to a tenth.

For ordinary use the monocular form will be found preferable to the binocular.

Care should be taken, in selecting the microscope, that one is procured that has some form of sub-stage to carry condensers for illumination, polariscope, etc.

The polariscope will be found of great benefit in identifying starches and similar bodies. It will serve to show whether sulphate of lime exists as gypsum, and to distinguish between it and sand.

The instrument above spoken of may be obtained at a price varying from $50 to $175, according to completeness and the reputation of the maker.

Polariscope. — This is a comparatively new instrument in analytical work, and has only been brought to its present state of perfection within a very few years. Many substances have the power of changing the plane of vibration of a beam of polarized light, and this change in direction is exactly proportional to the number of molecules with which the beam comes in contact. For instance, if we have a solution of sugar in a tube, and place this tube in the path of the beam, we find that it rotates the plane a certain number of degrees. Now, if we take a tube twice as long as the first, and replace the first one by it, we find that the plane suffers double the rotation ; or, if instead of lengthening the tube we add an additional amount of sugar to the solution, so that it is just twice as strong as the first solution, we find the same effect. This property is taken advantage of to determine the amount of sugar in a given sample.

There are two principal forms of instruments at present in the market, or, rather, in use in this country. A third form, that known as Wilde's polaristrobometer, is considerably used in Europe, but has never come into extensive use here.

These instruments are known as the Soleil and Laurent or pénombre.

The Soleil is manufactured under two different forms, — the Soleil, or the old form of the instrument; and the Ventzke-Soleil as made by Schmidt & Haensch or by Scheibler of Berlin.

The latter is the form which has been adopted by the United States government in the custom-houses where it is used in the valuation of sugar for determining the rate of duty.

In this instrument the zero point is determined by comparing the shade of two half-disks which are seen on looking through the instrument; the instrument being so adjusted that when the scale is at zero these disks shall appear of a pale rose-color. This color requires considerable skill and practice to observe it correctly; and the instrument cannot be used by those who are color-blind, since the change of color which takes place is from a green to red or *vice versa.*

In order to meet these difficulties the instrument known as the half-shadow or pénombre of Laurent was devised.

In this instrument the contrast is between yellow and black, or light yellow and very dark yellow. These being two colors that are not apt to be confounded, the instrument is much easier to use. Its defects are that it requires a monochromatic light, preferably the sodium flame, and it is very difficult to obtain this of sufficient strength. For a description of these instruments the reader may refer to any modern work on physics, or better to the catalogues of the makers.

The Soleil is described in Blyth's Manual of Practical Chemistry; the Soleil-Ventzke, in "Anleitung zur untersuchung die fur Zucker-industrie in Betract Kommenden Rohmaterialien, etc., von Dr. R. Frühling und Dr. J. Schulz." The best description of Laurent's instrument is in his catalogue, which may be obtained by addressing M. Laurent, optical-instrument-maker, Paris, France.

The method of using these instruments will be explained when the adulterations of sugar are spoken of.

The accessories necessary with the polariscope are as follows: —

A balance that is capable of carrying one hundred grams on each pan, and that will turn with ten milligrams when loaded. The balance made by Becker of New York as a prescription balance, in which the pans are on top of the case, answers very well.

A German-silver dish that will hold about 200 c.c. of water, with a weight that just balances it.

A set of weights that are adjusted to the polariscope are much more convenient than the use of separate weights. If the Soleil or Laurent is used, these weights should weigh 8.0735, 16.147, and 32.294 grams.

If the Soleil-Ventzke is used, they must weigh 13.024, 26.048, and 52.096 grams. By the use of these standard weights a very common source of error is avoided.

Half a dozen flasks which will hold 100 c.c.; and three or four which will hold 110 c.c., with two marks on the neck, one at 110 c.c., the other at 100 c.c.

I have in practice used 200 and 250 c.c. flasks for making up sugar solutions, but the 100 c.c. are those that are commonly used. The larger flask enables one to use a larger sample of sugar, and to thus diminish the liability to error.

Half a dozen specific-gravity jars that will hold about 100 c.c. These all have a broad foot so that they stand firmly on the table, and serve to support the funnel used in filtering the solutions.

Half a dozen 3½-inch funnels, and a supply of six-inch filters made of good white German filtering paper.

A solution of acetate of lead made by dissolving 600 grams of acetate of lead in two litres of water, and adding 200 grams of litharge; allow the bottle to stand in a warm place for twenty-four hours with frequent shaking, then filter, and preserve in well-stoppered bottles, as the solution absorbs carbon dioxide rapidly from the air.

Balance for Fine Weighing. — This should be capable of carrying 200 grams in each pan, and turn with one-tenth of a milligram. Becker's balances have proved very satisfactory: they are simply and strongly made, and not liable to get out of order. The balance should be carefully tested from time to time, to see that it is in good order.

Weights. — A set of weights from 100 grams to 1 mg. will be found sufficient. On the perfection of the balance and weights employed, will depend the value of the work.

It is sometimes said that a good workman will do good work with poor tools. But no chemist, be he ever so skilful, can do good work with a poor balance and inaccurate weights.

Platinum. — A chemist cannot have too many platinum dishes, their number generally being only limited by his means.

The following are almost indispensable in a well-fitted laboratory.

Four dishes for milk analysis and obtaining the ash of organic matters. These should be 6 ctm. in diameter and 15 mm. deep, and should weigh about 20 grams each. They *must* have flat bottoms.

One platinum crucible 4 ctm. deep and 25 mm. wide at top, with a lid in the form of a capsule.

One platinum dish holding about 150 c.c. of water: this should weigh about 50 grams, and is also best made with a bottom almost perfectly flat. Flat-bottomed dishes have a great advantage over the hemispherical in rapid evaporation.

A flat circular piece of platinum, about 7 ctm. in diameter, is very convenient for covering the small dishes when they are used to ignite substances that are liable to decrepitate. When all crackling has ceased they are removed, ignited, and the ash brushed into the dish.

Porcelain crucibles, a dozen each of Nos. 0 and 1, will be found useful. Porcelain crucibles must be used in the ignition of all substances containing easily reducible metals such as plumbic sulphate and argentic chloride.

Porcelain dishes, two or three nests of half a dozen each, the largest holding a half-litre. The four-inch size is very convenient for general use, and it is best to have at least half a dozen of these.

Beakers. — The wide form with lips known as Griffin's are the most convenient. Half a dozen nests are not too many.

Watch-Glasses. — A dozen three-inch with edges ground to fit. These are very convenient for holding substances in which we wish to determine the moisture. For this purpose two of them are used: they may be held together while the substance is being weighed, either by a rubber band, or best by a spring clip. The spring clip is easily made by taking a brass wire of about 2 mm. in diameter and 20 ctm. in length, bending a ring on each end of this of about 2 ctm. in diameter then bending the wire in the middle so that the rings will come opposite to each other. The wire should be what is known as spring brass.

A dozen four-inch watch-glasses. These are very convenient for covering beakers and other dishes while boiling, to prevent loss.

Gas-Lamps. — A blast lamp and bellows for intense heat. The Buffalo (N.Y.) Dental Manufacturing Company make the most convenient bellows now in the market.

Two or three ordinary Bunsen burners, also two or three flat gas-lamps. Those made by Burnham of Tenth and Sansom Streets, Philadelphia, are very convenient. He makes two sizes: the small one, or nursery-lamp, answers for all ordinary purposes. The large one is convenient for boiling wash-water, distilling water, and other purposes where considerable heat is required.

A small muffle-furnace. The gas muffle-furnace known as "Griffin's Miniature" will be found a great convenience. The muffle in this can be maintained for hours at a bright red heat without any attention, with the consumption of about twenty feet of gas per hour. Cream-of-tartar, bread, and similar substances are readily burned in this without loss to a white ash. The heat can be so regulated as to leave the ash unmelted, and of the form of the article burned. During the past year nearly twenty-five hundred ash determinations of wood have been made in my laboratory with this furnace; the ash retaining in most cases the exact form of the block, and becoming either perfectly white or of some color due to the ash-constituents. This furnace costs, as furnished by Griffin, about twenty dollars. Griffin's burner is best replaced by one described in "The Analyst" for September, 1881. I have used this form of burner in the larger muffle-furnace for three years with much satisfaction.

Water-Baths. — The ordinary copper water-baths sold by the dealers are of but little use, since they hold but one dish at a time, and require constant attention.

A much more convenient form is a hemispherical copper dish with three legs and a copper cover. The dish should be about 35 ctm. in diameter, and the legs of such a length that a Bunsen burner will stand under it in the most effective position.

The cover is pierced with five holes; a small one in the centre in which the platinum crucible will fit, and four around the edges of such a size that they will support the large platinum dish or the four-inch porcelain dish. Each of the holes is provided with a single ring with an opening in it of the right size to support the small flat platinum dishes. The rings as well as the central hole are provided with covers so that one or all the holes may be used at once. A cheaper form of the above is a granite-ware pan with a copper top.

For many purposes the pan can be placed on an ordinary cooking-stove.

Air-Bath. — A large air-bath, at least a cubic foot in contents, is a great convenience. The common tin ovens sold with gas-stoves answer very well. They may be kept at almost any temperature by means of a Bunsen burner and regulator.

Pipettes. — A set of five will be found convenient; the bulb on these should be cylindrical rather than globular or pear-shaped. They should have a capacity of 100, 50, 25, 10, 5, and 1 c.c. One holding 10 c.c., and graduated from 0 to 10 c.c. by tenths, is very convenient.

Burets. — Two holding 100 c.c. each, and furnished with Mohr's rubber tips and stop-cocks, and one of 50 c.c. with a glass stop-cock. These should all be provided with Erdman's floats.

Flasks Graduated. — One of a litre capacity, two of 500 c.c., two of 100 c.c., one of 50 c.c. capacity. These should all be provided with glass stoppers, and have the ring around the lower part of the neck.

Measuring Jars. — Half a dozen jars about 25 ctm. high, graduated into 100 c.c. These will be found useful as creamometers and also in ammonia tests.

Flasks. — A supply of ordinary ungraduated flasks will be found very useful. The flat-bottomed Bohemian flasks are the best for ordinary use. Half a dozen of each of the following sizes will not be too many: 32-oz., 24-oz., 16-oz., 8-oz., 4-oz.

Re-agents. — The ordinary re-agents described in Fresenius' Qualitative Analysis will be found sufficient for most cases.

Samples. — A gross of 6-oz. ordinary wide-mouth bottles, such as are used for horse-radish, will be found very convenient for preserving samples.

To conclude: the health officer cannot be too vigilant in his search for adulteration; nor too circumspect, when adulteration is found, in condemning.

He must be perfectly sure that he is right, and must throw all personal feelings aside, for nothing so prejudices a case as to have it appear that the officer has any object in view other than the performance of his duty; and in a large number of cases he will find the purposes of the law far better served by warning the parties privately, than by bringing the case into court. Any repetition of the offence should, however, be followed by prompt action.

The English officers have in a number of cases damaged themselves far more than they have helped their cause, by being too sure of their cases, and neglecting to make full examinations in regard to the sources of the article, the condition of the market, and various other facts that should have been taken into account.

Another source of trouble is that the officer is frequently called upon to attend to private business in a line similar to his public duties. While such work will in many cases be an actual assistance to him in his public duties, it is best for him to refuse it, since it will generally cause him more trouble than the fees for doing it amount to. I have known such cases as this: A milk-inspector has taken a sample of milk from a wagon to his chemist. The milkman has also taken a sample on the same day to the same chemist, the second sample being perhaps pure milk. The chemist, when called as a witness, is asked for the second analysis; and the jury are led to believe that the two samples were identical, and are asked by the counsel for the defence to acquit the defendant on the ground that the chemist cannot make two analyses of the same milk that will agree with each other.

BIBLIOGRAPHY.

The bibliography of the subject of food adulteration is very extensive, and is rapidly increasing; not so much from the fact that adulteration is increasing, as from the circumstance that it is a fashionable subject upon which to write just at present.

The works enumerated below are most of them quite recent, and cover the ground fully.

The trouble with most of the books on the subject is, that, while they all describe what has been done, the most of them are written by men who have had but little practical experience, or who wish to prove some particular theory.

ACCUM, FREDERICK. *A Treatise on Adulterations of Food and Culinary Poisons*, exhibiting the fraudulent sophistications of bread, beer, wine, spirituous liquors, tea, coffee, cream, confectionery, vinegar, mustard, pepper, cheese, olive-oil, pickles, and other articles employed in domestic economy, and methods of detecting them. London and Philadelphia, 1820.

This book is interesting as being the first attempt in English to give a systematic presentation of the subject. It is frequently referred to as "Death in the Pot," from the wood-cut on the title-page. It is extremely sensational in style, and has been the model which most newspaper-writers on the subject since that time have followed.

The Analyst. London, 1877 to date.

This is the official journal of the Society of Public Analysts of Great Britain. It contains a full report of their proceedings, including the papers read before the society, and gives the latest intelligence in regard to the methods of detecting adulterations. It also gives reports of the most important cases coming before the courts. It is published monthly at five shillings per annum, by Bailliere, Tindall, & Cox, King William Street, Strand, London, E.C., England.

The first volumes are out of print. The current numbers should be in the hands of all who make a study of the subject of food.

BLYTH, A. WYNTER: *A Manual of Practical Chemistry, the Analysis of Foods, and the Detection of Poisons*. London, 1879. 2d ed., 1882.

This book is one of the most valuable that has ever been published on the subject of the analysis of food. The processes given are mostly modern and easily followed, giving accurate results.

BLYTH, A. WYNTER: *A Dictionary of Hygiene and Public Health*, comprising Sanitary Chemistry, Engineering, and Legislation, the Dietetic Value of Foods, and the Detection of Adulterations. London, 1876.

This is a valuable compendium of sanitary science.

CAMERON, C. A. *Chemistry of Food.* London : 1868.

A small book on the values of various kinds of food.

FOX, C. B. *Sanitary Examinations of Water, Air, and Food.*

This is chiefly valuable for the chapters on water and air, which are very full.

GRIFFIN, J. J. *The Chemical Testing of Wines and Spirits.* London : 1872.

REDDING, CYRUS. *A History and Description of Modern Wines.* London : 1871.

This work contains an excellent chapter on the adulteration of wine.

DUPLAIS. *A Treatise on the Manufacture and Distillation of Alcoholic Liquors.* Philadelphia : 1871.

This work gives a very full description of the methods employed in manufacturing distilled liquors.

HASSALL, ARTHUR HILL. *Food and its Adulterations.* London : 1855.

Adulterations detected in Food and Medicine. London : 1857.

Food, its Adulterations, and the Methods for their Detection. London : 1876.

These three works, of which the first two are out of print, are substantially three editions of the same work. Dr. Hassal was originally employed by "The London Lancet" to make a series of investigations on the food supply of London. These investigations were published in "The Lancet," from 1851 to 1854 ; and were afterwards revised and extended, and published as "Food and its Adulterations," in 1855. The plates in the first edition of this work have been extensively copied, and are regarded as standard. The same plates are used in the second and third editions, but they lack the sharpness of the first edition. The edition of 1876 is indispensable for the food-analyst.

HUSSON, C. *Le Lait, la Crême, et le Beurre.* Paris : 1878.

LETHEBY. *On Food.* London and New York : 1872.

KENSINGTON. *Analysis of Food.* London : 1877.

This gives the results of a great number of analyses of food, collected from various sources.

KÖNIG, Dr. J. *Chemische Zusammensetzung der Menschlichen Nahrungs- und Genussmittel.*

The first part of this work contains a collection of a vast number of analyses of articles of food. These analyses are fully discussed in the second part.

MITCHELL, JOHN. *Treatise on the Falsification of Food.* London : 1848.

NAQUET, A. *Legal Chemistry*, translated by J. B. Battershall. New York: 1876.

This work contains a very full bibliography of works relating to food and poison.

NORMANDY, A. *The Commercial Handbook of Chemical Analysis*, new edition, by Henry M. Noad. London: 1875.

This book contains much valuable information in regard to commercial articles of food.

MARCET, W. *On the Composition of Food, and how it is Adulterated.* London: 1856.

BOUCHARDAT et QUEVENUE. *Du Lait.* Paris: 1857.

ALLEN, ALFRED H. *An Introduction to the Practice of Commercial Organic Analysis.* Vol. I. London: 1879. Vol. II., 1881.

Full directions are given for the analysis of alcohol and its derivatives. This is the best work on the subject now in print.

FLECK, H. *Die Chimie im Dienste der Oeffentlichen Gesundheitspflege.* Dresden, 1882.

PAVY. *Food and Dietetics.* London and Philadelphia: 1874.

BOLLEY, P. A. *Manuel Pratique d'Essais et de Recherches Chimiques.* Paris: 1877.

CHEVALLIER, M. A., et BAUDRIMONT. *Dictionnaire des Alterations et Falsifications des Substances Alimentaires, Médicamenteuses, et Commerciales, avec l'Indication des Moyens de les reconnaître.* 5ième ed. Paris: 1878.

This work is extremely full.

SMITH, EDWARD. *Foods.* London and New York: 1873.

SMITH, EDWARD. *Manual for Medical Officers of Health.* London: 1874.

SMITH, EDWARD. *Handbook for Inspectors of Nuisances.* London: 1873.

These two last works contain the full text of the English laws upon the subject of food and its adulterations.

BRYN, M. L. *A Treatise on the Adulteration of Food and Drink.* Philadelphia: 1852.

BECK, LEWIS C. *Adulterations of Various Substances used in Medicine and the Arts, with the Means of detecting them.* New York: 1846.

PIERCE, C. H. *Examinations of Drugs, Medicines, Chemicals, etc., as to their Purity and Adulterations.* Cambridge, Mass.: 1852.

These works are mainly interesting, as being among the earliest published on the subject in this country.

HARTLEY, ROBERT M. *An Historical, Scientific, and Practical Essay on Milk as an Article of Human Sustenance*, with a consideration of the effects consequent upon the present unnatural methods of producing it for the supply of large cities. New York: 1842.

This is the earliest attack made upon swill-milk produced by cows fed upon distillery-slops that I have met with.

CHURCH, A. H *Food: Some Account of its Sources, Constituents, and Uses*. New York: 1877.

PRESCOTT, A. B. *Outlines of Proximate Organic Analysis*. New York: 1875.

PRESCOTT, A. B. *Chemical Examination of Alcoholic Liquors*. New York: 1875.

CHAMBERS, T. K. *A Manual of Diet in Health and Disease*. Philadelphia: 1875.

SOUBEIRAN, J. L. *Nouveau Dictionnaire des Falsifications et des Adultérations des Aliments, des Médicaments, etc.* Paris: 1874.

MULLER, C. *Anleitung zur Prufung der Kuhmilch*. Bern: 1877.

PENNETIER, G. *Leçons sur les Matières Premières Organiques,—Origines, Provenance, Charactères, Composition, Sortes Commerciales, Alterations Naturelles, Falsifications et Moyens de les reconnaître, Usages.* Paris: 1881.

This new work is very fully illustrated, and contains much information that it is difficult to obtain elsewhere.

DEITZSCH, O. *Die Wichtigsten Nahrungsmittel und Getränke, deren Verunreinigungen und Verfälschungen*. Zurich: 1879.

ELSNER, F. *Die Praxis des Nahrungsmittel-Chemikers*. Leipzig: 1880.

MEDICUS, LUDWIG. *Gerichtlich-chemische Prufung von Nahrungs und Gemissmitteln*. Würzburg: 1881.

THUDICHUM and DUPRÉ. *A Treatise upon the Origin, Nature, and Varieties of Wine*.

It contains very full analysis of all the principal varieties of wine.

WANKLYN. *Tea, Coffee, and Cocoa*. London: 1876.

WANKLYN. *Milk Analysis*. London: 1873.

This little work created a revolution in the methods of milk analysis; and Wanklyn's methods, with but slight modifications, have become the standards for the analysis of milk.

In addition to the above books, many of the reports of various boards of health contain valuable articles on the subject of food. For the literature of water, Professor Nichols's various reports in the Massachusetts State Board of Health may be consulted with advantage.

OUR EYES AND OUR INDUSTRIES.

By B. JOY JEFFRIES, M.D.

OUR EYES AND OUR INDUSTRIES.

MASSACHUSETTS is largely engaged in the education and preparation of teachers, as also in the education of those who are to enter the so-called learned professions, where their daily bread is to be earned by the use of their eyes. If at any time during their career these organs fail either class, they are worse than beggars, since they have by educational refinement become habituated, and their families accustomed, to a certain amount of the amenities of life, the loss of which will be most keenly felt. Besides all these members of the educational and professional classes, are the great mass of those engaged in mercantile pursuits, whose very existence depends on their ability to use their eyes most continuously. All so far spoken of come from our universities, colleges, academies, or public schools. But from the latter come also the still more numerous class who must support themselves and their families by manual industries which tax the eyes fully as much if not more than does the pursuit of the educated professions.

While so much has been said, and so much written, in notes of warning, as to the dangers of overwork and strain of the eyes, in reference to those who are in or about to enter professional life, but little has been presented to our communities as to the equally dangerous deterioration of the eyesight of those who are to engage in our industries. Publicly I raised this note of warning in "The Boston Medical Journal," and in "The Massachusetts Teacher" in 1869, pointing out some unnecessary causes of impaired vision dependent upon defects in schools, school-books, and school-teaching. My experience since then in private practice, and, of course, more especially in work at the Massachusetts Eye and Ear Infirmary, has shown me that it was quite time that the community should be equally well instructed as to the dangers of the future in reference to the so-called mechanic class, on whose continued good vision depends the position of our State as a manufacturing centre. Defective vision from unnecessary causes during school life becomes therefore a rather important subject, touching, as it does, not only the mechanic's daily wages, but the capitalist's returns and income. All the so-called learned professions, law, medicine, theology, and the others now equally recognized as professions, are, in fact, but so many agencies whose business it is to keep in working order the merchant's brain and the mechanic's hands. But while the former may scheme and think out methods of profitably employing accumulated earnings, the latter can never support himself and surroundings, or be a producer, without the eyes to guide the hands. How restricted are the mechanical occupations of the blind, even when their sense of touch is best cultivated by patient teaching!

It has seemed to me, therefore, quite time that the unnecessary causes of impaired vision, as well also as the natural and unavoidable ones which specially affect the mechanic and working classes, should be equally explained and set before those who have it in their power to control them; namely, our educational and school authorities, and those who engage any and all classes of employés in mill or workshop. While the professional or educated man, as he grows up, can, and probably will, look after himself and perhaps also his children in this respect, it is very different with those upon whom our great industries are dependent for their success, and who are the muscle and sinew of our State. These require as good, or better, eyesight, by which I mean capacity for continuous labor for many years with the visual organ, as do the educated professional or mercantile class. A bookkeeper who has to write and compute in some large concern six or eight hours a day does not have to tax his eyes more than does the mechanic in certain departments of shoe manufacturing. These are unrealized and unrecognized facts which it has long been my purpose to bring before the community, and which it is the object of this article to point out and draw attention to.

Near-sightedness or myopia has been shown to be on the increase wherever civilization is calling for further education. The warning note of the steady increase of near-sightedness with school and college life, was first publicly given by Dr. Cohn of Breslau. In 1869 I urged that the same investigations should be carried out here. Since Cohn's report, in various places in Europe and finally in several cities in this country, the same sort of investigations have been carried out, and always with similar results, viz., that many children become myopic, and go on becoming still more so with their progressive work in school, college, and university. These facts are now so well known from the many reports, etc., that even the daily press has taken up the subject in notes of warning. In 1869 my suggestions and proposals were not only refused but resisted. The contrast at present is quite striking, when the school committee of a neighboring town publish in the pamphlet report the *names* of all the children with myopic or otherwise defective eyes, as well as those color-blind. The medical and even educational journals are discussing and reporting on this deterioration of our eyes. The ophthalmic surgeon is no longer smiled at as a simple enthusiast or interested party. The statistics are already ample in this country; and while they seem to prove that we are not so badly off in this respect as parts of Europe, since our conditions are not so bad, they yet show what is the tendency, and the results of past years of neglect of the hygienic conditions necessary to prevent increasing nearsightedness. It must be remembered that myopia and the tendency to it are transmitted. Now the bad conditions of the past generation are affecting the present in this respect. It seems impossible, as I look back upon it, that so little thought and attention should have been given to schools and scholars as was formerly the case. Is it any wonder that a former generation became myopic, and handed this condition to their children now growing up at school and college? This sort of thing has not all passed away, and I want to call parents' as well as educators' attention to the fact that as bad conditions are existing now. Educators, school-committees, or teachers, are *not*, however, responsible.

Defective schoolhouses from any cause produce myopia, and help increase it when naturally present or when the tendency to it exists from birth. As I have said, these facts have been finally admitted by the community, and those in authority are more amenable to suggestions concerning feasible means of controlling myopia. Parents, too, are beginning to realize that the absolutely necessary glasses for school-children cost money, even disregarding any question of loss of vision, etc. The resistance of those whose gains or pockets are touched by the adoption of better-planned schoolhouses and school furniture, as also of those who get the control of school-book printing, etc., is too great to be at present overcome. It will, however, come in time. The industrial classes have no way of being heard, and can only *vote.* When they finally learn that increasing near-sightedness is as bad for their children as for those of the wealthy, and that there are some unnecessary causes of it they themselves can, even remotely, affect, then this vote will be directed with more thought than it now is. A mechanic who has children who are to follow his trade, or get into a higher one, begins to reflect and inquire when these children cannot study at school without glasses which *must* be purchased. And, when these parents are told of the risk of the increasing difficulty, they begin to take some interest in what is to affect the children's future means of support. Common-sense, having now finally listened to and learned from those who know what myopia leads to, will readily see how it must interfere with the increasing demands on the eyes in so many of our industries, — apart, as I would repeat, from the professions so called.

The investigations of schoolhouses everywhere have shown that want of light, or light not coming rightly, are potent causes of eye troubles. There is no excuse whatever here in Massachusetts, even in our cities, for not having properly constructed schools, with all the necessary space around them. But notwithstanding all that has been shown and said, and the good models to copy from already built here and there, schoolhouses bad in every way are building and will be built. Educators who best know, and will give the time to learn, are not allowed to build schoolhouses. It is useless to try to hide this or not acknowledge the present condition of affairs. Parents must learn why their children are hurt by school-life, and vote the remedy.

It is very necessary that school-furniture should be adapted to the size, position, and condition of the children. This is a question which has been thoroughly discussed here, as well as abroad. In my notes of warning, in 1869, I reported that Dr. Cohn of Breslau, Germany, took the bodily measurement of the more than ten thousand children whose eyes he had tested; and measured, in comparison, the school desks and seats, from which he found that all school-furniture was badly constructed, so as to readily induce or increase near-sightedness. We sent from America with considerable pride our school furniture and appurtenances to the Paris World's Fair. These were carefully examined and measured by Dr. Cohn, and, like all the others, found so arranged as to produce the evils spoken of. But contractors will continue to manufacture the forms out of which they can make the most money. These facts are no less well known than hard to combat. From various causes the tongues of those who know, and should speak, are tied. It is in no spirit of pessimism that I write thus earnestly and frankly. I have been in all the schools of my native city above the primary, and have come face to face with some twenty-nine thousand scholars, while I tested them for color-blindness. Defective schoolhouses and appurtenances were pointed out to me; but in many cases this was not necessary, as I had only to use the senses of sight and smell to be aware of defects of furnaces, drainage, and closets, etc. Time and again was I appealed to as a medical man to examine and give my opinion concerning such defects. I was, however, so to speak, the privileged guest of the school-committee, in my work among the scholars. Moreover I well knew that the school board had not the authority to correct mistakes of building or the errors of the past. Money has been, is, and will be, terribly wasted in the construction of schoolhouses. Persistent efforts, combined with moral courage and strict honesty, can alone, and will finally, correct these abuses.

School-books, text and reference, are bitterly complained of by all the gentlemen who have been at work testing the children's eye-sight in different parts of the world. Of course poor paper, bad impressions, worn-out type, and crowding the pages by finer and finer type, mean more money for the contractors who over-persuade committees and school boards. As these latter, however, do have it largely in their power to correct abuses, I would point out here where improvements can be made which will be of great benefit, and not too greatly touch the pockets of school-book manufacturers. For this purpose I cannot do better than here give a slight *résumé* of the extremely interesting and practical paper of Dr. Javal of Paris, on "The Physiology of Reading." It cannot fail to excite great interest, and may help to arouse the attention of those who can by persistent effort do away with some, at least, of the unnecessary causes of impaired vision. These causes are affecting the present industrial generation, and are to be handed down to the next with the increased power of heredity.

Dr. Javal's article, "The Physiology of Reading," may be found in the "Annales d'Oculistique," published in Bruxelles, 1878–79–80, and in the "Revue Scientifique," June 25, 1881. A similar article on "The Physiology of Writing," by him, nearly equally important, appeared in the "Revue Scientifique" for May 21, 1881. In these two papers he shows what can be readily done, as to writing and printing, to help relieve the strain on the eyes, which he as all others agree is one of the great causes of increasing and progressive nearsightedness in our schools and colleges. I can only here sketch the article on "The Physiology of Reading." It appeals to all readers and printers.

"We must first consider the *typical form* letters are to have, by which is meant the characteristic elements of the letter. For instance, the typical form of a V is produced by two straight lines; the terminations, the space between the two arms, etc., are not what goes to make up the typical form of a V, but two lines of equal length, meeting below at an acute angle. The accessory modifications are no necessary part, and need not exist.

"In reading, the eye has no time to examine each letter, in all its parts. In reality, the point of fixation runs along a strictly horizontal line, cutting the letters just below their tops. The other parts of the letters are seen indirectly by those portions of the retina at greater or less distance from the centre. A knowledge of this fact must influence the form to be given the letters. This fact it is proper for us to prove, since it is quite a new idea. We discovered it thus: After gazing at the print steadily we got what is called the after image, which was that of a series of faint or grayish lines, with bright interspaces. The amount of black on the letters will give only a gray line. The explanation is that the eye runs horizontally to avoid unnecessary and tedious movements, and the line is determined by the forms of the printed letters. If we cover the upper half of a line it will require considerably more effort to decipher it than if the lower half is covered; in the latter case, one can read nearly as easily as if the whole line could be seen."

To test this the reader will see that this sentence will be much more easily read, the lower half being wanting, than this where the upper half has been removed. The special words are not chosen, nor is special type selected.

" To return now to the cause of this, and count the letters or their parts which project above and below the body of the short letters, say in the sentence before the last, and there will be found that about five sixths project above, and only one sixth project below, the line.

" Above the line of letters we find all the capitals (all the accents in French), the dots of i and j, and the letters b-d-f-h-k-l-t, whilst below we have the letters g-j-p-q-y. Taking into account the frequency of the capitals, the dots (accents in French), and long letters, we find out of a hundred exceeding the line, eighty-five project above and fifteen below. This forces the reader to keep the eye fixed on a point above the middle of the short letters.

" This being the fact, our effort should be to give the letters forms differing as much as possible from each other at the point of fixation. Now in the last of the periods of time we spoke of, viz., from 1700 to 1840, the type-cutters seem to have striven to *avoid* this. Cover the bottom of a line of modern print so as to let only the tops of the short letters be seen, and you will find a-c-e-o-s looking nearly exactly alike, as also -n- and -r-, whilst the distinctions between -h- and -b- and -n- and p- are but slight."

This defect is less with the modern Elzevirs, in which this is printed for the reader's benefit, and it is still less marked with the types of Garamond and those of Jenson

" Before passing the alphabet in review, it is to be noticed that certain letters are naturally more readily seen than others, the long ones of course from their greater size; then the more simple ones, as -u-, are more legible than the complicated ones like -a-. We must therefore do something to render these latter more distinct.

" We would notice, also, that certain die-cutters, in order to increase the regularity of appearance, endeavor to flatten the round letters laterally, and make the square ones more round. To this we object, and much prefer to introduce some marked differences towards the tops of the short letters; for instance, a difference readily noticeable between -b- and h-. So also we would not increase the size of the bodies of b-d-p and -q, to make them of the same size as -o-, for this attempt at regularity is quite useless.

" The upper arms of d-k and -l- cause no confusion. To render -b- and h- more unlike, we should take care to make the body of -b- well rounded, and the angle which unites the horizontal and second stroke of -h- as little rounded as taste will permit: hence for uniformity's sake the body of -d must be as round as possible. It must be a little larger than -b- to appear of the same size. The letters -f- and -t- are confounded when the top of the -f- is broken, which often happens with much-used type. We should strive to prolong the bar of -f- towards the right and that of -t- towards the left, to shorten these bars on the other side, and make them as wide as possible without being too unusual. Then we should make the -t relatively short, and thicken the angle at the top and left of the letter, avoiding the hook at the bottom, which was gradually substituted for the horizontal stroke of old typography. This hook is only graceful when delicate; and, as will be seen, we are opposed to fine hair lines The form which we propose for the hook being like the old one, is an additional reason for employing it, since, all our type having rather an ancient look, the study of good taste should be regarded. Among the long letters must be placed the -i-, the dot not being in contact with the body of the letter. We should make the dot thicker than the shaft of the letter. The expression *dot your i's* shows the value of the dots, and how they contribute to the visibility. It is not only important that the dot should be strong so as to avoid the confusion between -i- and -l- and -f- in small print, but also that it may not be broken off so easily. For this reason we would make the -i- a little stouter, to avoid the dot's looking disproportioned. The dot we should place as high as possible, to render it clear.

"The letters projecting downwards, g-j-p-q-y, are excellent ones. We should avoid making the -g- like the Italic -g-, because then it resembles more the -q-. Like the old Venetian print we would make the upper part more of an ellipse with axis horizontal, to increase the size, which is necessarily reduced vertically, and again use the acute angle at the top and left of the end, which was abandoned after Garamond. To -j-, we would give the old hook, by dropping off the button at the lower end: -j instead of -j-. Finally, for -y- the older form which is beginning to be seen, and is no less graceful than the newer one, where the lower part of the letter is vertical, as adopted by the French Imperial Press. The point of intersection of the two legs must be rather below the line, in order not to appear above it. For -p- and -q- we must make the body of q- rather larger than that of -p- to make them appear of the same size. Good cutters generally do this.

"As to the short straight letters, m-n and -u-, -m- ought to have a little less space between the legs; and, if the usual terminal characteristics should be used, then -u- should be a little more compressed than -n, especially at the top, in order to make it appear equal.

"We call *round* the a-c-e-o and -s-. We would conform to the custom of letting them slightly project above and below the line of the straight letters, to prevent them appearing smaller. As to -a-, we would return to the old Italian types, and of the manuscripts which served then as models, and would select an -a- whose head was very small, and did not project beyond the body. In fact, by looking at letters off at a distance, placed without order on a card, we can readily see that a-e and -s- are the worst in the alphabet. We must render -a- more simple, which may be done by reducing the size of the head, so that it will at a distance look like -r upside down (ɹ), and becomes then as legible as any other letter, if care is taken to make the body narrow and elongated. As to -c-, we would avoid the present form, which assists the confusion with -o- and -e-, and return to the older form more resembling a half-circle. For -e- we should not hesitate to go back to the old form -e-, which brings the horizontal bar nearer the line of vision in reading, and avoid having the bottom curve come up too high. Perhaps we might even make the cross-stroke inclined, as it is in some handwriting, thus increasing its length and importance. We should not fear to make the -o- quite round, though it might appear larger than -u- and -n-, and this notwithstanding the rules followed by cutters. There remains -s-, which, do what we may, is a bad letter. All we can attempt is to make it take up more room by making it more angular than usual. It would then be as legible as -z-.

"The letters having the oblique straight strokes, v-w-x and -z-, are not criticised, except that -w- and -v- must project a little below the line in order not to appear too short.

"There remains finally only -r- to be spoken of. Here we would not carry down the bar or arm, as recently done, because then it makes the -r look like -n-. We prefer the older form -r-, more original and legible."

Dr. Javal next discusses the thickness to be given the individual letters. I will not repeat it all here; but I agree with him that it is of great importance, especially with the school-books intended for children who are not myopic or presbyopic, and who are often forced to read in the class with very poor light. Dr. Javal shows what is meant by this; viz., —

[2] "This sentence is printed in the type used in the 'Revue Scientifique' in extremely delicate letters, and in that of M. Motteroz, who has employed the excellent idea of improving the modern type by reducing the length of the strokes."

[1] "This sentence is printed in the type used in the 'Revue Scientifique' in extremely delicate letters, and in that of M. Motteroz, who has employed the excellent idea of improving the modern type by reducing the length of the strokes."

"This sentence is printed in the type used in the 'Revue Scientifique' in extremely delicate letters[1], and in that of M. Motteroz[2], who has employed the excellent idea of improving the modern type by reducing the length of the strokes."

Next, the terminations of the letters are criticised. He shows that the cutters have insensibly done what he would do, in part at least. He says, "The English use, as we French, too long terminals, but the angle between the terminal and the rest of the letter is always rounded. And to this must we not attribute the superiority of the English and American print? This is such a delicate difference that perhaps the reader has not noticed that this 'Revue' is printed in English type. It may require a magnifying-glass to distinguish the difference, but it is nevertheless the fact."

To assist the comparison this sentence is printed in French type.

" From all that has been said, it is seen that there is cause for the growing favor of English print; and this should be a reason for returning to the Elzevir type, as it is incontestably superior, as the present specimen of this sentence shows.

" In conclusion we propose a rounded form, like that designed by Jangeon, shorter than any yet adopted. Its advantage is seen in the greater legibility, especially for the fine type.

" Now as to the distances between the letters, which plays a part in the legibility.

" To be assured of this, one need but hold this page off at a distance, to perceive that this sentence, where delicate spaces are left between all the letters, is more legible than the rest of the page.

" Now, as to leading, this sentence will renew the hourly experience, and assure one that the entire suppression of leading does not diminish the legibility. The letters as they come from the fount have more space above and below than at the side. Hence it is quite clear that leading is a simple extravagance, but which need not be given up except on the ground of expense. Leading and wide margins should be kept for elaborate volumes. The library and the cheap journal will do better to use larger type than to waste the paper taken up by leading between too fine types. The editors of the French papers well understand this, and never lead their columns."

In his discussion of the important point of the size of letters, Dr. Javal says, —

" The question of the dimensions of letters has come up since the invention of printing. The written and the printed letter, at first exactly the same, have followed two quite different paths. The first books of Gutenberg were sold as manuscripts. Who would now mistake a printed for a written page?

" The cheapness of paper and the necessity of rapidity have given our handwriting its peculiar open character. At the same time, this has forced the contraction of types, since the cost of the paper is increased by the press-work. Now, how has this increase acted during the four centuries? Can the means used to economize space be bettered?

" For manuals and dictionaries which must be carried about, for the large papers and school-books, primary especially, it is useless to advise any plan which does not economize paper, for the public will not consent to any increased price, and publishers would not adopt it. We must therefore seek *to increase the legibility without diminishing the number of letters contained on a page.*

" Now, there are five ways of increasing the quantity of material on a page of given size: 1. Leaving out the leading. 2. Lessening the distances. 3. Flattening the letters so as to get more in a line. 4. Using a more delicate or thinner type. 5. Reducing the projections of the long letters.

"The first has been employed since the earliest days of printing. In fact, as one may see by looking back to page 98, leaving out the leading does not interfere with the legibility; leading simply marks expensive copies. It is absurd to use delicate type and lead it. It is much better to use type of good size, and omit the leading, although the latter gives the page rather a sombre look. To establish a limit, we should say that with the type now in use, it was better to employ No. 8 heavy than No. 7 leaded."

"For instance, this left-hand column is printed in 5 leaded, whilst the right-hand column is printed in 6 heavy, and one sees that the latter can be read farther off than the former, whilst it contains the same amount of material in less space.

"For instance, this left-hand column is printed in 5 leaded, whilst the right-hand column is printed in 6 heavy, and one sees that the latter can be read farther off than the former, whilst it contains the same amount of material in less space.

"The second means of increasing the amount of material is to lessen the distance between the letters. Referring to page 98, it will be seen that it would be better to increase the space between the letters. In reality the printers seem to have reached the limits of crowding the type.

"The third method is giving the type a narrower form, which has been employed from the commencement of printing. The popularity of the Elzevir type is due to the possibility of getting more letters in a line.

"The fourth means the printers employ to get more material into a given space consists in making the letters smaller. It is to be noticed that types do not take up less space by being simply shorter, as will be seen from this series.

14 abcdefghijklmnopqrstuvxyz
13 abcdefghijklmnopqrstuvxyz
12 abcdefghijklmnopqrstuvxyz
11 abcdefghijklmnopqrstuvxyz
10 abcdefghijklmnopqrstuvxyz
9 abcdefghijklmnopqrstuvxyz
8 abcdefghijklmnopqrstuvxyz
7 abcdefghijklmnopqrstuvyz
6 abcdefghijklmnopqrstuvxyz
5 abcdefghijklmnopqrstuvxyz
4 abcdefghijklmnopqrstuvxyz

"We see that the length of the lines lessens also with the decrease in the height of the letters, but that the reduction in breadth is much more gradual than in height, for the cutters have found that the *decrease of legibility is principally owing to the lessened breadth.* This is a fact we long ago insisted on.

"Printing on a piece of rubber which we can stretch in any direction, or looking at ordinary letters through cylindrical glasses by which we can make the type look taller or broader, will prove our assertion. Moreover, the value of broad type may be seen by holding a small type as far off as we can read it, and then, turning the page at an angle of 45° on its vertical axis, we shall find that we cannot read it, whilst turning it at 45°

degrees on the horizontal axis does not prevent our reading it easily. The value of the breadth of the letter is thus at once seen."

Dr. Javal shows how the question of wages and the delicacy of the female hand in type-setting have really modified the characteristics of the types. He says, "As to the smallest size which we would admit, it would be 8, for children learning to read."

"Another means of reducing the space occupied by printed letters is shortening the long letters." "In the papers printed with modern type, the long letters are so reduced that the space between the lines is really less than the space a short letter occupies on the line. It would seem, therefore, that we have reached the limit of reduction of the long letters. This is, however, by no means the case, as we may entirely leave out the lower projections of the long letters without much affecting their legibility. In fact, two years ago the Paris Omnibus Company, in order to save spaces of value, put their signs on a narrow band at the feet of the passengers riding on top. Necessity was the mother of invention, and the company devised the idea of substituting capitals for the letters projecting below, as has been done in this following sentence.

"It will be seen that the leGibilitY suffers much less than one would suPPose, since, as we have alreadY shown, the letters with PROJections below occur seven times *less* freQuentlY than those with PROJections above.

"One idea of reducing the length of the lower member rather more than the upper one seems to us to have this advantage: that, the short letters not then being in the middle of the whole height, those turned wrong side up will produce such a strong effect as to catch the attention of the proof-reader.

"We have thus proposed certain modifications of the letters, of value to increase the legibility; and we give here, in repeating the sentence, the types which come nearest to our ideas of those which are to be had in commerce."

Dr. Javal then explains the value of his proposed changes in reference to smaller and smaller letters, etc. As the type grows larger these are not so much called for, and we need not depart so widely from what is established and familiar, etc.

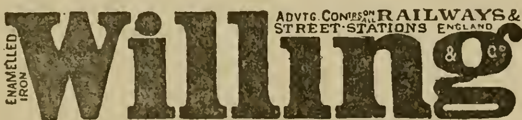
"These and all compact types produce a disagreeable effect when they are leaded. In reality what use is there in reducing the projections when there is leading? The space can be more profitably used by giving the letters a reasonable length, particularly in books where we do not desire to save all possible room. But for school-books, primary especially, that must be cheap, and free of faults (thanks to which, generations are threatened with near-sightedness), for the daily papers so crowded and so badly printed, forming, as they do, almost the only reading of the majority of men, — for all these it seems to us that the type we have described is the most preferable.

"To give a practical example, suppose the publisher of the 'Revue Scientifique' desired to reduce the price of subscription by printing with types hardly legible. It would not do to offer the public the specimen below, which is a reduction by photogravure, in such proportion that the printed part is just one-half the size of this, whilst the second specimen, which is by printing full in N°. 6 of better form, is not only more legible, but also more compact.

"To give a practical example, suppose the publisher of the 'Revue Scientifique' desired to reduce the price of subscription by printing with types hardly legible. It would not do to offer the public the specimen below, which is a reduction by photogravure, in such proportion that the printed part is just one-half the size of this, whilst the second specimen, which is by printing full in N°. 6 of better form, is not only more legible, but also more compact.

"To give a practical example, suppose the publisher of the 'Revue Scientifique' desired to reduce the price of subscription by printing with types hardly legible. It would not do to offer the public the specimen below, which is a reduction by photogravure, in such proportion that the printed part is just one-half the size of this, whilst the second specimen, which is by printing full in No 6 of better form, is not only more legible, but also more compact.

"As a second example we here reproduce by photogravure a sign, a marvel of its kind, which attracts the attention of every one travelling in England.



"We were quite surprised to find that the agents of Willing have discovered all the artifices which we have proposed. The utilization of space is most carefully studied in these seven letters. In the type we would propose, the letters would be thinner, the bases less heavy, the -g would go a little below the line, but on the whole our type would be more or less like the above."

As to the length of the lines, Dr. Javal has shown in a very carefully prepared article in the "Annales d'Oculistique," and also in the number of the "Revue Scientifique," above given, that very extended lines on a wide page are the fruitful source of developing near-sightedness. There is a certain change of the focus of the eye necessary in following long lines, which is very annoying, and positively hurtful. Every adult will realize this in reading quartos. Let us recall how readily the children lose their place in trying to turn back from the end of the line to the commencement of the next Perhaps our types may be set some day from right to left and from left to right in alternate lines, which would help save our eyes. Such radical change I do not even dare propose now. I would recommend Dr. Javal's most interesting and practical essays on the physiology of writing and reading to all school boards, educators, and printers. I will but quote his final sentence.

« This postscript is printed with N°. 8 of Olive Lazare of Marseilles. In this sentence thin paper is placed between the letters. I doubt if anything was ever printed in 8 so legible. One would suppose it was in 9. »

School Time and School Hours.

School time and school hours have been much considered; and, when so, always with the result of both being shortened. Our climate here in Massachusetts has been too little regarded, in apportioning both school time and school hours. Harvard University was forced, from the sickness and not infrequent deaths in September, to give up this month, and found that attempts at work after the middle of June were time thrown away. Now if this is true of young men from seventeen or eighteen to twenty-one or twenty-two, is it not equally true of school-children from five to seventeen? As a professional man I have had to watch many children, and I have talked with many teachers who felt free to tell me the real truth; and my firm belief is, that the whole work of exhibitions and the preparations for them, coming as they do at the end of the winter's labor and in the hottest weather, are nothing but a waste of time, brains, and money, and a very large factor in breaking down the physical condition of the scholars, which prepares them for the evil effects of the causes influencing their eyesight.

I am quite ready to meet the storm of indignation this will arouse, because I can speak from personal knowledge and experience, and because I well know who are my opponents. These latter are the teachers who are desirous of showing off their classes, which is practically throwing dust in the eyes of supervisors, school committees, etc. Then there are the whole classes of parents who thirst for their children's notoriety, and who besiege the schoolroom doors long before they are open on exhibition days. These are a nuisance and a curse to the sensible, honest teacher, so many of whom feel the absurdity of this whole exhibition business, and are thoroughly ashamed of it, but who are powerless to stem the current, and yield from very fear of loss of place or employment. Just before this exhibition work is commenced in the hot weather, *and after which no more is learned*, let the children be sent home to go to the country or seashore, or even roam the streets and haunt the public baths, and they will come back in infinitely better condition to stand the next year's work.

In our climate, children from five to seventeen can study, and study hard, under proper direction and restriction, for about nine months in the year. The other three in summer are waste of time and very great waste of physical condition, without which they cannot study at all. The extra strain and wear and tear from the preparation for examinations and exhibitions in the heat of June and July is also added to by the most absurd and hurtful custom of forcing the children to begin again the first Monday in September. No private school could exist where it was attempted, and private schools exist because this is required by the public ones. I am naturally referring to city schools and city life, and because in these all examiners have found the worst hygienic conditions affecting the eyesight. In Brussels the schools are dismissed when the glass stands at 83°. Now, the first fortnight in September is pretty sure to be the most unendurable of the summer, exhausted as we are by the previous heat. The whole of this last September (1881) was a fearful tax on scholars and teachers, but I am pleading only for the former. No schools should open before the middle of September here in Massachusetts. An earnest and faithful teacher told me that the month was thrown away even in the higher classes, and interest lost in the new studies just being entered on, which required extra exertion and more brain work. I speak with all due consideration, and as a medical man, when I say that the first fortnight of September takes away from the children a large part of the benefit they have got from the summer vacation. This applies still more to the poorer classes, who cannot escape the heat, and from whom must be ever recruited our *industrial material.*

Wearing Glasses.

Now, as to the necessary correction of near-sightedness by properly adjusted glasses. The persistent efforts of ophthalmic surgeons are beginning to bear fruit.[1] More parents of the middle and lower classes now bring their children to our special charities in our larger cities. Of the 13,200 eye patients who applied at the Massachusetts Charitable Eye and Ear Infirmary in Boston during the past two years, 1,793 were those suffering from errors of the refraction and accommodation of the eye, and who needed to be carefully examined and tested for the glasses they required. Among these are of course very many of the present or future workers in our industries. In the smaller cities, towns, and villages, where no specialists or special hospitals exist, adults for themselves and also for their children purchase at high prices the wrong glasses of the jeweller, spectacle-dealer, or, still worse, of the peripatetic quack oculists or spectacle pedlers who overrun New England. These generally assume the name, or claim to be partners, of some of the well-known surgeons connected with special hospitals. Their cousins who do not dare try such games stand quietly at the city street-corners or railroad-stations, sure of enough fools in the course of the day to make it pay. These, like the peripatetic "professors," will soon, I think, assume the title, and be certainly believed by their customers.

Of as great if not greater importance in relation to the eyes of our industrial classes is the congenital condition called hypermetropia, or over-sightedness. Myopia, or near-sightedness, is due to the globe being *too long* or egg-shaped; and the other condition is due to the globe being too short, or too flat. It is a very common natural defect, only understood the last five and twenty years in its very practical bearings. When we look at a near object we recognize, by a sensation of effort, that the eye has to adapt itself or become focussed — *accommodate*, as it is technically called — for the distance of the near object. Now, this power of change in the eye's focus is greatest when we are some *ten years old*, and gradually decreases from then onward through life. The shorter the globe, the greater must be this accommodation; that is, the more hypermetropic, the greater the

[1] I take the liberty of referring here to my little book on "The Eye in Health and Disease," A. Moore, Boston, 1871, where will be found a simple explanation of the errors of refraction and accommodation of the eye, written for the laity and fully illustrated on these points.

strain. When this change becomes difficult, and the strain causes pain, then the only relief is the use of carefully adjusted glasses. The community have finally recognized the need of glasses with near-sightedness, and are beginning to heed the repeated declaration of the fact that increasing myopia is most dangerous, leading not infrequently to total blindness. The natural and congenital condition of the eyeball being *too short* has not yet been appreciated or acknowledged by the laity, much less its ready relief by the use of properly adjusted convex glasses. A distinguished London ophthalmic surgeon long ago said, "Inability to use the eyes without pain and discomfort is, in the great majority of cases, due to over-sightedness; and those patients who under any other course of treatment haunt our out-patients' rooms for months and years without relief, may be speedily and permanently cured by the proper treatment of their hypermetropia, by glasses. Let us but consider the crowd of seamstresses, watchmakers, engravers, etc., who are rendered incapable of following their employment, whose future is starvation if this fact is not attended to. This is no fancy or exaggerated statement, but the every-day experience of all ophthalmic surgeons. About one-third of the cases of trouble with the refraction or accommodation of the eye are dependent on this congenital condition of the eye being too short, an optical defect only to be remedied by the use of convex glasses.

Hence no matter how *young* the person, they may need strong glasses. "What! use grandfather's glasses?" "Who ever heard of such a thing? We won't listen to it; and then to wear glasses always!" The specialist hears this till he is fairly sick of the sound, and replies, "Yes, use grandfather's glasses, or the child will break down, have to give up all study because it causes pain, and become only a hewer of wood or drawer of water, instead of a skilled artisan; or, in the upper classes, able to earn a professional livelihood, instead of becoming a drone."

As I said, there is danger of blindness from excessive or increasing near-sightedness; and this danger is becoming understood and feared in the community. But there is also danger of blindness from hypermetropia. To Professor Donders, of Utrecht, Holland, the world owes its present practical knowledge of this congenital defect. He found also that ninety per cent of crossed or squinting eyes were caused by over-sightedness. An eye which turns in away from its fellow, and hence is not used in common with it, begins to lose its power of vision, forgets how to see, and this power is not regained unless the squint is *early* corrected by an operation, and the proper glasses subsequently steadily used. Among the thirty thousand school-children I have tested for color-blindness, and hence come in close contact with, I saw hundreds of cases of squint due to over-sightedness *not corrected by operation or glasses.* These were naturally among the children of the poorer classes; as among those of the middle or upper, the opprobrium of "cock eye" leads to the parents' having the deformity remedied by operation, only too often without due recognition of the true cause of the trouble, and the necessary proper correction of the hypermetropia by glasses. But these squinting children desire to become our artisans, in which they will fail, as they practically have but one eye, and that a poor one.

The power of accommodation, that is, the effort the muscle inside the eyeball must make to focus sharply, is much more called upon in over-sighted eyes, of course in proportion to the degree of the trouble. Now, this power being greatest in early youth, and decreasing from then onwards, there may at any time come, perhaps somewhat suddenly, especially after exhausting disease or overwork, pain and utter inability to use the eyes for near work. Again, the giving out of the eyes is very apt to come, say between twenty-five and thirty-five, when among the industrial classes occupations have been chosen, and another trade cannot be learned, hence loss of eyesight is a question of starvation for themselves and families. On the other hand, properly adjusted glasses, not picked out by a spectacle vender or pedler, will entirely relieve the whole trouble, and enable persons to go on with their work as well or better than before, and their skilled labor will be thus saved for their employers, to whom it is often of course a great loss of time and money to endeavor to replace a man or woman who has learned to do certain work. I do not touch on the effect of hypermetropia in the upper or professional classes, since it is the industrial side of the question I desire to bring forward, and prove the money value of helping the employé. The physical need and commercial value of properly adapted glasses should be understood by all who are in charge of our great industries, in so many of which nowadays there is a constant call for the best eyesight.

When the over-sighted among the industrial classes apply to the ophthalmic surgeon, and are properly fitted with glasses, and the natural condition explained, etc., however well convinced of the relief afforded by glasses and the necessity of this relief, yet a constant answer is made in refusal to get them, "I can't wear glasses where I work: the 'boss' wouldn't keep me if he saw I had to use spectacles." Now, whilst this may be doubted or denied by the heads, presidents, treasurers, or superintendents of many industrial establishments, yet a more careful inquiry on their part of the custom of the *sub*-superintendents, etc., would reveal the fact that it was more or less definitely understood that a man with glasses was of no further use or not to be hired. The ophthalmic surgeons who work in our charitable special hospitals see this only too often, and have already in medical societies and elsewhere raised their voices in behalf of the employé, and in explanation of the need of his using what renders his eyes like others, and able to bear the work imposed on them, and hence able to guide his educated fingers, of such value in our industries. The wearing of glasses when needed should be encouraged, and not looked at askance, or even forbidden. The artisan classes in the large cities have already learned much on this point, because so many have now been properly fitted, not by glass dealers or pedlers, but by the patient, plodding work of the surgeons who give their time without pay to the patients crowding the waiting rooms of our special hospitals. When a man finds that glasses relieve pain in his eyes and enable him to work as he did years before, he is not likely to throw them aside or try to do without them, but will, if not allowed to wear them, if his position be endangered, or his work doubted, or his wages reduced thereby, simply leave that factory, and seek employment where it *is* recognized that the work of his hands guided by eyes rendered perfect by glasses is of value, and that there is money in *retaining* just such employés.

The human eye may be near-sighted or over-sighted in only one meridian, the horizontal or vertical, or any intermediate angle. This is not due to the globe being too long as in myopia, or too short as in hypermetropia, but to the faulty curve of the clear part of the eye in front, just as an irregular or faulty watch-glass would distort the figures and hands on the dial. This is a very frequent defect which when not corrected by properly made and selected glasses deprives the person of the use of his eyes. The unsuccessful attempts of spectacle dealers and opticians to provide proper glasses, and test their customers' eyes, is only too well known by ophthalmic surgeons to whom the poor people finally come, mulcted in time and pocket and discouraged at all attempts at relief. I never saw a case of astigmatism perfectly corrected by an optician. I have seen many provided with glasses wholly unsuited, and of no sort of value as helps to work, etc. Some spectacle dealers have already found out that honesty is the best policy, and at once advise their astigmatic customers to apply to some surgeon, or, when they cannot do this, to our charitable special hospitals. Dr. Cohn found, out of twenty-three astigmatic school-children, only one wearing cylindrical correcting glasses, and he says, "The patient, who, after long searching at the optician's, does not find any glass to suit him, is rejoiced to suddenly see every thing clear and plainly through a cylindrical glass." Another distinguished physician, himself astigmatic, says, "Cylindrical glasses have completely changed my existence; before using them I was obliged to forego all work at night, but now I read, so to speak, indefinitely by the light of a single candle."

The industrial classes are as much affected by the congenital condition known as astigmatism as are the educational or professional. Hundreds of astigmatic artisans break down from inability to use their eyes in the calling they have chosen, on account of this peculiar defect, only thoroughly understood and properly corrected these last twenty-five years. To Professor Donders of Utrecht, Holland, is the world again indebted for the practical solution of the trouble and the relief obtainable. Those directing our great industries where continued acute vision is necessary on the part of employés to make their industries *pay*, should give some heed to these arguments in behalf of their workmen, and urge rather than discountenance the testing the eyes, and wearing proper glasses.

The power of changing the focus of the eye, which is greatest at about ten years of age, changes, as I have said, and gradually decreases till at about forty-five or forty-eight, the necessary accommodation cannot be continued, and must be assisted by a convex glass. Now it is just at this time of life that an artisan is in the best physical condition to continue his skilled labor in which experience has perfected him. If the workman is near-sighted, then, although he will continue to need the same glasses for distance, he will need weaker and weaker ones for near objects, and finally be able to lay aside spectacles, except out-doors. Recall our friends whose faces we always associate with gold spectacles, and as they get on in life notice how they first push these gold frames up on the forehead at dinner, and afterwards in reading, and finally take them off, always, however, replacing them on the street, or in church, concert, etc. Only so far as all this goes, can a person be congratulated on being near-sighted: the other side of the picture I have already given.

Again, if the workman is over-sighted, with increasing years the glasses used for work must be stronger and stronger. The idea that this will go on till no glasses can be had strong enough, is simply ridiculous, as there is only a certain definite amount of change, beyond which the alteration does not go, and which is far within even moderately strong glasses.

The perfectly normal eye needs glasses at forty-five to forty-eight years of age just when the workman's experience is of value, and, just when he is likely to have a family growing up dependent on him for support, just when also he cannot turn to any other work. To deprive him of their use would be to force him out of the artisan into the lower laboring class, fairly a cruelty.

In the female sex the refusal to wear glasses, and the various pretexts and concealments so well known and recognized by the ophthalmic surgeon, are perhaps pardonable, because the admitting that they are forty-five to forty-eight years of age is confessing that they are beyond the child-bearing age, — in other words, have "grown old." Curiously enough, one rarely, if ever, hears of a woman being threatened with loss of place or employment because she has come to need glasses. On the other hand, I cannot refrain from repeating that men who require the help of spectacles and who could *work as well as ever* with them, are only too frequently afraid to wear them for fear of loss of employment. The superintendent or the "boss" ignorantly supposes that the man's eyesight has given out, while on the contrary, if he has *properly* chosen glasses, it will be better than the few years before, when he has been striving to use his eyes, which he could not focus accurately, and hence has produced imperfect or bungling work, which work has finally drawn the attention of the boss, who threatens dismissal. The poor workman seeks aid and help at some special hospital, where he finds his sight is perfect with the right glasses there ordered for him after careful testing and examination These he does not dare to wear in the shop, as the boss "don't want no man wearing spectacles." There is a most extraordinary ignorance and prejudice on this subject in the community, which it is the special purpose of this article to try and overcome. Now the workman has become skilled, steady with age and family ties, his vision will keep good till sixty-five or seventy, or beyond if he always has the proper helps to see. I ask, then, is there not money in retaining him, and should he not be kindly urged and advised to wear what his eyes require? I am too familiar with all these facts not to *know*, and hence here insist that such foolish refusal to do what nature needs is one of the unnecessary causes of impaired vision.

Special Causes of Impaired Vision.

I have thus far been speaking of the *natural* conditions of the eye. I would now call attention to some undoubted causes of impaired vision connected with certain industries; in other words, the special diseases or injuries produced by them. There is as great a mistake in regarding as dangerous to the eyes occupations which are not so, as in considering as quite safe others which are hurtful. I would here point out some of the industries in which money can be made or saved by attention to points either not involving any expense, or but trifling in comparison with what is saved.

A corporation treasurer told me that he once concluded to test at his mills whether all the doctors said about increased health and strength from perfect drainage had any truth in it. Accordingly, though all the drains and sanitary points connected with the mill-hands' houses would have passed muster from ordinary observers or masons, etc., he had the whole thoroughly overhauled, and each and every defect rectified. The cost was naturally considerable, some thousands of dollars, and the money seemingly thrown away, till the superintendent in charge found the absence of the skilled hands from sickness was greatly reduced, and a careful estimate proved that the whole expense of repair of drainage, etc., was thus cleared in one year. How much greater was the gain in health, strength, and happiness for the employés, benefited, perhaps, against their wills, as is so often the case!

Now, dust and dirt and foul air are the most potent causes in producing granular lids, the curse of many of the industrial classes, depriving them of months of labor if not of eyesight itself. Whilst we cannot tell the directors of our industries just how much they can save by eliminating dust, dirt, and foul air in their factories or works, we could perhaps excite their pity by showing them the effects of the same on the employés as they apply for help in our ophthalmic clinics and eye hospitals. In this article, however, no appeal is made to any feeling of humanity, but simply and directly to the pockets of stockholders, who may be induced to interest themselves, and direct superintendents and others to take cognizance of these things.

Years ago, the needle-grinders in England refused to wear the magnetic protectors over the nose and mouth, which relieved their work of any special danger, because their wages were then reduced, and they preferred the money for a merry life and a short one, though they knew it would end in lingering pain. The time has, however, about passed for this sort of thing. Most artisans nowadays are alive to the value of their physical condition as affecting their power to labor, and hence their wages.

The waste of eye-power and positive injury to the organ from lack of attention to light, position of work, and illuminating sources, are more difficult to here render comprehensible to those who have the means in their hands of correcting abuses. An expert will hardly go through any establishment without seeing the apparently total disregard of the very points which would save eyesight, and render labor so much more comfortable, safer, and hence more profitable. How often do we see an artisan at work with an uncovered flickering gas-jet close to his eyes, when an almost costless piece of tin would protect them, and give him a better light! When, in another generation or two, we shall have become accustomed to a white, instead of a yellow, artificial light, there will be saved one great cause of impure air, inadequate light and hurtful heat. This latter is often wholly overlooked in the too close proximity of all lights, student-lamps, and gas-jets, to the head as well as eyes. Let those who doubt it test, even with the hand, the temperature of the head and brow on the side towards the light and the other in comparison. The simplest additional shade stops this, by making a current of air between itself and the lamp.

A little intelligent interest on the part of superintendents and bosses would often save the company the valuable services of those who give up their handiwork from defective vision just when their educated skill is of most value. Without any reason, work-benches, tables, etc., are often placed exactly as they should not be, simply from ignorance, carelessness, or prejudice. How often do we see artisans placed facing a window, the sun glaring in so as to cause most irritating reflection from their work before them! The strain on the eyes from the constantly-repeated act of accommodating or focalizing, as the man looks back from out the window to his work, is wholly unthought of till he breaks down under it, just at the age when he is of the most value to his employer, and his wages are most needed by his increasing family. A great many good men could be retained, and a good deal of money saved, by practical inspections and suggestions in our workshops and factories, provided, of course, that those in authority would heed the specialists' reports and act on them. At present the boss's reply to all this is, "It's the man's lookout, not ours, and we can easily supply his place." Setting aside all questions of humanity, this is not true. The loss of men with trained fingers, in a special work, is of great importance. No doubt the general deterioration of many kinds of fine work is due to the present lack of continued (for years) mechanical labor. Herein lies one of the elements of the success of foreign crafts. Of course this is by no means the whole cause of the "scamping" in our mechanical industries. It is, however, an unnecessary one, which can be avoided without expense, and with gain to employers, whose attention I would challenge by this paper.

Special call for special work is sometimes a cause of positive danger, as is shown by the case I will now describe. It will, of course, meet with indignant and interested denial, by those whose pockets are touched. I, therefore, have examined the matter most carefully and most practically, taking no hearsay evidence, and convincing myself by personal examination. Those who will do as I have will, I believe, agree with me.

I have, for some time, noticed certain of the wood-cuts in the journals and magazines becoming, as I thought, poorer, blurred, and slurred, and which I could only explain by an attempt at art too high for me. My diagnosis was, that such work must be cheaper, and hence some one was making money by it, as it was not equal to the wood-cuts of former days. Wood-engravers coming to me as patients induced me to investigate the subject; and I found what has since, and recently, caused a good deal of talk in artistic and artisan circles, namely, that these wood-cuts were made from photographs on the block, thereby saving the otherwise necessary drawing on the wood. I remembered once wanting a wood-engraver to *give the idea* from a drawing hung up before him, besides what was merely photographed on the block. He greatly objected to having to look away from his work and back again at it. He would rather try to do what I suggested *as he worked* on the block, and I stood at his side. From the many and various recent articles in the daily press, magazines, etc., it is very evident that such wood-cutting is cheaper, but, as I have ascertained, it is most destructive to the eyes. The reason for this is, that the eye must constantly change its focus from the middle distance of accommodation when the picture is placed before the artist. The eye must let go or release this accommodation if it uses none in looking through the engraver's magnifying glass, or increase the accommodative effort if it employs the maximum of accommodation when using the glass. Now, young eyes, before twenty-five years, may stand this, but will be early used up by it. Many as young as thirty are affected by this cutting from photographs on wood. Of course with the photograph the lines are much more indefinite, and much more is left to the individual skill and fancy of the artist. This sort of extra work his eyes can stand, though it calls for much greater mental labor. His eyes cannot stand or hold out under the strain of accommodation necessarily connected with the looking off to the picture in front of him, from which the photograph has been taken on to the block. I have personally tested this, and do not wonder at so many engravers refusing to cut from photographs. It will not pay them in the long run, and engraving-offices will soon find that the damage to the eyes is such that men will want as much pay as would cover the cost of drawing on the block. As an ophthalmic surgeon, I have heard the complaints of engravers as to photographs. Young men who can do this work now for a few years, and who get present work in consequence, are naturally loath to say much about it for fear of losing place or work. The facts are, that photographs on wood can be cut badly by green hands, who receive but little pay, and then be "fixed up" afterwards by more experienced men. The publishers are not saved money, but the proprietors of the engraving-offices are. The latter are all, of course, in favor of photographs on wood. With them the using-up the eyes of their young men is of no consequence, as plenty of others are ready to step into their places. I have seen an engraver completely broken down by this cutting photographs, which is particularly irritating. He now refuses all such work, and has no trouble in cutting from drawings. In reality the photograph gives too much. What to leave out is difficult to decide, and hence there is much more brain work necessary. I am authoritatively informed that the better class of engravers have raised their prices, in some cases nearly double.

The wear and tear on the eyes from the constant change of focus and accommodation, has been described to me by engravers, who, of course, did not know the cause of the trouble. They complained also of the loss of time before they could see distinctly as they turned from the picture to the block, and that the first few lines then made were apt not to be good. All wood-cuts from photographs have to be worked over with loss of time and at expense of exactness.

I do not speak without knowledge, and have the evidence of at least ten first-class engravers in this country.

I expect to excite the ire of those who are pecuniarily interested in photograph work. I have, however, no other interest than that of any physician in the patients who apply to him. Engravers are satisfied with my explanation of their not being able to endure this photograph work. I have confined myself to the strictly professional point of view, and not intruded any artistic ideas of others or of my own. On these points critics have recently expressed themselves strongly in the public prints.

I have dwelt on this subject of engraving from photographs, as well illustrating how certain forms of work are hurtful, and how the harm may be done from ignorance, and also not corrected or stopped from short-sighted mercenary motives, though it would pay better in the long-run to heed the warnings given. The artisan class have but little means of combining and resisting; thus those who have learned to be of value are thrown aside, from the ruling desire to get the golden eggs by cutting open the goose.

NOTE. — In the "Revue Scientifique" for June 25, 1881, in which Dr. Javal's article is published, at p. 817, is the following: —

"*Near-sightedness in the Schools.* — On account of myopia becoming more and more frequent in the schools, from defective desks and seats, and bad lighting, etc., the minister of public instruction has appointed a commission on the hygiene of the sight in schools, with directions to examine the material conditions affecting the increase of myopia, and to endeavor to suggest means of avoiding them. This commission is comprised of Drs. Gavaret, president, Panas, Gariel, Maurice Perrin, Javal; Mortmahon, inspector-general of primary instruction; Hachette and Masson, publishers; and Gauthier-Villars, printer."

THE COLOR-SENSE AND ITS DEFECTS.

The sense of color which the eye possesses, in addition to the sense of form, has almost been forgotten as a distinct sense, so intimately does it seem associated with an impression of form. Upon it, however, depend many of our industries, as much as upon the sense of form. Its careful cultivation is very necessary for the future success of several of our Massachusetts industrial employments. At the present an educated sense of color is of great value to its possessors, and to those who require their skilled labor. Whilst women can and do enter the industries formerly occupied solely by men, the latter, from a lack of an educated sense of color, are prevented from entering the others now occupied by the female sex, simply because they lack this specially cultivated color-sense derived from natural education. All this entirely aside from the fact, which I as well as others have so thoroughly shown by the testing of thousands of males, that the latter are so destitute of and unfamiliar with color names. Color-names can and should be taught our boys in school, by which their color sense would be educated to fit them for the positions and occupations they are to support themselves by; I mean the several handicrafts. The ridiculous and false teaching as to colors now so prevalent in schools must be given up, and the color sense be appealed to and gradually educated, as is the form sense, by methods in conformity with the facts of science. On this I have dwelt, in my report to the Boston School Board on the examination of twenty-eight thousand school-children for color-blindness.[1] There is no system in the primary schools, no methods of any value, notwithstanding the praiseworthy efforts of individual teachers which I have met with. But among these latter I have found the very best deceived. A color-blind boy wholly escaped the observation of an experienced teacher who had paid special attention to the education as to colors; working, however, only with the worse than useless materials placed in her hands, or at her disposal. She was naturally indignant with me for my suggestion, and hardly credited the direct proof of the boy's color-blindness as I tested him before her, though this proof was perfectly convincing to all the other bystanders. This teacher failed simply because the means of instruction were so poor, and through no fault of her own. She followed the prescribed course. Such methods of teaching color-names and educating the color-sense as are now being largely employed in Europe, and which I am endeavoring to introduce into this country, would not only save the time of scholars and teachers, but the former could hardly escape detection if their color sense was

[1] I would also refer to an article of mine in "Education," March-April number, 1882, entitled "Color-names, Color-blindness, and the Education of the Color-sense in our Schools."

defective or they were color-blind.[1] This would be of great value to them, as, since the color sense cannot be altered by education or familiarity with colors, or any known means, it is all-important that a boy should be warned, and his parents told, that he cannot enter the professions, trades, or pursuits where a normal color sense is necessary, and where perhaps he may be excluded by law: for instance, as locomotive engineer, or pilot, etc.; besides these, however, those many industries where the color sense is absolutely required, and many positions, as in the dry-goods business, where color-blindness will sooner or later lead to dismissal. It will not as heretofore be overlooked or concealed, since a knowledge of it is becoming so widely spread, and even the characteristic mistakes somewhat understood.

The community cannot be too often reminded not to confound the lack of knowledge or use of color-names, as also the lack of proper appreciation of colors due to an uneducated color sense, and the congenital or acquired *loss* of the color sense in whole or part. The latter has been heretofore, and will be frequently, concealed. It has often led to much mortification, disappointment, and loss of time and money, as well as to grave and *fatal* mistakes. These latter I have elsewhere insisted on.[2] Here I would simply show to the owners and directors of our great industries the money value, first to them, then to their children, of systematic education of the color sense by simple and thorough methods in our schools, especially the teaching the color-names and the educating the color-sense of those scholars who are likely to learn but little through home life and surroundings, because from this class particularly are to come the future artisans upon whom will depend many of our Massachusetts industries.

[1] Color-chart for the Primary Teaching of Colors and Education of the Color-sense. By Dr. Hugo Magnus and Dr. B. Joy Jeffries. L. Prang & Co., Boston, 1882.

[2] Color-blindness: its Dangers and Detection. Houghton, Mifflin, & Co., Boston: revised edition, 1882.

LEPROSY AS RELATED TO PUBLIC HEALTH.

COMPILED BY THE HEALTH OFFICER.

LEPROSY AS RELATED TO PUBLIC HEALTH.

In December, 1882, a former resident of Salem, who had been absent several years from his native city, chiefly at the Sandwich Islands, returned to Salem, having contracted leprosy during his absence. At the invitation of the local board of health, he was visited by members of the State Board, and also by Drs. White and Wigglesworth of Boston, who confirmed the diagnosis.

The statement of the leper, together with that of other persons who had known him in former years, showed that he had contracted the disease while living in Honolulu, and that it had first made its appearance upon him several years before he came home.

On his arrival in Salem in December last, the external marks of the disease were very evident. The skin of the face, especially of the forehead, the ears, the nose, and eyebrows, the hands and the feet, was greatly disfigured with tubercles of variable size. The skin of the thighs, the chest and abdomen was mottled and discolored. The toes were ulcerated and suppurating The pharynx and the soft palate presented an inflamed and tubercular appearance. The voice was altered. His eyesight was also dimmed. The sight of one eye was gone, and he could only read coarse print with the other by means of a strong light. The large nodules were mostly devoid of feeling. His general condition was feeble. His appetite was impaired.

He was placed in the Salem almshouse in an isolated apartment, and soon after a temporary house was constructed for him outside the almshouse, where he remained, gradually failing, until his death in the following March.

Since this disease clearly comes within the meaning of the act relating to contagious diseases, and since no allusion has thus far been made to it in previous reports of this Board, a brief account of its history and prevalence may not be deemed out of place at the present time.

History. — The existence of leprosy may be traced backward into the remotest ages of written history. From its early existence in Egypt and Syria, it may be traced into Persia, Hindostan, Turkey, and also into all the countries of Europe. Emigration spread it widely from the east to the west, and from the south toward the north.

The return of the Crusaders appears to have played an important part in its distribution. In the thirteenth and fourteenth centuries there was scarcely a town in which it did not exist; and leper-houses were numerous where the order of St. Lazarus devoted their lives to the care of the sick. There were at one time nineteen thousand such houses in Europe intended for the isolation of the sick.

In all European countries it was the policy of Church and State, in the fourteenth and fifteenth centuries, to stamp out the disease. Bulls were issued by popes, and stringent laws were passed as to the medical examination, condemnation and status of lepers. The leper was made legally and politically a dead man. His marriage ties were dissolved, the service for the dead was performed over him, and he became an outcast. These measures had their effect in rapidly lessening the disease; but it has never been entirely eradicated from the nations of the earth.

In proof of an identity of type, at least for nearly four centuries, there is still in existence a painting by Holbein, at Munich, dated 1516, representing a group of lepers. It faithfully portrays a man whose face is covered with round, reddish knobs. There are also other lepers in the group, in various stages of the disease, whose external characteristics agree very closely with the modern figures of Danielsson and Boëck, and the descriptions of other modern writers. Virchow says that these pictures must have been painted from studies of actual lepers in a leper-house of the mediæval period.

Present Distribution. — Leprosy is endemic at the present day in many parts of the inhabited world, under diverse conditions as to climate, degree of civilization and habits of life.

It exists chiefly in India, China, the Malay Archipelago, Egypt, Palestine, Turkey, the Grecian Islands, the Coast of the Black Sea, certain Mediterranean ports, Spain, Portugal, Norway, Russia, Iceland, Scotland, Madeira, the Canaries, New Brunswick, Canada, Brazil, Mexico, Central America, Madagascar, Africa, Mauritius, the Seychelles, New Zealand, and the Sandwich Islands. It is increasing in Crete and in the Sandwich Islands.

This wide distribution in many places where it had no ancient history is attributed to the tide of immigration which followed the era of Portuguese and Spanish discovery.

In North America, it is known at New Orleans, at San Francisco, Charleston, New Brunswick, and in Scandinavian settlements in the Northwestern States. Twenty cases have been observed at Sacramento, and several were returned from San Francisco to China by the health authorities.

A peculiar interest attaches to the history of leprosy as existing in the Hawaiian Islands, and also at Tracadie in New Brunswick.*

In consequence of its slow and insidious progress, it is not possible to fix the exact date of its first appearance at Hawaii. Its existence there may be safely stated as less than a half century, and it had made but little progress until within the past twenty-five years. Its prevalence is now so general as to threaten the existence of the nation, which, from this and other causes, has diminished rapidly within the past century of its existence.

As a proof of national decline, may be adduced the vital statistics of the Islands : —

In 1870 the births were 2,413, and the deaths 3,819. In 1871, births, 2,559 ; deaths, 3,502.

Here, in a native population of but little over 40,000, we find an enormous death-rate, and an excess of deaths over births of 2,349 in two years, or 47 per cent.

Leprosy appears to be confined almost exclusively to the native population in the Sandwich Islands, a few foreigners only being affected.

* Although neither of these localities is within the limits of the United States, our commercial relations with these nations are such as to awaken a greater interest in their condition.

New Brunswick. — Tradition refers the introduction of leprosy into the little settlement of Tracadie to the middle of the last century. But no authentic case can be traced farther back than 1815. Its progress since that time has not been rapid nor widespread, the disease being limited to a comparatively small tract of country. A hospital was built in 1844, and in 1849 a permanent lazaretto. The total number of cases treated in both institutions has not been more than one hundred and fifty. Isolation was at first rigorously enforced, even at the risk of charges of cruelty. Since 1868 the lazaretto has been under the care of the Sisters of Hôtel Dieu of Montreal, and a milder régime has prevailed.

United States. — Within the domain of the United States, leprosy has not at any point made active progress. The rapid immigration of the past two years must, however, introduce into the country a greater or less number of persons in the incubative or doubtful stage of leprosy. On our Eastern coast, such cases may be looked for among the Scandinavian immigrants, especially those from Norway, where there are still about two thousand lepers. These people have settled chiefly in the Northwestern States, Minnesota alone having 100,000 Scandinavian settlers. Thus far, however, leprosy does not appear to have found a foothold among them, and no persons born in the Northwestern settlements have as yet been found to be affected.

Dr. Bendeke of Minneapolis says: "It occurs in much less proportion here among the emigrants than in Norway; and I ascribe this only to the better hygienic situation of the people as to food, clothing, exposure, etc."

On our Western coast, the chief source of the disease is China. A leper hospital has been established at San Francisco, and fifty-two cases had been admitted in ten years, all of whom, with a single exception, were Chinese; and no case has been reported of a native citizen of California acquiring leprosy.

Other foci of the disease have been observed at Charleston, S. C., and also in Louisiana. In the former city, Dr. Geddings has observed sixteen cases in the past thirty-five years, and published a report of the same in the Transactions of the International Medical Congress held at Philadelphia in 1876.

Occasional cases have also been reported in the Gulf States during the past and present centuries.

Symptomatology.—Usually the first sign noticed is a weariness upon exertion, and often a tendency to melancholy. There may be slight anæsthesia of parts where disease is about to appear; swelling in the track of nerves: an erythematous eruption appearing and disappearing. Later symptoms are febrile excitement, chills, hyperæsthesia, pain in the limbs and swelling over the malar bones, and enlargement of the lobes of the ears. Cutaneous hypertrophy is an important element in diagnosis. There is often a vesicular eruption. The appetite may be voracious, and the general health may not at first be affected. Occasionally a claw-like contraction of the fingers is noticed. These symptoms may come and go many times before the disease becomes finally established.

Tubercular Leprosy.—There is usually fever, with heat and pruritus, followed by copper-colored patches appearing and disappearing. These patches gradually become elevated into tubercular eminences, while there is a general thickening of the skin. The face, hands and feet are the most common seat of tubercular deposit. The furrows of the forehead are exaggerated, the ears, lips and nose enlarged, and the cheeks become more prominent. The face assumes a mulatto expression. Suppuration, with thickened pus, occurs; ulceration involving the subcutaneous tissues, but rarely the bones. The skin becomes denuded of hair, eyebrows, eyelashes and beard. There is ulceration of the cornea, with conjunctivitis and ectropion. The mucous membranes of the fauces, larynx and nares are involved, and there is dysphagia, alteration or loss of voice, smell and taste.

Anæsthetic Leprosy.—In this form, hyperæsthesia, often painful, precedes the anæsthesia. The cutaneous changes may be trivial, but when well marked there is ulceration, beginning in an eruption of bullæ, or there may be similar patches to those appearing in the tubercular variety, which ulcerate more superficially and discharge thin pus, healing with smooth cicatrices, denuded of hair. If hair returns, it is white. Later the skin is dry and shrivelled, at first in spots. The ulcerative process expends itself on the fingers and toes generally, the phalanges dropping off one by one; or they are absorbed or crumble away, the skin healing after each amputation. Often there is opacity of the cornea, ectropion, tightness of the facial integuments and a look of premature old age.

Vision and voice are not so much affected as in the tubercular form. The characteristic feature of this variety is the anæsthesia of the whole body, and especially of the limbs. It explains the freedom from suffering of the leper. The anæsthesia begins in spots, and spreads irregularly, without reference to nerve distribution.

Well-marked cases of the two varieties are not easily selected, the two usually being mixed in an individual, though one predominates.

Leprosy has been recognized as early as the third year, but it is rarely diagnosticated before the age of puberty, from which time it occupies an average period of ten years in attaining its development. In the anæsthetic form the effect on the duration of life is not so marked as in the tubercular.

Lepers are very susceptible to the influence of cold, and are often affected with pulmonary diseases, erysipelas, nephritis and ascites, and succumb easily to a want of proper food.

Death usually takes place from intractable diarrhœa, or dysentery, either acute or chronic.

Leprosy in its relation to Public Health. — The questions which render leprosy a matter of special interest as affecting public health are those of etiology, modes of propagation, and the question of contagion.

The causes of leprosy have been sought for in the peculiarities of climate, soil, diet and habits of life. As regards climate and soil, the wide geographical distribution of the disease would seem to preclude them as elements or factors of causation. Opinions differ much as to the question of diet. The eating of tainted fish has been strongly urged as a cause. Leprosy is found in a most aggravated form among fish-eating people, as in Norway and Crete; and, on the other hand, it also prevails in inland districts where fish are but little used.

Doubtless an improper diet and bad hygienic surroundings aggravate the disease.

All these causes acting together for centuries did not produce the disease in the Hawaiian Islands, nor was it known there until some time after the islands were open to foreign trade and commerce with other nations. Hence it is reasonable to suppose that it was imported from other places. The first leper in Hawaii was not recognized till 1853. The natives attribute its origin to China, and this belief is confirmed by history and observation.

Inheritance. — There can be but little doubt as to the question of inheritance in leprosy. Its decided influence on the disease is maintained by nearly all writers on the subject. Hereditary influence is universally accepted in China, and intermarriage of lepers is there forbidden. On the other hand, it is not safe to accept the theory of inheritance as the only mode of propagation. The history of the disease in the Sandwich Islands may again be adduced in opposition to an exclusive theory of inheritance, since scarcely a single generation has elapsed from the time of its appearance in the Islands. The theory of inheritance must necessarily require a much longer time for its proof. Especially is this true of a disease whose incubative stage is measured not by days or months, but by years.

The relation of Leprosy to Syphilis. — The careful study of medical men has been favorable to the belief that syphilis is a predisposing cause only, and productive of a condition favorable to the reception of leprosy in an individual. A recent report of the Hawaiian Board of Health contains an article by Dr. Fitch of Honolulu asserting that leprosy is a fourth stage of syphilis. The weight of professional opinion, however, is to the contrary.

Contagion. — As to the part played by contagion, Dr. White says, in his excellent article:* "Heredity as the

* "The Question of Contagion in Leprosy." Am. Jour. Med. Sciences. Oct., 1882.

only, or an important factor, is entirely out of the question. It would have required several generations to have accomplished such results. We must look, then, to the customs of the race as exceptionally favorable to inoculation as the only possible explanation, — such as the crowding together of large families in small huts, sharing the same mats and blankets, eating poi with the fingers from the same calabash, drinking of ava from the same vessel, passing the pipe from mouth to mouth, their licentious habits, the absence of all fear or disgust of the disease as a bar to ordinary association, cohabitation or marriage."

The contagious nature of leprosy, although vehemently denied by a few, has certainly been recognized from the earliest ages. In proof of this view are the rigid Levitical enactments of the ancient Jews; the stringent work of both Church and State, in the fourteenth and fifteenth centuries, to stamp out the disease by isolation, dissolution of marriage ties, and social ostracism; and, in the present day, the forcible segregation of lepers from their homes, their relatives and their friends, by sanitary legislative action. These measures have had a salutary effect wherever they have been introduced and enforced for a long period of time, and doubtless contributed to the general disappearance of the disease in the sixteenth and seventeenth centuries throughout Europe.

In the Hawaiian Islands the disease is made a subject of legislation by "An Act to prevent the spread of leprosy," of which the main points are as follows: —

1. The Minister of the Interior may set apart lands for the location of leper establishments.

2. He may acquire by purchase land not owned by the government, for the same purpose.

3. The Board of Health may isolate and confine lepers. Justices may cause lepers to be arrested and conveyed to places of isolation and treatment.

4. The Board of Health may establish a hospital for the temporary detention and treatment of lepers.

5. Labor may be required of lepers to a reasonable amount.

6. Their property made liable for their support.

7. Board of Health to account for moneys and render a report.

As an evidence of the importance of this branch of their duties, the Hawaiian Board of Health expended for the execution of the Leper Act, and for the support of the Leper Colony, in 1872, the sum of $31,000, out of a total of $51,000 for all health expenses. In 1874, $55,000 for the Leper Colony. In 1880, $85,000, out of a total of $174,500. In 1882, $90,000, out of a total of $237,500.

Sanitary science has been regarded as new, and, in fact, has made the most of its progress within the past twenty-five years; but so far as leprosy is concerned, it has existed for centuries. The necessity of isolation was recognized and rigorously enforced in the patriarchal era, three thousand years since: and wherever the disease has invaded and menaced the public safety of a nation, the same principle has been recognized, in the construction of leper-houses, lazarettos, asylums, etc., the enactment of laws requiring isolation, the prohibition of intermarriage, and confiscation of property. The same principle was recognized in the Middle Ages in Europe, and also exists at the present day in a varying degree in all places wherever leprosy has gained a foothold.

A careful consideration of the history of leprosy as now existing in two different countries, Norway and the Hawaiian Islands, may afford additional light upon the subject of contagion. In the former country, in 1856, there were 2,863 known cases of leprosy, of which number 235 were in hospitals, and the remainder living in their homes. In later years isolation has been more rigidly enforced, with the result of a diminution of the whole number to 2,704 in 1866, of which number 795 were in hospitals. In 1876 there were 2,008 cases, and there has been a regular decrease since that date to 1,582 cases in 1880, a total decrease of 45 per cent. in twenty-five years. This result has been attributed in a great measure to more careful isolation.

On the other hand, in Hawaii the disease has rapidly increased during the same period. Although it has not been known in the Islands more than forty or fifty years at the most, there are now at least 800 lepers, an enormous number when compared with the small indigenous population of 40,000. This people appear to have been extremely susceptible to the introduction of any infectious disease. Syphilis, leprosy and small-pox have made sad havoc among them. At least 500 persons died of small-pox in 1881.

The excessive death-rate already mentioned threatens the life of this little nation, which must sooner or later be wiped out of existence unless the decimation of the people is arrested.

If it be urged that isolation and other sanitary measures have not succeeded in controlling the spread of leprosy in the Sandwich Islands, it should also be stated that in the earlier years of sanitary control the execution of the law was opposed very generally, especially by concealment and deceit.

Again, a great obstacle to the thorough understanding of the contagion of leprosy consists in its indefinite and lengthy period of incubation. The shortest time of development is one year, and it has appeared as late as nineteen years after inoculation.* So long a range is unknown in the case of any other disease. In small-pox, scarlet fever and other diseases, the period of incubation is short, decisive and well defined, and hence the active cause is readily recognized. But when this period is measured by years instead of days, the actual facts and conditions of exposure are apt to be forgotten or denied *in toto*.

As a matter of vital importance to the safety of the Hawaiian nation, a board of health was organized as early as 1865; and, in accordance with the provisions of the act already cited, a hospital for temporary detention and examination of lepers was established, — a sort of probationary station to which all suspected lepers were taken and examined, or placed under surveillance until they were determined to be either lepers or non-lepers.

* An instance illustrating the doctrine of contagion, and also of extremely long period of incubation. Dr. Hillebrand narrates a case in Borneo where a boy of European parentage was accustomed to play with a leprous child of color. The native boy thrust a knife into the anæsthetic part of his body, which act was immediately repeated by the white lad with the same knife. The latter was soon after sent to Holland, where he grew to maturity, and nineteen years later developed the disease, returning to Borneo a confirmed leper.

After the establishment of the Kalihi hospital, the next move was the purchase of a portion of the island of Molokai for a colony whence all those who had been determined to be lepers at the Kalihi hospital should be transferred for a permanent residence.

There had been examined up to 1872, 1,288 persons, of which number 570 were discharged at once, and 145 subsequently; 529 were sent to Molokai. Deducting loss by death and other causes, 385 remained March 31, 1872.

The number of admissions in the following year appears to have greatly increased, for Dr. Trousseau's report states the number in the settlement as 800, or 2 per cent. of the entire population.

The commitments in 1874–1876 were 297, and the deaths from leprosy 299.

The entire admissions to Molokai in ten years were 1,570, an annual average of 157. The deaths in the same time were 872.

The settlement at Molokai is admirably adapted to isolation, which is naturally afforded by the topographical character of the place. A precipitous wall 2,000 feet in height on the one hand, and the sea on the other, render escape almost impossible.

In some villages among the islands, leprosy appears to be much more prevalent than in others.

Of Kalaupapa, a village on the same island of Molokai, Mrs. Bird says, in a recent book of travels: "It may safely be pronounced one of the most horrible spots on earth, — a home of hideous disease and slow-coming death with which science in despair has ceased to grapple; a community of doomed beings, socially dead, whose only business is to perish; wifeless husbands, husbandless wives, children without parents and parents without children; men and women who have no more a portion for ever in anything that is under the sun; condemned to watch the repulsive steps by which each of their doomed fellows goes down to a loathsome death, knowing that by the same they too must pass."

So far as leprosy concerns the public health, Dr. White continues: "At the extreme north and south and west of our boundaries, and directly in the heart of the country, have been planted centres of the disease, from which, under favorable conditions, it may spread in all directions. . . . It is evident that the disease may make more rapid advance in one part than in another."

Referring to the measures necessary to exterminate the disease, he says: "These measures should be the establishment of graded hospitals, in possibly insular localities, in various parts of the country, to which all access should be prevented, except under restrictions determined by professional rules; the enactment of laws which should make residence compulsory and perpetual, and the concealment of the disease punishable by severe penalties. These rules should apply to so-called sporadic as well as to endemic and imported cases; but the latter might be given the option of returning to their native land. The immigration of lepers should be prohibited, and arrested at ports of arrival by inspection as far as possible, as other contagious diseases now are by quarantine regulations."

Dr. Piffard urges the necessity of a national central lazaretto; the confining therein of all lepers now in the country; and the watching of immigration, and giving each leprous immigrant the option of returning to the country whence he came or of entering the lazaretto. This will have to be done sooner or later, and the sooner the less difficult the undertaking.

Bacillus. — A bacillus peculiar to leprosy has been discovered, and may now be considered as a settled fact, its presence having first been asserted by Hansen as early as 1873, and also identified by other foreign observers, among whom are Koch, Köbner, Neisser, Cornil and Suchard. While its presence has thus been repeatedly demonstrated, its position with relation to the inoculability of leprosy is a matter far more difficult to determine, for the reason that most of the animals commonly employed for the purpose of experiment are too short-lived for use with reference to a disease whose incubative period is of such long or indefinite duration.

Dr. Belfield states: "It is, then, established that a bacillus of specific size and shape is a constant element of the diseased tissues in tubercular leprosy. Yet this fact of association does not, of course, prove that the bacillus causes the morbid process, since it is conceivable that it appears as a sequence rather than as a cause of the disease. This latter conception is certainly not entirely satisfactory. It does not plausibly explain why this bacterial variety, and this one only, is found, and always found, in the leprous nodules, but in no other diseased state.

BIBLIOGRAPHY OF LEPROSY AS RELATED TO PUBLIC HEALTH.

Anderson (A. F.). *Leprosy in the Straits Settlements.* Colored photographs. London: 1872.

Atkinson (I. E.). *A Case of Tubercular Leprosy.* Chicago Med. Exam.: 1881. xliii, 612–616. Also Archiv. Med N. Y.: 1882. vii, 251–261. Also Clinica Zaragosa. 1881. v, 401–409. 1882. v, 1–11.

Belfield (W. T.). *The Bacillus of Leprosy.* Journal of cutaneous and venereal diseases. Vol. I, No. 10, p. 295.

Bemiss (J. H.). *A few cases of Leprosy.* Lahaina Maui, H., I. Reprinted from N O. Med. & Surg. Journal. April, 1880.

Bermann (I.). *The Bacillus Lepræ.* N. Y. Arch. Med. vii. 1882. 262–266.

Besnier (E.). *La lèpre, est-elle contagieuse? La bacterie de la lèpre* Gaz. hebd. de med. Paris: 1880. 2s. xviii, 114–116.

Bidenkap. *Tilfaelde af spedalskhed.* Norsk. Mag. f. Laegevidensk. Christiania: 1880. x, 8–12.

Bird, Isabella L. *The Hawaiian Archipelago.* London: 1875.

Bocellin (P.). *La practique de maistre Pierre Bocellin, chyrurgien & citoyen de la noble cite de Belleys en Savoye sur la matiere de la contagieuse & infective maladie de lèpre.* 48 p. 4°. Lyons: 1540.

Bordier (A.). *La lèpre: parasitisme: contagion: consequences thérapeutiques.* Jour. de therap. Paris: 1880. vii, 297–304.

Boston Med. & Surg. Journal:
The relation of Leprosy to Syphilis. cvii, 35.
Hawaiian and Norwegian Leprosy. Ibid. cviii, 353.
A case of Leprosy in Salem, Mass. Ibid. cviii, 18.

Burns (H. D.). *A clinical study of Leprosy.* Arch. Med. N. Y.: 1881: vi, 201–224.

CALHOUN (C. W.). *A study of leprosy at Mt. Lebanon, Syria.* Med. Record. N. Y.: 1882. xxii, 692.

CARTER (H. V.), Bombay. *Leprosy and Elephantiasis.* Col. plates. London: 1874.

Ibid. *The pathology of Leprosy, with notes on the segregation of Lepers.* Medico. Chirurg. Transactions. Vol. LVI. p. 267. London: 1873

CAVASSE (J.). *Contribution à l'etude de la lèpre aux Antilles et dans le Levant.* Paris: 1881. 110 p. 4°.

CAYLEY (W.), *et al. Case of Leprosy with enlarged glands.* Tr. Clin. Soc. London: 1880. xiii, 172–174.

CHARCOT. *Lèpre anœsthèsique.* Progrès Méd. Paris: 1880. viii, 1049–1051.

CONI. *La lepra en Buenos Aires.* Rev. Méd. quir. Buenos Aires: 1881–2. xviii, 491-493.

CORNIL (V.). *Note sur le siége des bacteries dans la lèpre et sur les lesions des organes dans cette maladie.* Union Mèd. Paris: 1881. 3s. 32. 1042–1057.

CORNIL (V.), et Suchard. *Note sur le siége des parasites de la lèpre.* Ann. de dermat. et syph. Paris: 1881. 2s. ii, 653–657.

COWLEY (L. M.). *La secuestracion de los leprosos ante la academia de medicina.* Crón. Med. quir. de la Habana: 1880. vi, 193–195.

CROCKER (H. R.). *Case of Anœsthetic Leprosy.* Tr. Clin. Soc. London: 1880. xiii, 172–174.

DALE (F. C.). *Leprosy and its history in the Hawaiian Islands.* West. Lancet. San Francisco: 1878. vii, 401-405.

DANIELSSEN and BOËCK. *Report of Norwegian Commission* 1848. Plates.

Ibid. *Traité de la Spedalskhed, ou Elephantiasis des Grecs.* Paris: 1848.

DE GARAY (A.). *Apuntes sobre el mal de San Lázaro.* Escuela de Med. México: 1882–83. iv, 137, 150, 165, 176, 186, 203.

DROGNAT-LANDRÉ (C. L.). *De la contagion seule cause de la propagation de la lèpre.* 80 p. 8°. Paris: 1869.

EKLUND (F.). *Etude sur la lèpre.* Ann. de dermat. et syph. Paris: 1882. 2s. iii, 220–223.

EKLUND (F.). *Om Spetelska.* Norsk. Mag. f. Laegevidensk. Christiania: 1879. ix, 1179–1192.

FABRE (A.). *Lèpre anesthésique.* Marseille Méd. 1879. xvi, 606–612.

FERRARI (P.). *Il contagio e l'eredità della lebbra.* Giov. ital. d mal. ven. Milano: 1882. xxiii, 295–299.

FRYE (J. W.). *Special Report on Leprosy.* Tr. Am. Dermat. Assoc. Chicago: 1881. v, 40–44

FITCH (G. L). *Report on Leprosy.* Honolulu: 1882. pp. 47, 62. 10 photos.

GAUCHER (E.) et Hillairet. *Parasitisme de la lèpre.* Progres. Med. Paris: 1880. viii, 1039, and Gaz. Med. de Paris, 1880. 6s. ii, 682.

GONZALES DEL VALLE (A.). *Secuestracion de los leprosos.* Crón. med. quir de la Habana: 1880. vi, 387–390.

GRÖNVOLD (C.). *Notes of four cases of leprosy in Minnesota* Arch. dermat. Philadelphia: 1879. v, 35–39.

HAHN (P.). *De la lèpre.* Nancy: 1882. 4°.

HANSEN (A.) *Etudes sur la bactérie de la lèpre.* Arch. de biol. Gand.: 1882. iii, 659.

HANSEN (G. A). *Studien über bacillus Lepræ.* Archiv. f. path. Anat. etc. Berlin: 1882. xc, 542-548.

Ibid. *The bacillus of leprosy.* Quart. Jour. Micros. Sci. London: n. s , xx, 92–102. 1 pl.

Ibid. *Bacillus lepræ.* Nord. Med. Ark. Stockholm: 1880. xii, 1–10.

HARRIS (V. D.). *Report on certain microscopic specimens of various tissues obtained from a case of true leprosy.* Tr. Clin. Soc. London: 1880. xiii, 11.

HAVANG (W. F.). *The Louisiana lepers.* Med. & Surg. Reporter. Philadelphia: 1880. xliii, 417.

HAWAIIAN BOARD OF HEALTH REPORTS. 1870–1882.

HEDENIUS (P.). *Några ord om spetälskun och hennes orsaker.* (Some words on leprosy and its causes.) Upsala Läkaref. Förh.: 1883. xviii, 216–228.

HENSLER (P. G.). *Vom abendländischen Aussatze in Mittelalter.* Hamburg: 1790.

HERNANDO (B.). *La lepra in Granada.* Rev. esp. de oftal. sif., etc. Madrid: 1881. Año V. Vol. I, 193–213.

Ibid. *Clinica Zaragosa.* 1881, v, 401–409. 1882, vi, 1–11.

HILL (H. W.). *True Eastern leprosy.* Lancet. London: 1880. ii, 779.

HILLIS (J. D.). *Leprosy in Brit. Guiana. An account of W. I. leprosy* London: 1881. 275 p. 22 plates. Royal 8°.

HILLIS (J. D.). *Report on the Leper Asylum at Mahaica.* Br. Guiana for 1877. Demarara: 1879.

HIRSCH. *Handbuch der historisch, geographischen Pathologie.* Erlangen: 1860.

HOGGAN (G.) & (F. E.) *Über nerven veränderungen bei lepra anæsthetica.* Monatsch. f. prakt. dermat. Hamburg: 1882. 1, 3–5.

HUTCHINSON (J.). *Fish-eating and leprosy.* Lancet. London: 1880. ii, 747.

HYDE (J. N.). *A clinical lecture on Anæsthetic leprosy.* Am. Practitioner. Louisville, Ky.: 1879. xix, 81–97.

ISRAËLS. *Leprosy in the Netherlands.* Tijdschr. voor Geneeskunde. Vol. I. 1857.

IRELAND (W. W.). *Remarks on leprosy in Madeira.* Arch. dermat. Philadelphia: 1879. v, 40.

LEO (A. J.). *Beitrag zur Geschichte der Lepra.* Inaug. dissert. 15 p. 8°. Leipzig: 1870.

LÈPRE (LA) *est contagieuse. Par un missionaire attaché aux léproseries.* Paris: 1879.

LEPROSY IN AMERICA. N. Y. Med. Jour., 1879. xxix, 196–200.

LEPROSY (MODERN INDIAN). *A report of a tour in Kattiawar in* 1876, *with addenda on Norwegian, Cretan and Syrian leprosy.* Bombay: 1876.

LEPROSY. *Collection of official papers, and reports relating to the distribution and causation of leprosy in the different provinces of India.* In compliance with a resolution of the Government of India. No. 1, 136. 1875. Calcutta: 1879. 151 p. folio.

LIVEING (R.). *Elephantiasis Græcorum, or true leprosy.* London: 1873.

Ibid. *Goulstonian Lectures.* Brit. Med. Jour. No. 637. March, 1873.

LUCIO (R.) e I. ALVARADO. *Opusculo sobre el mal de San Lazaro, o elefanciasis de los Griegos.* Escuela de med. Mexico: 1880–81. No. 2, 1–11.

MALLINS (H.). *A case of Leprosy in the early stage.* London Lancet, 1881. ii, 996.

MCGREW (J. S.). *Leprosy in the Sandwich Islands.* N. Y. Med. Record, 1881. xix, 639.

MCPHEDRAN (A.). *Leprosy in Cape Breton, Nova Scotia.* Canada Jour. Med. Sci. Toronto: 1881, vi, 27; 1882, vii, 15.

MENDEZ (A.). *Es contagiosa la lepra?* Siglo Med. Madrid: 1881. xxviii, 708–710.

MEREUSKY (A.). *Lepra unter der Zulu-bevölkerung der Natal Colonie.* Arch. f. path. anat., etc. Berlin: 1882. lxxxix, 187–189.

MILROY (G.). *Is leprosy contagious?* Med. Times and Gazette. London: 1880. ii, 263–266.

MONASTIRSKI (N.). *Zur pathologie des knoten-aussatzes.* Vierteljschr. f. dermat. Wien: 1879. vi, 203–256. 4 pl.

MONCORVO DE FIGUIREDO. *Relatorio apresentado á academia imperial de medicina do Rio de Janeiro sobre o trabalho do Dr. E. R. Coni intitulado, "Contribucion al estudio de la lepra anesthetica Quijila (Brazil), Gafeira (Portugal)."* Ann. Brazil de Med. Rio de Janeiro: 1878–79. xxx, 349–400.

MUNRO (W.). *On the Etiology and History of Leprosy.* Edinburgh. M. J. 1876–79. xxii, 23, 24, passim. contin. 1879–80. xxv, 130–138.

NEISSER (A.). *Weitere Beitrage zur Ætiologie der lepra.* Arch. f. path. anat. de Berlin. 1881. lxxxiv, 514–542. Also, Breslau Aerztl. Ztschr. 1879. i, 200–214.

PIFFARD (H.). *Cases of Leprosy* Phila. Med. Times, 1881–82. xii, 720–722. Also, Med. Record, N. Y., 1882. xxii, 78–81.

Ibid. *La lepra.* Med. y ciur. centro. Am. Guatemala, 1881. ii, 166–174.

Ibid. *Leprosy in the United States.* Journal of cutaneous and venereal diseases. Vol. I, No. 10, p. 289.

PLUMACHER (E. H.). *Leprosy and the means taken to prevent its spread at Maracaibo.* Sanitarian. 1883. N. S. 1, 71–74.

POQUET (J. B.). *Contestacion al Sr. D. Luis Ruano, sobre el contagio de la lepra.* Crón. Méd. Valencia: 1878–79. ii, 585–630. Also, 1879–80. iii, 227–232.

RAY (G. C.). *Some remarks on leprosy.* Indian Med. Gaz. Calcutta: 1881. xvi, 45.

RESÚMEN *numérico de los individuos atacados de lepra ó mal de San Lazaro que existia en España en* 1878. Crón. Med. Valencia: 1879–80. iii, 712–715.

ROYER (A.). *Etude sur les leproïdes du type Lazarin.* Lyon. Paris: 1882. 72 p. 4°.

SAXE (A. W.). *Hawaiian Leprosy.* Trans. Med. Soc. California, Sacramento: 1881. xi, 278–301.

SANGALLI (G.). *La lebbra dell alta Italia Massime di Comacchio.* R. Ist. Lomb. di. sc. e lett., Rendic. Milano, 2s., xiii, 588–633.

SCHMIDT (H. D.). *A contribution to the pathological anatomy of leprosy.* Arch. Med. N. Y.: 1881. vi, 225–251.

Ibid. *Is the bacillus lepræ a reality or a fiction?* A critical review. Chicago Med. Jour. and Ex , 1882. xliv, 337–353.

SCHWIMMER (E.). *Lepra etojövetele Magyarovszagen.* (History of Leprosy.) Orvosi hetil. Budapest: 1879. xxiii, 905–929.

Ibid. *Über das vorkommen der lepra in Ungarn.* Pest. Med. Clin. presse. Budapest: 1880 xvi, 33–53.

SHOEMAKER (J. V.). *Report of a case of leprosy in Philadelphia.* Med. bull. Phil.: 1883. v, 61–64.

SHULIOVSKI (D.). *O bakterijach lepri* Med. Vestnik. St Petersburg: 1881. xxi, 89.

SIMPSON (J. Y.). *Leprosy in Britain.* Edinb. Med. and S. Jour. 3 articles. Vols. LXVI, LXVII, 1846–47.

SMITH (A. C.). *Leprosy in America.* Trans. Am. dermat. assoc. N. Y.: 1879. 57–61.

SMITH (J. M.). *Leprosy in the Hawaiian Islands.* West. Lancet. San Francisco: 1881–82. x, 49–52.

STATISTIK *over de Spedalske i Norge i Aaret* 1878. Christiana: 1879. 28 p. 4°.

TAKADA SHINKO. (*Diagnosis of leprosy.*) Tokei iji Shinghi, June 25, 1881.

THORNTON (W. H.) *A visit to the lazaretto at Tracadie, N. Brunswick,* Canada M. and S. Journal. Montreal: 1880–81. ix, 521–529.

TRYON (J. R.). *Leprosy in the Hawaiian Islands.* Am. Jour. Med. Sc. 1883. N. S , lxxxv, 443–450.

TYSON (W. J.). *Lepra Tuberculosa.* Brit. Med. Journ. London: 1883. i, 866.

UNDERHILL (G. B.). *Leprosy as it exists in Louisiana.* N. O. Med. and S. Jour., 1881–82. N. S , ix, 513–526.

VALLIN. *Un cas de lèpre hyperæsthesique, contagion probable.* Union Med. Paris: 1880. 3s., xxx, 891–895.

VICIOT (E.). *De la lèpre anesthetique.* Lyon: 1879. 18 p. 4°.

VINEBERG (H. U.). *Leprosy and the leper settlement Molokai, Sandwich Islands.* Canada M. and S. Jour. Montreal: 1881–2. x, 513–522.

Virchow (R.). (*Mediæval leprosy*), five articles. Virchow's Arch. vols. 18–20. 1860–61.

Ibid. *Die Krankhaften Geschwülste.* Berlin. Vol. 2. 1863–67.

Ibid. *Der Aussatz auf der iberischen halbinsel.* Arch. f. path. anat., etc. Berlin: 1881. lxxxiv, 417.

Ibid. *Ein Aussatzhaus bei Skutari.* Arch. f. path. Anat., etc. Berlin: 1879. lxxvii, 171–174.

Virnjski (D.). *Nabludenija nad prokajemnin.* (Investigations of Leprosy.) Med. Vestnik. St. Petersburg: 1879. xix, 377.

Wernich (A.). *Über die Ætiologie, das Erlöschen und die hygienische Bekämpfung des Aussatzes.* Leipzig: 1879. 8°.

White (J. C.). *The Question of Contagion in Leprosy.* Am. Jour. Med. Sci., 1882. N. S., lxxxiv, 433-454.

Wilson (S.) *Leprosy.* London Lancet, 1880. ii, 779.

Woods (G. W.). *Leprosy.* Hygienic and Medical Reports. U. S. Navy, Washington, D. C., 1879. iv, 737–775.

Wortabet (J.). *Leprosy in Syria.* Brit. and foreign Med. Chir. Review. ciii, p. 173. London: 1873.

REPORTS OF THE WATER BOARDS, COMMISSIONERS, AND COMPANIES OF MASSACHUSETTS.

REPORTS OF THE WATER BOARDS, COMMISSIONERS, AND COMPANIES OF MASSACHUSETTS.

The following report is made in compliance with an act of legislature passed in 1879 requiring regular triennial returns to be made by all water boards and companies located in this Commonwealth, these reports to be made on a uniform plan, upon blanks furnished by the State Board for the purpose, the same to be published by the Board in its report to the Legislature, properly arranged by counties, and those in each county alphabetically.

A certain want of uniformity is noticeable in these returns, rendered unavoidable in consequence of the different plans of organization of water companies and boards, their location, and their relation to other organizations in neighboring cities and towns.

The entire number of companies and boards having water-works in operation at the beginning of 1883 was seventy-one, from which returns have been received at the office of the Health Department. They are as follows: —

In *Barnstable County.* — None.

In *Berkshire County.* — Ten: the Adams Water Company, the Great Barrington Water Company, the Cheshire Water Company, the Berkshire Water Company (in Lee), the Lenox Water Company, the North Adams Fire District, the Ashley Water Works (in Pittsfield), the Richmond Water Company, the Stockbridge Water Company, the Williamstown Aqueduct Company.

In *Bristol County.* — Four: the Attleborough Water Supply District, Fall River Water Works, New Bedford Water Works, Taunton Water Works.

In *Dukes County.* — None.

In *Essex County.* — Eight: Beverly Water Works, Danvers Water Works, Haverhill Aqueduct Company, Lawrence Water Works, Lynn Water Works, Newburyport Water Company, Peabody Water Works, Salem Water Works.

In *Franklin County.* — Two: Glen Water Company (in Greenfield), Turner's Falls Water Company (in Montague).

In *Hampden County.* — Six: Agawam Water Company, Chicopee Water Company, Holyoke Water Works, Springfield Water Works, Westfield Water Works, West Springfield Aqueduct Company.

In *Hampshire County.* — Three: Amherst Water Company, Northampton Water Works, South Hadley Falls Water Works.

In *Middlesex County.*—Sixteen: Arlington Water Works, Cambridge Water Works, Concord Water Works, Everett Water Works, Lincoln Water Works, Lowell Water Works, Malden Water Works, Medford Water Works, Melrose Water Works, Natick Water Works, Newton Water Works, Somerville Water Works, Waltham Water Works, Highland Water Works (in Winchester), Woburn Water Works, Wayland Water Works.

In *Nantucket County.* — One: Wannacomet Water Company.

In *Norfolk County.* — Two: Brookline Water Works, Dedham Water Company.

In *Plymouth County.* — Four: Brockton Water Works, Hingham Water Company, Kingston Aqueduct Association, Plymouth Water Works.

In *Suffolk County.* — Two: Boston Water Board, Chelsea Water Works.

In *Worcester County.* — Thirteen: Athol Water Company, Clinton Water Works, Fitchburg Water Works, Gardner Water Company, Leominster Water Board, Milford Water Company, Northborough Water Works, Southbridge Water Supply Company, Spencer Water Company, Webster Water Works, Westborough Water Works, Worcester Water Works, Uxbridge Water Company.

In addition to the companies and boards mentioned above, there are also seventeen other companies, whose works were not in operation at the beginning of the year. Some of these have been organized several years, but the majority have organized under special acts of the present legislature.

They are as follows : —

Bristol County. — North Attleborough.

Dukes County. — Cottage City.

Essex. — Amesbury, Marblehead, Nahant.

Hampden. — Palmer.

Middlesex. — Hudson, Hopkinton, Lexington, Marlborough, Wakefield.

Norfolk. — Franklin, Quincy, Sharon, Wellesley, East Weymouth.

Plymouth. — South Abington.

There are also two villages, Easthampton and West Brookfield, in which a few families only receive water, supplied by certain manufacturing corporations, they have not made returns, since they can hardly come within the meaning of the act of 1879.

The incompleteness of certain returns in estimates of quantity, or of areas of land or of water-surface, are excused by the returning parties by reference to the clause limiting expense of survey to fifty dollars.

Replies to the following questions are required by the Statute of 1879. The numbers at the head of the columns in the tabular statement correspond to the numbers of these questions.

1. Its name, character or other legal basis, and place of business.

2. The source or sources of its water-supply, and the name, if any, and location of each.

3. The superficial area of its water-surface, if lake, pond, reservoir, or large well.

4. The area of water-shed supplying such source or sources.

5. The general geological and topographical character of the water-shed.

6. The estimated capacity of each such source by average daily flow.

7. The estimated capacity of each such source by minimum daily flow.

8. Whether the water-shed is also wholly or in part that of other lakes, rivers, ponds or reservoirs, besides that used by the party making return; and if so, to what extent.

9. Whether or not the source employed by the party making return is used jointly by some other for a water-source; and if so, by whom.

10. Whether there are other sources within ten miles, not already appropriated by law, that could be availed of in connection with the source or sources now enjoyed by the party making return; and if so, what, and their location, area, water-shed, and the means necessary to connect, with the distance from present source, and from territory to be supplied.

11. What danger of contamination the waters at present held are liable to.

12. Whether or not an analysis has been made of the water at present used, and the results of any such; by whom and where.

13. Whether the waters at present used have been stocked with fish; if so, to what extent, by whom, and where.

14. What, up to date, has been the cost of the water works in use, including rights, lands taken, and all damages paid; stating cost of water-rights separately, and to whom paid.

15. Whether the storage capacity of the present source can be increased, and at what probable cost, exclusive of damage by flowage, and at what damage to private parties or corporations.

16. Whether any town, village, or city discharges its sewers or drains into the source used by the returning party, or their tributaries.

17. The population of the town, city or village, so discharging its sewers or drains into said source, and the character of its manufactures.

18. The apparent results of such sewage.

19. The average daily consumption, for the year, of the population supplied by the party making return.

20. The per centum used by families.

21. The average consumption per family per diem.

22. The probable increase of demand, as near as can be estimated, for the next year.

23. The water-rates established.

24. The system of distribution, whether by gravity, stand-pipe, direct pumping, reservoir or otherwise.

25. The condition of water debt and sinking fund.

26. How the effluent water is now got rid of.

27. Into what stream or body of water it finally flows.

28. What protection against impurity of present source not now provided is desired.

29. What additional expense such protection would involve, and to whom.

REPORTS OF THE WATER BOARDS, COMMISSIONERS, AND COMPANIES OF MASSACHUSETTS.

BERKSHIRE COUNTY.

1.	2.	3.	4.	5.	6.	7.	8.
Adams,	-	-	-	-	-	-	-
Ashley Water Works, Pittsfield.	Ashley Lake and mountain brooks in Washington.	80 acres,	No estimate,	No estimate,	No estimate,	2,000,000 gals.,	No.
Berkshire Water Co., Lee,	Codding Brook, in Washington.	5 acres,	5 sq. miles,	-	200,000 gallons,	50,000 gals.,	No.
Cheshire Water Co.,	Two large springs in Cheshire,	One-half acre,	-	-	-	-	-
Great Barrington Water Co.,	A mountain brook and springs,	One half acre,	No estimate,	No estimate,	No estimate,	No estimate,	No.
Lenox Water Co.,	A spring and a small stream. Location not stated.	-	1,500 acres,	Mountainous, with considerable limestone.	35,000, 150,000 =185,000 gallons.	25,000, 100,000 =125,000 gallons.	Used exclusively by Company.
North Adams Fire District,	Notch Brook, a mountain stream 500 feet above village.	No estimate,	No estimate,	-	No estimate,	No estimate,	No.
Richmond Water Co., at Richmond Furnaces.	Small brook, starting from a spring.	Reservoir one-third acre.	-	-	-	-	-
Stockbridge Water Co,	Mountain springs.	2 rods square,	200 acres,	Woodland, loam, granite.	15,000 gallons,	8,000 gals.,	No.
Williamstown Aqueduct Co.,	An ever-flowing spring at base of Stone Hill.	4 to 6 feet in diameter.	A hill 6 square miles, no surface water.	Mica slate and limestone.	No estimate,	No estimate,	No.

BRISTOL COUNTY.

1.	2.	3.	4.	5.	6.	7.	8.
Attleborough Water Supply District.	Wells dug and driven near Ten Mile River.	One well ten feet in diameter, a brick gallery 100 feet by 5 by 4 feet, and	-	-	300,000 gallons,	* 300,000 gals.,	-

		seven 2-inch driven wells.					
FALL RIVER WATER WORKS,	Watuppa Lakes,	5.43 sq. miles,	31¼ sq. miles,	Hills of gravel and sandy loam, partially wooded.	35,000,000,	-	Stafford and Sandy ponds are also tributaries.
NEW BEDFORD WATER WORKS,	Artificial reservoir by dam at head of Acushnet River.	300 acres,	3,300 acres,	Porous sand and gravel, form'd of and underlaid by primitive rocks, covered with pine woods.	Capacity of storage reservoir, 313,000,000 gals. Maximum flow in 1861, 42,163,668 gals.	Minimum flow 2,999,808 gallons.	No.
TAUNTON WATER WORKS,	An open filtering basin with covered conduit, near Taunton River. Also a direct pipe to river, can be used if necessary. For description see 9th Annual Report of State Board of Health.	-	-	-	Capacity of 1,500,000 gals. in a dry season.	-	-

* On account of depth of supply it is not affected by drought.

Reports of Water Boards, Commissioners, &c. — Continued.

BERKSHIRE COUNTY — CONTINUED.

1.	9.	10.	11.	12.	13.	14.
ADAMS,	–	–	–	–	–	–
ASHLEY WATER WORKS, PITTSFIELD.	No,	There are other available sources, but they cannot be connected with present system.	No,	No,	No,	Cost of works, $200,000; damages, $2,000.
BERKSHIRE WATER CO., LEE,	No,	No,	None,	No,	No,	Works incomplete; land damage $300.
CHESHIRE WATER CO.,	–	Kitchen Brook, in Cheshire, 5,000 gallons per minute. Connect by a dam and pipe one-half mile.	None,	None,	No,	About $18,000; damage small.
GREAT BARRINGTON WATER CO.,	No,	Answer indefinite,	None,	Water declared pure by local physicians.	No,	About $25,000.
LENOX WATER CO,	No,	Other mountain springs,	None,	Prof. Crafts; no figures given.	Trout,	$25,797.30; damages and rights, $2,409.95.
NORTH ADAMS FIRE DISTRICT,	No,	–	None,	Analysis made but no authority given.	No,	About $160,000.
RICHMOND WATER CO., AT RICHMOND FURNACE.	–	–	Sewage and cattle.	None,	No,	About $5,000; damages $300.
STOCKBRIDGE WATER CO.,	No,	Yes; springs ½ mile distant, can be utiliz'd by iron pipes.	None,	No,	No,	Cost about $20,000.
WILLIAMSTOWN AQUEDUCT CO.,	No,	Other springs, higher up, can be had if needed.	None,	No,	No,	$12,000.

BRISTOL COUNTY — CONTINUED.

1.	9.	10.	11.	12.	13.	14.
ATTLEBOROUGH WATER SUPPLY DISTRICT.	No,	–	None,	July, 1875. Total impurities per gallon, 4 20 grs.; organic and volatile, 2.80 grs.; mineral, 1.40 grs.; sulphate of lime,	–	$82,000; no cost for water rights.

				small; chlorides, medium; carbonates and nitrates, none; unoxidized organic matter, small. H. W. Vaughan, Chemist, Providence, R. I.		
FALL RIVER WATER WORKS, .	No, . . .	Middleboro' and Stafford Ponds.	*		No, . . .	Total cost, not including damages not yet adjusted, $1,498,418.20.
NEW BEDFORD WATER WORKS, .	No, . . .	Two ponds, Long Pond and Little Quittacus, 2½ miles away from present supply, in Lakeville and Middleboro'. Area 1,800 and 320 acres; water-shed 35,000 acres; could be connected by a canal or conduit.	None, . .	Prof. W. R. Nichols, 1878.	No, . . .	$1,292,952.02; water rights $23,739.56.
TAUNTON WATER WORKS, . .	No, . . .	Great ponds of Middleboro' and Lakeville, by aqueduct at a cost of not less than $500,000.	From sewage of East Taunton. Manufacturers of E. Taunton have promised not to pollute the river.	Prof. W. R. Nichols, 1877.	No, . . .	$422,224 66; land damages $6,258.

* Danger of contamination, only from residences on the west water-shed of the North Lake.

Reports of Water Boards, Commissioners, &c. — Continued.

BERKSHIRE COUNTY — CONTINUED.

1.	15.	16.	17.	18.	19.	20.	21.	22.
ADAMS,	- -	- -	- -	- -	- - -	- -	- -	- -
ASHLEY WATER WORKS, PITTSFIELD.	Can be increased without damage, at a cost proportional to the extent of increase.	No,	- -	- -	1,500,000 gallons,	80 per cent.,	800 gallons,	10 per cent.
BERKSHIRE WATER CO.,	Can be increased by dams without damage.	No,	- -	- -	There are about 40 takers.	Mostly domestic use.	No estimate,	Double.
CHESHIRE WATER CO.,	Can be increased without damage for $2,000.	- -	- -	- -	- - -	- -	- -	Slight.
GREAT BARRINGTON WATER CO.,	Storage capacity cannot be much increased.	No,	- -	- -	- - -	- -	- -	Small.
LENOX WATER CO.,	Can be increased for $2,000.	No,	No,	- -	40,000 gallons,	9-10ths,	300 gallons,	None.
NORTH ADAMS FIRE DISTRICT,	No estimate,	No,	- -	- -	No estimate,	- -	- -	- -
RICHMOND WATER CO., AT RICHMOND FURNACE.	Can be increased for $5,000.	Not directly,	- -	- -	- - -	- -	- -	About 20 families.
STOCKBRIDGE WATER CO.,	At a cost of $1,000; no damage.	No,	- -	- -	No estimate,	No estimate,	No estimate,	- -
WILLIAMSTOWN AQUEDUCT CO.,	No estimate,	No,	- -	- -	No estimate; abundant supply.	- -	- -	No estimate.

BRISTOL COUNTY — CONTINUED.

1.	15.	16.	17.	18.	19.	20.	21.	22.
ATTLEBOROUGH WATER SUPPLY DISTRICT.	Can be doubled for $3,000, by driving more wells; no damage.	No,	- -	- -	50,000 gallons,	Nearly all,	100 gallons,	No estimate.

Fall River Water Works, .	By a dam across the narrows, at a cost of $50,000.	No, . .	– –	– –	1,830,886, . .	50 per cent.,	223 gallons,	A probable decrease in consequence of meters to be used.
New Bedford Water Works, .	No estimate.	No, . .	No, . .	No, . .	2,326,352 gallons, .	– –	113 gallons,	10 per cent.
Taunton Water Works, . .	Can be increased by extending the covered conduits and taking more land therefor.	No, . .	– –	– –	500,000 to 600,000 and in warm weather 1,000,000 gallons.	No estimate,	– –	– –

Reports of Water Boards, Commissioners, &c. — Continued.

BERKSHIRE COUNTY — CONCLUDED.

1.	23.	24.	25.	26.	27.	28.	29.
ADAMS,	-	-	-	-	-	-	-
ASHLEY WATER WORKS, PITTSFIELD.	*	Gravity,	$200,000,	-	Housatonic River.	None,	None,
BERKSHIRE WATER CO,	Single family, $8; tenement houses each family, $6; water-closet, $4; Bath-tub, $4.	Gravity,	None,	No sewers,	Housatonic River.	-	-
CHESHIRE WATER CO.,	Per family, $7.50 — $10,	Gravity,	No debt,	-	Hoosac River,	-	-
GREAT BARRINGTON WATER CO.,	$8 per year per family,	Gravity,	None,	By sewers,	Housatonic River.	-	-
LENOX WATER CO.,	$10 per family; bath-tubs, $5; water-closet, $5; other fixtures by special rates.	Gravity and pumping.	None,	Sewers and irrigation process.	-	None,	-
NORTH ADAMS FIRE DISTRICT,	-	Gravity,	$160,000,	Sewers and cesspools.	Hoosac River,	-	-
RICHMOND WATER CO., AT RICHMOND FURNACE.	None,	Gravity,	None,	-	Williams River,	Stop sewage fr'm outhouses and barns and keep cattle out.	Richmond Iron W'ks to whom the waterw'ks belong.
STOCKBRIDGE WATER CO.,	$8 per family,	Gravity,	None,	By drains and percolation.	Housatonic River.	†	-
WILLIAMSTOWN AQUEDUCT CO,	$8 per family,	Gravity,	None,	-	Hemlo'k Brook.	-	-

BRISTOL COUNTY — CONCLUDED.

1.	23.	24.	25.	26.	27.	28.	29.
ATTLEBOROUGH WATER SUPPLY DISTRICT.	One faucet, $6; each additional, $2.50; one water-closet, $5; each additional, $3.50; bath-tub, $5; each additional, $3.50. *Boarding-Houses.* — Each bath-tub or water-closet, $10. *Private-Sta-*	Stand-pipe and pumping.	Debt, $60,000; sinki'g fund, $7,000.	Surface drainage.	-	-	-

	bles. — One horse, $5. *Measured Water.* — Per 1,000 gallons, 40 cts.						
FALL RIVER WATER WORKS, .	30 cts. per 1,000 gallons, . . .	Standpipe, .	– –	Through the outlet of the lakes and Quequechan River.	Mt. Hope Bay,	†	No estimate,
NEW BEDFORD WATER WORKS, .	One faucet, $2.50; each additional, $1.25; bath-tub, $2.50; each additional, $2.00; pan water-closet, $2.50; each additional, $1; hopper-closet, $10; each additional, $5 *Stables.* — One horse, $2; two horses, $3; one cow, 50 cts. Hose, for gardens, windows, &c., $2.50. *Hotels.* — Each bed, $1; hopper-closet, $15. *Metered Water.* — 1,000 gallons, 15 cts.; 1,000 gallons for manufacturing purposes, 2½ cts.	Reservoir, .	Debt, $700,000; no sinking fund.	Sewers and cesspools.	Acushnet River and Buzzard's Bay.	– –	– –
TAUNTON WATER WORKS, . .	One faucet, $5; each additional, $2; bath-tub, $3; each additional, $2; pan water-closet, $5; each additional, $2.50; hopper-closet, $10. *Boarding-Houses.* — One faucet, $10; each additional, $3; pan-closet, $10; hopper-closet, $20. *Hotels.* — Each bed, $3. *Stables.* — One horse, $4; each additional, $1.50; each cow, $1.50. Fire hydrants, $30. *Measured Water.* — 1,000 gallons, 12½ to 25 cts., according to quantity used.	Direct pumping.	Debt, $380,000; sinking-fund, $62,481.11.	Sewers, cesspools and surface drainage.	Taunton Great River.	– –	–

* Single families, $5 to $7.50 per year; private bath-tub, $2.50; public bath-tub, $5; single water-closet, $3.75; each horse, $1.25; each cow, 94c.; metered water, 7½ to 12½c. per 1000 gals.

† Water is filtered through perforated tile and layers of charcoal and gravel.

‡ The water board recommends that immediate action be taken by the city to purchase a strip of land along the west shore of North Watuppa Pond, from the New Boston Road, near the ice-houses, to the "Narrows," so called, of sufficient width to build a road and construct a sewer, in which to collect the wash from the east slope on the west side of the pond, and deliver the same into the south pond at the "Narrows," in order to prevent any impurities from entering the waters of the North Pond by the occupation of the lands for dwellings, etc.

Reports of Water Boards, Commissioners, &c. — Continued.

ESSEX COUNTY.

1.	2.	3.	4.	5.	6.	7.	8.
BEVERLY.*							
DANVERS WATER WORKS, . .	Middleton pond, in Middleton,	105 acres, .	1,867 acres, including pond.	- -	- -	- -	No.
HAVERHILL AQUEDUCT COMPANY,	Lakes Kenoza, Saltonstall and Pentucket.	Kenoza, 231; Saltonstall, 41; Pentucket, 38—310 acres.	2 square miles,	Gravelly hills used for pasturage — a little woodland.	No estimate, .	- -	No.
LAWRENCE WATER WORKS, . .	Merrimac river, . . .	- -	4,136 square miles.	- -	5,184,000,000 cubic feet per day.	181,440,000 cubic feet per day.	- -
LYNN PUBLIC WATER WORKS, .	Breed's and Birch ponds in Lynn and Saugus.	Breed's pond, 58 acres; Birch pond, 67 acres.	Breed's pond, 590 acres; Birch pond, 490 acres.	Wooded country underlaid with ledge; not inhabited or cultivated.	Both ponds 1,750,000 gals. per day.	No estimate, .	No.

Newburyport Water Company,	Bartlett's springs, . . .	Pumping basin, 1¾ acres.	No estimate, .	Gravelly and sandy hills.	500,000 gals., .	340,000 gals., .	No.
Peabody Water Works, . .	Mineral spring pond and Brown's pond, in Peabody,	M. S. pond, 62 acres; Brown's pond, 26 acres; Reservoir, 10 acres. T'l, 92 acres.	550 acres, .	Basis of sienite and greenstone, surrounded by wooded hills.	1,000,000 gals. per day.	600,000 gals.. .	- -
Salem Water Works, . .	Wenham lake, in Wenham, .	320 acres, .	1,716 acres, .	Hills, . . .	No estimate, .	- -	No.

FRANKLIN COUNTY.

Glen Water Co., Greenfield,	Glen brook in Leyden, . .	4 acres, .	12 sq. miles, .	Mountainous, .	- -	400,000 gals., .	No.
Turner's Falls Water Co., Montague.	Connecticut river, . . .	- -	- -	- -	- -	- -	- -

* Refers to Report of Salem Water Works.

Reports of Water Boards, Commissioners, &c. — Continued.

ESSEX COUNTY — CONTINUED.

1.	9.	10.	11.	12.	13.	14.
BEVERLY.*						
DANVERS WATER WORKS, . .	Danvers Lunatic Hospital.	Swan pond—a mile or more from Middleton pond—68 acres. Water-shed, 222 acres, can be connected by a trench 2,000 feet long.	None, . .	No record, . . .	Yes; by town of Middleton.	$208,028.15. Damages, $8,605.14.
HAVERHILL AQUEDUCT COMPANY,	- -	Merrimac river, . . .	None, . .	Drs. J. R. Nichols and S. D. Hayes. No figures given.	No, . . .	- - -
LAWRENCE WATER WORKS, . .	City of Lowell.	No other practicable sources,	Sewage of Lowell, Nashua, Manchester, Concord, and towns above.	Prof. W. R. Nichols, 1877.	By fish commissioners of New Hampshire.	$1,762,832.24. Water rights, $15,000.
LYNN PUBLIC WATER WORKS, .	No, . . .	Saugus river, Ipswich river, Penny brook and Hawkes brook and Humphrey's pond.	None, . .	Prof. W. R. Nichols, .	Stocked with black bass by water board.	$1,037,900.10.

Newburyport Water Company,	No, . . .	Kimball's pond and Powow river in Amesbury. Jackmann's springs and Artichoke river in Newburyport.	None, . .	Karl Castlehun, . .	- -	$295,000.
Peabody Water Works, . .	No, . .	Suntanz lake, 200 acres, in west part of town.	one, . .	None, ...	Brown's pond stocked by Mr. Shorey.	$275,000, bought of Salem and Danvers Aqueduct Co.
Salem Water Works, . .	No, . . .	None, ...	None, . .	Drs. Jackson and Nichols, 2.22 grains of solid residue to gal.	Yes, . . .	$1,406,648.07

FRANKLIN COUNTY — Continued.

Glen Water Co., Greenfield,	No, . . .	Coleraine brook, . . .	None, . .	- - -	No, . . .	$80,000.
Turner's Falls Water Co., Montague.	- -	- - -	- -	- - -	- -	- - -

* Refers to Report of Salem Water Works.

Reports of Water Boards, Commissioners, &c. — Continued.

ESSEX COUNTY — Continued.

1.	15.	16	17.	18.	19.	20.	21.	22.
Beverly.*								
Danvers Water Works, . .	Pond can be raised two or three feet by a dam at cost of $200 or $300.	No, . .	- -	- -	412,719 gals., including amount supplied to the hospital.	- -	- -	5 to 10 p.c.
Haverhill Aqueduct Company,	Can be largely increased at a small cost.	None, . .	- -	- -	No estimate, .	- -	- -	- -
Lawrence Water Works, . .	Yes, by only slight additional cost of fuel, labor and machinery.	Lowell, Nashua, Manchester & Concord.	Pop. 110,000. Manufactures of all kinds.	Slight traces detected at Lawrence.	1,950,000 gallons, .	67 p. c., .	185 gallons,	120,000 gallons per day.
Lynn Public Water Works, . .	Can be increased at a small cost.	None, . .	None, . .	None, . .	1,510,764 gallons,	75 p. c., .	183.5 gallons	About 7 p.c.,

NEWBURYPORT WATER COMPANY,	No estimate, . . .	- -	- -	- -	180,000 gallons, .	60 p. c., .	200 gallons,.	About 40 p.c.,
PEABODY WATER WORKS, . .	Can be increased for $10,000. Damages nominal.	- -	- -	- -	575,434 pumped daily, and about the same am't by gravitation.	38 per ct., .	50 gals., .	Small.
SALEM WATER WORKS, . .	It can, at no cost except damage to abutters.	None, . .	- -	- -	2,000,000 gals. .	- -	210 gals., .	10 per ct.

FRANKLIN COUNTY — CONTINUED.

GLEN WATER CO., GREENFIELD,	Yes; for $5,000, . .	- -	- -	- -	300,000 gals., .	- -	- -	- -
TURNER'S FALLS WATER CO., MONTAGUE.	- - -	- -	- -	- -	- - -	- -	- -	- -

* Refers to Report of Salem Water Works.

Reports of Water Boards, Commissioners, &c. — Continued.

ESSEX COUNTY — Concluded.

1.	23.	24.	25.	26.	27.	28.	29.
Beverly.*							
Danvers Water Works, . .	One faucet, $6; each additional, $1; bath-tubs, $5; water-closets, $5. *Boarding-Houses.* — One faucet, $10; each additional, $2. *Stables.* — One horse, $5; each additional, $2.	Pump and reservoir.	Debt $205,000. Sinking fund $5,227.	No drainage system yet.	- -	- -	- -
Haverhill Aqueduct Company,	Each family not more than three, $5; each additional person, $1; water-closet, $5. *Private Stables.* — Each horse and carriage, $3; boarding-houses, $10 to $20; bath-tub, $3; bar-rooms, $10 to $30.	Gravity for low service. Pump and tank for high service.	- -	- -	Merrimac river and Atlantic ocean.	- -	- -
Lawrence Water Works, . .	- - -	Reservoir, .	Debt, $1,300,000. Sinking fund, $170,552.99.	Sewers to Merrimac river.	Atlantic ocean,	2†, . . .	-
Lynn Public Water Works, .	One faucet, $6; each additional, $2; bath-tub, $5; each additional, $3; water-closet, $5; each additional, $3; hopper closets at special rates. *Boarding-Houses.* — One faucet, $10; each additional, $3; water-closet or bath-tub, $10. *Private Stables.* — One horse, $5; each additional, $3; cow, $1.50. *Measured Water.* — 1,000 gals., 20 to 40 cts, according to quantity.	Pump and reservoir.	Debt, $999,500. Sinking fund, $54,879.17.	Sewers, . .	Lynn harbor,	- -	- -

Newburyport Water Company,	One faucet, $8; each additional, $3; bath-tubs, $6; each additional, $4; water-closet, $6; each additional, $4. *Boarding-Houses.* — One faucet, $15; each additional, $4. *Private Stables.* — One horse, $8; each additional horse, $4; one cow, $2. *Measured Water.* — 1,000 gals., 30 to 50 cts., according to quantity.	Reservoir and direct pumping combined.	-	Drains, etc., .	Merrimac river,	-	-
Peabody Water Works, . .	-	Stand-pipe and gravitation.	Included in the town debt, which is about $300,000. Sinking fund, $51,461.99.	Into Goldthwait's brook.	North r ver, Salem.	-	-
Salem Water Works, . .	Each family of 4, $3; each additional person, $0.50; water-closet or bath-tub, $5; hopper-closet, $8. *Hotels and Boarding-Houses.* — Each bed, $3. *Private Stables.* — $6; each horse over two, $3; each cow, $1. *Measured Water.* — 1,000 gals., 13 to 20 cts., according to quantity.	Pump and reservoir.	$898,500. Sinking fund, $211,715.75.	-	-	-	-
FRANKLIN COUNTY — Concluded.							
Glen Water Co., Greenfield,	Each family, $8; bath-tub, $2; water-closet, $2. *Stables.*—One horse and cow, $3; stores and shops, $5; livery stables, ten horses, $20; each additional horse, 75 cts; fish markets, $10; restaurants, $10.	Gravity, .	Permanent loan.	-	Green river, .	-	-
Turner's Falls Water Co., Montague.	-	-	-	-	-	-	-

* Refers to Report of Salem Water Works.

† Special legislation, based on investigation and recommendation of experts, to prevent, at least, increased pollution of water supply.

Reports of Water Boards, Commissioners, &c. — Continued.

HAMPDEN COUNTY.

1.	2.	3.	4.	5.	6.	7.	8.
Agawam Water Co., . . .	Springs, ...	No estimate, .	No estimate, .	Sandy plain, .	Unknown; it is double the required am't.	No estimate, .	No, . . .
Chicopee Water Co., . . .	Springs and brooks and artificial reservoirs.	5 acres, .	– –	Sandy plains, .	400,000 gals, .	325,000 gals., .	No.
Holyoke Water Works, . .	Ashley's and Wright's ponds, in Holyoke.	211 acres, .	1,726 acres, .	A narrow valley between ridges of trap.	2,568,121 gals.,	No estimate, .	No.
West Springfield Aqueduct Co.	Darby brook, West Springfield.	Reservoir of 3 acres, . .	No survey, . .	Sandy plain, .	No estimate, .	350,000 gals., .	No.
Springfield Water Works, .	Ludlow reservoir, in Ludlow and Belchertown.	445 acres, .	10 82-100ths sq. miles,	Underlaid with syenite and covered with drift, sand and gravel.	No estimate, .	No estimate, .	No.

Westfield Water Works.	Moose Meadow brook, in town of Montgomery.	$39\frac{1}{4}$ acres,	$4\frac{1}{4}$ sq. miles,	Rocky and mountainous,	2,000,000 gals.,	500,000 gals.,	No.
HAMPSHIRE COUNTY.							
Amherst Water Co.,	Amethyst brook, in Pelham,	1 acre and 25 rods.	8 sq. miles,	Gneiss rock, with alluvial covering, forests and pastures.	-	-	-
Northampton Water Works,	Roberts Meadow brook, in towns of Chesterfield and Westhamptou.	Reservoir of 3 acres.	$9\frac{1}{4}$ miles,	Hills of granite and gravel, with steep declivities.	4,000,000 gals.,	450,000 gals.,	No.
South Hadley Falls Water Works,	Buttery brook, in So. Hadley,	Reservoir, 2 acres.	3 sq. miles,	Sandy soil, $\frac{3}{4}$ cultivated, $\frac{1}{4}$ forests.	200,000 gals.,	150,000 gals.,	No.

Reports of Water Boards, Commissioners, &c. — Continued.

HAMPDEN COUNTY — Continued.

1.	9.	10.	11.	12.	13.	14.
Agawam Water Co., . . .	No, . . .	– – –	None, . .	None, ...	Brook trout, .	No reply, . . .
Chicopee Water Co, . . .	No, . . .	– – –	None, . .	– – –	– –	$60,000.
Holyoke Water Works, . .	No, . . .	Other sources, but not defined.	None, . .	Prof. Goessmann of Agricultural College.	Yes; land locked salmon.	$336,466.03. Damages $4,317.71, .
West Springfield Aqueduct Co.	No, . . .	Other sources not defined, .	None, . .	None, ...	– –	$60,000. Damages $4,500.
Springfield Water Works, .	No, . . .	Yes; but not defined, . .	But little, . .	Prof. W. R. Nichols. No figures given.	A few German carp in 1882.	$1,258,752.38.

WESTFIELD WATER WORKS,	No,	Yes; but not defined,	None,	Prof. R. W. Woodward of New Haven, Conn.	No,	$253,725.99. Water rights, $1,349.90.
HAMPSHIRE COUNTY — CONTINUED.						
AMHERST WATER CO.,	– –	Buffum brook, 3 miles distant.	None,	By Prof. Harris, of Amherst College. Figures not given.	No,	About $55,000. Damages not yet settled.
NORTHAMPTON WATER WORKS,	No,	Other sources not defined,	None,	Prof. Goessmann, in 1870.	No,	$220,000. Water rights and damages, $20,792.
SOUTH HADLEY FALLS WATER WORKS.	No,	Connecticut river,	None,	None,	No,	$60,000.

Reports of Water Boards, Commissioners, &c. — Concluded.

HAMPDEN COUNTY — Continued.

1.	15.	16.	17.	18.	19.	20.	21.	22.
Agawam Water Co.,	-	No,	-	-	Unknown,	-	-	-
Chicopee Water Co.,	For $1,000,	-	-	-	300,000 gals.,	95 per ct.,	No est.,	-
Holyoke Water Works,	Can be increased. No estimate of cost,	No,	-	-	Estimated at 2,000,000 gals.	-	-	-
West Springfield Aqueduct Co.	Can be increased. No estimate.	-	-	-	-	-	-	-
Springfield Water Works,	Yes; no estimate of cost,	-	-	-	About 2,000,000 gals.	-	-	5 per ct.

WESTFIELD WATER WORKS,	Yes; at a cost of $20,000. Damage only by flowage.	-	-	-	No estimate,	-	-	Small.
HAMPSHIRE COUNTY — CONTINUED.								
AMHERST WATER CO.,	Can be doubled for $2,000.	-	-	-	-	-	-	-
NORTHAMPTON WATER WORKS,	Another reservoir could be made further up the stream for $7,000.	-	-	-	450,000 gals.,	89 per ct.,	267 gals.,	60 to 80 families.
SOUTH HADLEY FALLS WATER WORKS.	Can raise dam 2-3 ft. at cost of $2,000.	No,	-	-	150,000 gals.,	98 per ct.,	-	But little.

Reports of Water Boards, Commissioners, &c. — Continued.

HAMPDEN COUNTY — CONCLUDED.

1.	23.	24.	25.	26.	27.	28.	29.
AGAWAM WATER CO.,	$15 per year per family for all purposes, including stables, &c.	Gravity,	No reply,	-	Connecticut river.	None,	-
CHICOPEE WATER CO.,	Each tenement, $7; bath-tub, $4; each additional, $2; water-closet, $4; each additional, $2. *Private Stables.* — Each horse, $2; each cow, $2; special rates for hotels, boarding-houses, markets, &c., &c.	Gravity,	Small debt,	Sewers,	Chicopee river,	-	-
HOLYOKE WATER CO.,	Each family not over seven persons, $6; each additional person, 60 cts.; bath-tub, $3; water-closet, $3; each additional, $2; hopper-closet, $10; meat market, $10; fish market, $12. *Hotels, &c.* — Each bed, $2. *Private Stables.* — Each horse, $2; each cow, $1. *Measured Water.* — per 1,000 gals , 5 to 15 cts , according to quantity.	Gravity,	Debt, $250,000; Sinking fund, $66,130.70.	-	-	-	-
WEST SPRINGFIELD AQUEDUCT CO.	-	Gravity,	Debt, $40,000; No sinking fund.	-	Connecticut river.	-	-
SPRINGFIELD WATER WORKS,	*Dwelling-House* — One family, $8; one water-closet, $4; each additional, $2; bath-tub, $4; each additional, $2; stores, $4. *Private Stables* — One horse, $4; each additional, $2. *Measured Water.* — 1,000 gals., 8 to 30 cts , according to quantity.	Gravity,	$1,200,000.	Sewers,	Connecticut river.	-	-

Westfield Water Works,	Dwellings, $5 to $8, according to assessed value; stores, $5; meat and fish markets, $8; bath-tubs, $2; water-closets, $3. *Private Stables.* — One horse, $2; each additional, $1. Fire hydrants, maintained at private expense, free.	Gravity,	$250,000. No sinking fund.	-	Westfield river.	-	-
HAMPSHIRE COUNTY — Concluded.							
Amherst Water Co.,	One family, $8; water-closet or bath-tub, $4; each additional, $2; offices, $2; stores, $4. *Stables.* — One horse, $4; each additional, $2; cow, $2. Steam engines, per horse-power, $5.	Gravity,	-	Partly by sewers, etc.	-	-	-
Northampton Water Works,	Dwellings, $5 to $7, according to value; bath-tubs, $2; water-closets, $2; each additional, $1; hopper-closets, four times the above rates; private hydrants, $3 to $5; markets, stores, bakeries, restaurants, etc., $7 to $10. *Private Stables.* — Each horse, $2; each additional, $1; sheep, per 100, $6. Tobacco lands, per acre, $1. *Measured Water.* — 1,000 gals., 15 to 20 cts., according to quantity. Fire hydrants, at private expense, free.	Gravity,	Debt, $200,000. Sinking fund, $5,875.	Drains, absorption and sewers.	Mill river and Connecticut river.	-	-
South Hadley Falls Water Works.	One family, $8; markets and provision stores, $10; bath-tubs and closets, $2; garden hydrants, $3 to $5; one horse, $2; each additional horse, $1; sheep, per 100, $4; building purposes, 10 cts., one cask of lime; fire hydrants, free.	Gravity,	$40,000. Sinking fund, $2,500.	Cesspools and sewers.	Connecticut river.	-	-

Reports of Water Boards, Commissioners, &c. — Continued.

MIDDLESEX COUNTY.

1.	2.	3.	4.	5.	6.	7.	8.
Arlington Water Works, .	Sucker brook in East Lexington.	Reservoir, 31 acres.	$4\frac{1}{2}$ square miles.	Gravelly soil, hilly country.	No estimate, .	No estimate, .	No.
Cambridge Water Works, .	Fresh pond, Little pond and Wellington brook in Cambridge and Belmont.	Fresh pond, 185 acres; Little pond, 19 acres.	Fresh pond, 500 acres; Little pond and Wellington br'k, 1,200 acres.	Highly cultivated farming land.	Fresh pond, 1,700,000 gallons.	-	-
Concord Water Works, . .	Sandy pond in Lincoln, . .	152 acres, .	456 acres, including water surface.	Rocky woodland, including but little cultivated land	425,000 gals., .	425,000, $1\frac{1}{2}$ yrs. supply, or 230,000,000 gallons are	Is a part of the water-shed of Charles river.

				and two or three houses.		stored above conduit and below mean water level. At certain seasons there is no overflow from the pond.	
Everett,*	-	-	-	-	-	-	-
Lincoln Water Works,†	Sandy pond in Lincoln,	152 acres,	300 acres or more.	-	-	-	-
Lowell Water Works,	Merrimac river,	-	-	-	-	2,629,950 gals.,	-
Malden Water Works,	Spot pond in Stoneham,	296 acres,	1,100 acres,	Woody and hilly; granite foundation.	-	-	-
Medford Water Works,	Spot pond in Stoneham,	See Malden,	1,100 acres,	Woody and hilly; granite foundation.	-	-	-

* Supplied by city of Boston.

† Water-works conducted at expense of the takers as a mutual benefit association. No figures given.

Reports of Water Boards, Commissioners, &c. — Continued.

MIDDLESEX COUNTY — CONTINUED.

1.	2.	3.	4.	5.	6.	7.	8.
MELROSE WATER WORKS,	Spot pond in Stoneham,	See Malden,	1,100 acres,	Woody and hilly; granite foundation.	No estimate,	– –	– –
NATICK WATER CO.,	Dug pond in Natick,	60 acres,	– –	– –	– –	– –	– –
NEWTON WATER WORKS,	Open filter basin parallel to and 50 feet from Charles river.	112,226 square feet.	No estimate,	Sand and gravel, slopes toward the river valley.	2,000,000 gals.,	1,200,000 to 1,500,000.	This watershed supplies water to Milford, Dedham, Brookline and Waltham.
SOMERVILLE — MYSTIC WATER WORKS.*	Mystic Lake in Medford, Arlington and Winchester.	Replies by	city of	Boston.	– –	– –	– –

WALTHAM WATER WORKS, . .	Filter basin on bank of Charles river.	Basin about ¼ acre.	No estimate, .	- -	No estimate, .	No estimate, .	Largely.
WINCHESTER—HIGHLAND WATER WORKS.	Artificial reservoir by a dam, .	60 acres, . .	450 acres, .	Rough, rocky ground; surface undulating.	350,000 gals., .	75,000 gals., .	No.
WOBURN WATER WORKS, . .	Filtering well on border of Horn pond; also water of pond if necessary.	Area of well, 984 sq. feet; pond, 103 acres.	4,700 acres, .	Uneven and hilly surface.	Capacity of well, 1,250,000 gals. No water as yet drawn from pond.	- -	Winter pond, Wedge p'nd and Mystic pond.
WAYLAND WATER WORKS, . .	Snake brook, a tributary of Lake Cochituate. Filtering gallery 10 feet of gravel.	13 acres, . .	No record, .	No record, .	100,000 gals., .	25,000 gals., .	Part of the water-shed of Lake Cochituate.

* Water is supplied to Somerville from the Mystic Works of the city of Boston. All pipes are owned by Somerville, and are connected with the 24-inch and 30-inch supply mains of Boston, which pass through Somerville.

Reports of Water Boards, Commissioners, &c. — Continued.

MIDDLESEX COUNTY — CONTINUED.

1.	9.	10.	11.	12.	13.	14.
ARLINGTON WATER WORKS,	No,	None available,	None, except East Lexington drainage.	No record kept,	No,	$305,949.74; water rights, $79,241,37.
CAMBRIDGE WATER WORKS,	-	Doubtful,	Drainage of Belmont. Overflow of Cider Mill brook. Niles' slaughter-house and increase of population on water-shed of the pond.	Prof. E. S. Wood, 1881,	No,	$1,745,614.47.
CONCORD WATER WORKS,	Town of Lincoln.	Nagog pond, in Littleton and Acton.	Two dwelling-houses on the water-shed; bathing.	By Prof. C. A. Goessmann, Amherst, Mass	-	$72,197.67; land damages, $4,570.

EVERETT,*	-	-	-	-	-	-
LINCOLN WATER WORKS,†	By Concord,	-	-	-	Yes. Black bass, by town of Lincoln.	-
LOWELL WATER WORKS,	Lawrence and other cities.	-	-	W. P. Atwood, 1883,	-	$3,391,749.61.
MALDEN WATER WORKS,	Melrose and Medford.	-	None,	S. D. Hayes, 1879. Total solids four grains per gallon. Ammonia and chlorides small.	Black bass, by town of Stoneham.	$362,101.53; water rights, $34,156.24.
MEDFORD WATER WORKS,	Malden and Melrose.	-	-	S. D. Hayes, 1879. Total solids four grains per gallon. Ammonia and chlorides small.	-	$294,473.10; damages, $33,171.25.

* Supplied by city of Boston.

† Water works conducted at expense of the takers as a mutual benefit association. No figures given.

Reports of Water Boards, Commissioners, &c. — Continued.

MIDDLESEX COUNTY — CONTINUED.

1.	9.	10.	11.	12.	13.	14.
MELROSE WATER WORKS,	Malden and Medford.	-	-	J. R. Nichols, 1871. No record given.	-	$181,706.02; water rights about $100,000, divided about equally between Malden, Medford and Melrose.
NATICK WATER CO.,	-	-	-	-	-	Damages, $20,000.
NEWTON WATER WORKS,	See No. 8,	Supply inexhaustible,	Drainage of a skin washing factory, and two hotels.	Arthur Hudson, Aug., 1882.	No,	$911,189.65; water rights, $25,000.
SOMERVILLE — MYSTIC WATER WORKS.*	-	-	Drainage of Winchester, Woburn and Stoneham.	-	-	$342,608.76 for street mains.

WALTHAM WATER WORKS, . .	By Dedham, Brookline and Newton.	- - -	Sewage from towns above, especially mills and residences.	Prof. W. R. Nichols; no figures.	No, . . .	- - -
WINCHESTER—HIGHLAND WATER WORKS.	No, . . .	No,.	None, . .	Prof. W. R. Nichols, 1880.	Black bass, by town.	- - -
WOBURN WATER WORKS, . .	No, . . -	No,.	No danger to the well; much to the pond from tanneries.	Prof. C. T. Jackson, 1873.	Horn pond stocked.	$528,036.79.
WAYLAND WATER WORKS, . .	- -	- - -	- -	By Prof. W. R. Nichols. No record given.	None, . .	Cost of works, $30,-000; damages and rights, $2,680.

* Water is supplied to Somerville from the Mystic Works of the city of Boston. All pipes are owned by Somerville, and are connected with the 24-inch and 30-inch supply mains of Boston, which pass through Somerville.

Reports of Water Boards, Commissioners, &c. — Continued.

MIDDLESEX COUNTY — CONTINUED.

1.	15.	16.	17.	18.	19.	20.	21.	22.
ARLINGTON WATER WORKS,	Probably no estimate,	East Lexington, a little.	Small,	No apparent results.	No estimate,	No estimate,	No estimate,	- -
CAMBRIDGE WATER WORKS,	No,	Town of Belmont slightly.	- -	- -	2,474,616 gallons,	70 p. c.,	154 gallons,	- -
CONCORD WATER WORKS,	No,	No,	- -	- -	125,000 gallons,	80 per cent.,	- -	From 50,000 to 150,000 gallons.

EVERETT,*	- - -	- -	- -	- -	- - -	- -	- -	- -
LINCOLN WATER WORKS,†	- - -	No,	- -	- -	- - -	- -	- -	- -
LOWELL WATER WORKS,	- - -	- -	- -	- -	2,622,615 gallons,	- -	202 gallons,	- -
MALDEN WATER WORKS,	- - -	- -	- -	- -	No estimate,	- -	- -	- -
MEDFORD WATER WORKS,	- - -	- -	- -	- -	No estimate,	- -	- -	-

* Supplied by city of Boston.

† Water works conducted at expense of the takers as a mutual benefit association. No figures given.

Reports of Water Boards, Commissioners, &c. — Continued.

MIDDLESEX COUNTY — Continued.

1.	15.	16.	17.	18.	19.	20.	21.	22.
Melrose Water Works, . .	Storage capacity regulated by law. Could be increased. No estimate made.	- -	- -	- -	1,076 water takers, No estimate of quantity.	80 p. c., .	75 gallons, .	50 families,
Natick Water Co., . . .	Lake Cochituate. No damage.	- -	- -	- -	6,000 gallons, .	3-4ths, .	50 gallons per capita.	50 families,
Newton Water Works, . .	- - -	- -	- -	- -	600,000 gallons, .	- -	35½ gals. per capita.	Same as last year.
Somerville — Mystic Water Works.*	- - -	Sewage of certain factories and dwellings.	- -	- -	- - -	- -	- -	- -

WALTHAM WATER WORKS, . .	- - -	Towns above have no public sewers.	- -	Not appreciable.	553,700 gals., .	90-95 per ct.,	- -	15,000,000 gals. for the year.
WINCHESTER—HIGHLAND WATER WORKS.	- - -	- -	- -	- -	About 150,000 gals.,	- -	- -	Slight increase.
WOBURN WATER WORKS, . .	Could be increased at cost of $5,000. No estimate of damages.	- -	- -	- -	824,349 gals., .	85 per cent.,	325 gallons,	5 per cent.
WAYLAND WATER WORKS, . .	At small expense, . .	No, . .	- -	- -	25,000 gals., . .	75 per cent.,	- -	3 per cent.

* Water is supplied to Somerville from the Mystic Works of the City of Boston. All pipes are owed by Somerville, and are connected with the 24-inch and 30-inch supply mains of Boston, which pass through Somerville.

Reports of Water Boards, Commissioners, &c. — Continued.

MIDDLESEX COUNTY — CONTINUED.

1.	23.	24.	25.	26.	27.	28.	29.
ARLINGTON WATER WORKS,	One faucet, $5; each additional, $2; bath-tub or water closet, $5; each additional, $3; for two faucets, one hot and one cold, in one basin, one charge only. *Boarding-Houses.* — One faucet, $10; each additional, $2; bath-tub or closet, $10; each additional, $3; stores, offices, etc., one faucet, $5; markets, saloons, etc., $5 to $25. *Hotels.* — Each bed, $3. *Stables.* — One horse, $5; each additional, $4; cask of lime, 6 cts.	Gravity,	$300,000,	-	Mystic pond and Mystic river.	-	-
CAMBRIDGE WATER WORKS,	*Dwelling-Houses.* — One faucet, $5; each additional, $2.50; bath-tub, $6; each additional, $4; water-closet, $6; each additional, $2; hopper-closet, without self-regulating faucet, $10. *Boarding-Houses.* — One faucet, $10; each additional, $3; markets, saloons, etc., $6 to $25; *Hotels.* — Each bed, $3.50 *Private Stables.* — One horse, $5; each additional, $3. *Measured Water.* — 1,000 gallons, 20 cents.	Stand pipes. Direct pumping and reservoirs.	Debt, $1,478,500; sinking fund, $483,437.81.	-	-	-	-
CONCORD WATER WORKS,	-	Gravity,	Debt, $66,500; sinking fund, $2,800.	Cesspools, etc.	Concord and Merrimac rivers.	Protection needed from private dwellings near	Tight cesspools to be built by owners

						margin of pond.	of said houses, and contents properly disposed of.
Everett,*	– – –	– –	Debt, $100,000; sinking fund, $14,000.	– –	– –	– –	– –
Lincoln Water Works,†	– – –	Pumping,	– –	– –	– –	– –	– –
Lowell Water Works,	– – –	Reservoir,	Debt, $1,875,000; sinking fund, $356,459.52.	Sewers and drains.	Merrimac and Concord rivers.	– –	– –
Malden Water Works,	– – –	Gravity,	Sinking fund, $42,635.48.	– –	Malden river,	– –	– –
Medford Water Works,	One family, $4; also a tax of $1 on each $1,000 valuation; water-closet or bath-tub, $5. *Boarding-Houses.* — Additional and family rates, $4. *Hotels.* — Each bed, $3; stores, shops, offices, etc., $5 to $30. *Private Stables.* — One horse, $5; one cow, $2; each additional cow, $1. *Measured Water.* — Per 1,000 gallons, 20 to 40 cts.	Gravity,	Sinking fund, $33,729.38.	– –	– –	– –	– –

* Supplied by city of Boston.

† Water works conducted at expense of takers as a mutual benefit association. No figures given.

Reports of Water Boards, Commissioners, &c. — Continued.

MIDDLESEX COUNTY — CONCLUDED.

1.	23.	24.	25.	26.	27.	28.	29.
MELROSE WATER WORKS,	One faucet, $6; each additional, $2; water-closet, $5; each additional, $3.	Gravity,	Debt, $150,000; sinking fund, $11,906.56.	-	Malden river,	Laws to prevent bathing in pond.	-
NATICK WATER CO.,	-	Reservoir,	$170,000; sinking fund, $29,000.	-	Lake Cochituate.	-	-
NEWTON WATER WORKS,	One faucet, $6; each additional, $2; bath-tub, $5; each additional, $3; water-closet or urinal, $5; each additional, $3. *Boarding-Houses.* — Same rates as above. *Hotels.* — Each bed, $3; bath-tubs, water-closets and urinals, double rates. *Private Stables* — One horse, $5; each additional, $3; cask of lime, each, 6 cts. *Measured Water.* 100 gallons, $3\frac{1}{2}$ cts; special rates to markets, factories, railroads, etc., etc.	Direct pumping, the surplus going to reservoir.	Debt, $900,000; sinking fund, $103,415.38.	-	Charles river,	Factories and hotels should be obliged to purify their sewage at their own expense.	-
SOMERVILLE — MYSTIC WATER WORKS.*	-	Reservoir,	Debt, $335,000,	-	-	Complete removal, by sewers, of all filth now discharging into the Mystic pond.	-

WALTHAM WATER WORKS, .	One faucet, $6; each additional, $2; bath-tub, $5; each additional, $3; water-closet, $5; each additional, $3; urinal, $2. *Boarding-Houses.*—One faucet, $10; each additional, $2; bath-tub or closet, $10; each additional, $3. Hotels, each bed, $1. Markets, saloons, restaurants, &c., $6-$25. *Private Stables.*—One horse, $5; each additional, $2. Cask of lime, 6 cts. Measured water, 100 gals., 3 cts.	Reservoir and direct pumping.	$340,000, .	Sewers and percolation.	Charles river,	The plan recommended by the Metropolitan sewage commission.	-	-
WINCHESTER—HIGHLAND WATER WORKS.	- - -	Gravity, .	$225,000, .	Cesspools, .	Abajona river,	- -	-	-
WOBURN WATER WORKS, . .	One faucet, $6; each additional, $2; bath-tub or water-closet, $5; each additional, $3. *Boarding-Houses.*—One faucet, $10; each additional, $2. *Public Baths.*—One tub, $10; each additional, $5. *Stables.*—One horse, $5; each additional, $3. Markets and restaurants, $6 and upward. Each cask of lime, 6 cts. Measured water, 100 gallons, 1¼ to 2 cts.	Pump and reservoir.	$466,300; sinking fund, $89,524.16.	Cesspools, .	Horn pond, Wedge pond and Abajona river.	Drainage sh'ld be excluded from Horn p'nd entirely.	-	-
WAYLAND WATER WORKS, . .	$6 per faucet for one family, .	Gravity and pump for increased fire protection.	$29,000, . .	- -	Lake Cochituate.	- -	-	-

* Water is supplied to Somerville from the Mystic Works of the city of Boston. All pipes are owned by Somerville, and are connected with the 24-inch and 30-inch supply mains of Boston, which pass through Somerville.

Reports of Water Boards, Commissioners, &c. — Continued.

1.	2.	3.	4.	5.	6.	7.	8.
NANTUCKET COUNTY.							
Wannacomet Water Co., of Nantucket.	Wannacomet pond, 2 miles west of town.	8 acres, . .	25 acres, .	Sandy soil, with some clay.	Pond is about 18 ft. deep; is about the sea-level, variation of 22 in. in dry and wet weather.	- -	No.
NORFOLK COUNTY.							
Brookline Water Works, .	Filtering gallery, or wells, at Cow bay, in West Roxbury.	Gallery, 3,600 sq. ft.	No survey, .	Coarse gravel, .	2,000,000 gals.,	800,000 gals., .	- -
Dedham Water Co., . . .	Well near Concord river, .	300 sq. ft., .	Underground supply.	- -	400,000 to 500,000 gals.	400,000 to 500,000 gals.	Possibly of Charles river, consisting of springs underground.
PLYMOUTH COUNTY.							
Brockton Water Works, .	Head waters of Salisbury river.	90 acres, .	2 sq. miles, .	Woods and rocky hills.	- -	- -	- -

Hingham Water Co., . . .	Accord pond, in Hingham, South Scituate and Rockland.	98 acres, .	366 acres, .	Disintegrated primitive rock, woodland and pasturage.	600,000 gals., .	- -	- -
Kingston Aqueduct Association.	Cuff's spring, in Kingston, .	- -	- -	- -	10,000 gals., .	- -	- -
Plymouth Water Works, . .	South pond, Boot pond and Pump station pond, in Plymouth.	464 acres in all,	No estimate, .	Sand and gravel with wooded hills.	1,500,000 gals.,	1,000,000 gals.,	No.

Reports of Water Boards, Commissioners, &c. — Concluded.

1.	9.	10.	11.	12.	13.	14.
NANTUCKET COUNTY — Continued.						
Wannacomet Water Co., of Nantucket.	No, . .	Maxcy's pond, half mile south, could be connected by pipe or ditch.	None, . .	No analysis, . . .	Stocked with with bass by Mr. Joy in 1877.	Do not know.
NORFOLK COUNTY — Continued.						
Brookline Water Works, .	- -	- -	- -	No analysis, . . .	No, . . .	$621,530.83; water rights, $23,626.06.
Dedham Water Co., . . .	No, . . .	Buckmaster pond, in West Dedham, 4 miles away, about 30 acres; or Neponset or Charles river can be connected.	No apparent danger.	Prof. E. S. Wood, .	No, . . .	$102,000; no damages.
PLYMOUTH COUNTY — Continued.						
Brockton Water Works, . .	- -	- - -	None, . .	Prof. W. R. Nichols, .	No, . . .	$235,363.91.

HINGHAM WATER CO., . . .	– –	None near this source, .	– –	Prof. W. R. Nichols, 2.05 grains of solid residue per gallon.	Yes; by Hingham, South Scituate and Rockland.	$122,025; water rights, $5,750.
KINGSTON AQUEDUCT ASSOCIATION.	– –	Jones river passes through the town, and could be used. Its water-shed comprises a part of the towns of Kingston, Plympton and Pembroke.	None, . .	Prof. J. F. Babcock; no figures given.	– –	– – –
PLYMOUTH WATER WORKS, .	Overflow used by factories, .	– – –	None, . .	Prof. W. R. Nichols, .	No, . . .	$131,176.22; water rights, $21,684.73, — $152,860.95.

Reports of Water Boards, Commissioners, &c. — Concluded.

NANTUCKET COUNTY — CONTINUED.

1.	15.	16	17.	18.	19.	20.	21.	22.
WANNACOMET WATER CO, OF NANTUCKET.	Storage capacity could be increased, but there would be no water to fill it.	- -	- -	- -	- - -	- -	- -	50 consumers.
NORFOLK COUNTY — CONTINUED.								
BROOKLINE WATER WORKS, .	- - -	- -	- -	- -	59.6 gals. per capita.	- -	- -	- -
DEDHAM WATER CO., . . .	Could be connected with Charles river at slight cost, and without damages.	No.	- -	- -	75,000 gals., . .	2-3ds, .	200 gals., .	1-3d.
PLYMOUTH COUNTY — CONTINUED.								
BROCKTON WATER WORKS, .	Can be doubled; no estimate.	- -	- -	- -	- - -	- -	- -	Double.

Hingham Water Co.,	Yes; no estimate,	-	-	-	-	-	-	-
Kingston Aqueduct Association.	For $1,000,	-	-	-	5,000 gals.,	90 per ct.,	80,	-
Plymouth Water Works,	-	-	-	-	460,000 gals.,	60 per ct.,	190 gals.,	About 3 per cent.

Reports of Water Boards, Commissioners, &c. — Continued.

NANTUCKET COUNTY — CONCLUDED.

1.	23.	24.	25.	26.	27.	28.	29.
WANNACOMET WATER CO., OF NANTUCKET.	- - -	Pump into an iron tank and thence distributing by gravity.	Debt: bonded, $20,000; floating, $7,000, — $27,000. Sinking fund, $1,000.	- -	- -	- -	- -
NORFOLK COUNTY — CONCLUDED.							
BROOKLINE WATER WORKS, .	One faucet, $3; bath-tub, $2.50; water-closet, $2.50.	Pump and reservoirs.	- -	Sewers, . .	Charles river,	- -	- -
DEDHAM WATER CO., . . .	One faucet, $6; each additional, $2; bath-tub or water-closet, $5; each additional, $2. *Boarding-Houses.* — One faucet, $10; one bath-tub, $10; one water-closet, $10. *Private Stable.* — First horse, $5; each additional, $2. Measured water at special rates. Building purposes, each cask of lime, 6 cts.	Pump and stand-pipe.	None, . .	On surface or into cesspools.	Charles and Neponset rivers.	- -	- -
PLYMOUTH COUNTY — CONCLUDED.							
BROCKTON WATER WORKS, .	One faucet, $6; bath-tub, $5; each additional bath-tub, $3; water-closet, $4; each additional water-	Gravity, .	- -	- -	- -	- -	- -

	closet, $2; hopper-closet, $8 *Boarding-Houses.* — One faucet, $10; each additional faucet, $2.50; water-closet, $10; each additional, $3. *Private Stables.* — One horse, $4; each additional horse, $2; cask of lime, 8 cents. Fire hydrants, $25. Measured water, 20 to 30 cts.						
HINGHAM WATER CO., . . .	One family, $8 to $10, according to value of house; bath-tub or water-closet, $4; each additional, $2. *Boarding-Houses.* — Of 12 rooms or less, $15; exceeding 12 rooms, $20; bath-tubs or closets, $6; each additional, $3; offices, stores, etc., $5. *Private Stable.* — One horse, $5; each additional, $1; each cow, 50 cts.; each cask of lime, 5 cts. For town of Hull, 25 per cent. added to above rates.	Gravity, .	None, . .	- -	- -	- -	- -
KINGSTON AQUEDUCT ASSOCIATION.	One dollar per head, including horses and cattle.	Direct pumping.	None, . .	- -	Jones river, .	None, . .	- -
PLYMOUTH WATER WORKS, .	One family, according to value of house, $5 to $11. *Boarding-Houses.* — According to number of rooms, $15 to $30; bath-tubs and water-closets, $2 to $3; meat-markets, $6; fish-markets, $12. *Private Stables.* — One horse, $3; each additional horse, $1.50. For shipping each barrel of water, 12 cts.; cask of lime, 10 cts.; fountains, $3 to $12.	Direct pumping 12 hours a day, and from reservoir the remainder of the day.	Debt, $102,000; sinking-fund, $2,200.	Partly by sewers.	Ocean, . .	- -	- -

Reports of Water Boards, Commissioners, &c. — Continued.

SUFFOLK COUNTY.

1.	2.	3.	4.	5.	6.	7.	8.
Boston Water Works,	Mystic lake in Arlington, Medford and Winchester. Lake Cochituate in Natick, Framingham and Wayland. Sudbury river in Marlboro', Westboro', Upton, Hopkinton, Ashland and Framingham.	Mystic lake, 200 acres; Lake Cochituate, 800 acres; 3 reservoirs on Sudbury river and Farm pond, 700 acres.	Mystic lake, 27 square miles; Lake Cochituate, 19 sq. miles; Sudbury river, 75 sq. miles.	Mystic — rocky in upper part, gravel in valley, with abrupt slopes. Lake Cochituate and Sudbury river — drift formation underlaid by rock, mostly syenite; some abrupt slopes in upper part; large swampy areas in valleys.	Mystic lake, 15,000,000 gals. Lake Cochituate, 16,000,000 gals. Sudbury river, 25,000,000 gals., including effect of present storage.	Mystic lake, 7,000,000 gals. Lake Cochituate, 9,000,000 to 10,000,000 gals. Sudbury river, 20,000,000 gals., including effect of present storage.	The water-shed of Horn pond $7\frac{1}{2}$ sq. miles and of Winchester reservoir, .71 sq. mile, are a part of the Mystic watershed. The water-shed of Dug pond and upper p'rt of Snake brook are a very small part of that of Lake Cochituate.
Chelsea Water Works,*	-	-	-	-	-	-	-

WORCESTER COUNTY.

ATHOL WATER CO., . .	Thousand-acre-meadow brook in Phillipston.	Reservoir, 16 acres.	1 square mile.	Rocky and swampy in some places.	300,000 gals, .	150,000 to 200,000.	No.
CLINTON WATER WORKS (not in operation at date of report).	Wekepeke in Sterling, . .	Reservoir, 2½ acres.	1,400 acres, .	Granite and slate; abrupt hills.	1,000,000 gals.,	300,000 gals., .	- -
FITCHBURG WATER WORKS, . .	Scott reservoir, supplied by Scott brook. Shattuck brook.	Scott reservoir, 36 acres; distributing reservoir, 13 acres.	Scott reservoir, 500 acres; Shattuck brook, 1,060 acres.	Hilly, wooded farming land.	Scott brook, 815,000 gals.; Shattuck brook, 1,660,000 gals.	Scott brook, 100,000 gals; Shattuck brook, 200,000 gals.	No.
GARDNER WATER CO., . . .	Crystal lake, ...	120 acres, .	⅓ square mile,	Rough and stony.	- -	- -	- -

* *Chelsea Water Works.* — The city of Chelsea is supplied with Mystic Lake water by a contract originally made with Charlestown in 1867.

Reports of Water Boards, Commissioners, &c. — Continued.

WORCESTER COUNTY — CONTINUED.

1.	2.	3.	4.	5.	6.	7.	8
LEOMINSTER WATER WORKS, .	Morse brook, Haynes brook, Quarter-of-a-mile brook, Slack brook and Hale brook.	Haynes reservoir, 70 acres; Morse reservoir, 11 acres; distributing reservoir, 5 acres — total, 86 acres.	1,215 acres, .	Hard, rocky, clay and gravelly land, without much swamps, except at Haynes reservoir; surface of ground uneven. High, steep hills, some of solid rock, making a quick watershed.	1,800,000 gals.,	500,000 gals., .	No.
MILFORD WATER CO., . . .	Filtering gallery near Deer brook, and storage reservoir 3 miles above.	90 acres, .	2,500 acres, .	Hilly and rocky.	No record, .	No record, .	No.
NORTHBORO' WATER WORKS, .	South branch of Cold Harbor brook in Shrewsbury, Mass.	Storage reservoir, 9 acres.	1,400 acres, .	Alluvial and drift, boulders and gravel; hills, pastures and woodlands.	2,000,000 gals.,	600,000 gals., .	No, . .
SOUTHBRIDGE WATER SUPPLY Co.	From springs in a valley 100 feet above Main street.	Artificial pond of 5 acres.	25 acres, .	Open land with some forest.	- -	- -	- -

SPENCER WATER CO., . . .	Shaw pond, in Leicester, .	67 acres, .	155 acres, .	Hills of gravel, partially wooded.	350,000 gals., .	- -	No, . . .
UXBRIDGE WATER CO., . .	Reservoirs in Uxbridge, . .	1-8th acre, .	Springs, .	- -	36,000 gals., .	- -	No, . . .
WEBSTER WATER CO., . . .	Lake Chaubunagungamaug, in Webster.	1,280 acres, .	8 or 9 sq. miles.	Range of ills wooded.	- -	- -	- -
WESTBORO' WATER WORKS, .	Sandra mill pond, . . .	50 acres, .	675 acres, .	Soil gravelly, surface hilly, growth of small wood.	1,250,000 gals.,	600,000 gals., .	- -
WORCESTER WATER WORKS, .	Lynde brook, Leicester, Mass.,	153 acres.	1,870 acres, .	Soil clay, with occasional rocky hills; Sbed "quick," a large percentage of rainfall being collected.	About 3,000,000.	Supply brook is dry for about three months of each year.	Entirely used by city.

Reports of Water Boards, Commissioners, &c. — Continued.

SUFFOLK COUNTY — CONTINUED.

1.	9.	10.	11.	12.	13.	14.
BOSTON WATER WORKS,	Woburn and Winchester get water from the water-shed of Mystic lake; Somerville, Chelsea and Everett are supplied from Mystic lake by Boston; Natick pumps water from Dug pond; Wayland takes water from Snake brook; Westboro' takes water from the water-shed of Sudbury river.	Shawsheen river in Lexington, Bedford, Burlington, Wilmington, Billerica, Andover and Tewksbury can be connected with Mystic water-shed by a conduit 5 miles long; water-shed, 34 sq. miles; distant from Boston, 18 miles. Assabet river can be connected with Sudbury river by a conduit several miles long; water-shed depends on the point of connection, about 25 miles from Boston; Charles river can be connected with Sudbury river at So. Natick; water-shed 150 sq. miles; short connection by pipe and pumping, 15 miles from Boston.	Sewerage and manufacturing refuse from adjoining towns.	Numerous analyses by Profs. Nichols, Hosford, Wood, Merrick and Gray. Water soft and wholesome for domestic purposes; amount of organic matter contained generally larger in water from Sudbury river.	Lake Cochituate has been stocked; there is a fish-way at Mystic lake.	Cost of Cochituate Water Works, including Sudbury river works, to May 1, 1882, $16,943,863.37. Cost of Mystic works, $1,634,108.82; water damages on Sudbury river, $543,190.64.
CHELSEA WATER WORKS,*	- -	- - -	- -	- - -	- -	$354,211.

WORCESTER COUNTY — CONTINUED.

ATHOL WATER CO.,	No, . . .	Small streams four miles distant.	Water of reservoir has been bad for three years past.	Yes; no definite statement.	Trout and white dace.	$120,000; water rights $500.
CLINTON WATER WORKS (not in operation at date of report).	- -	Yes, ...	None, . .	No, ...	No, . . .	- - -
FITCHBURG WATER WORKS, . .	No, . . .	Pearl Hill brook, water-shed, 2,200 acres; Meeting House pond in Westminster, area, 1,100 acres.	None, . .	- - -	Overlook reservoir stocked by city with black bass; Scott reservoir with land-locked salmon by private parties.	$434,000; water rights, $5,500.
GARDNER WATER CO., . . .	- -	- - -	None, . .	By State Board of Health.	Black bass, by private parties.	$115,000; water rights not settled.

* *Chelsea Water Works.* — The city of Chelsea is supplied with Mystic Lake water by a contract originally made with Charlestown in 1867.

Reports of Water Boards, Commissioners, &c. — Continued.

WORCESTER COUNTY — CONTINUED.

1.	9.	10.	11.	12.	13	14.
Leominster Water Works, .	No, . . .	One other source where 178 acres of water-shed can be connected by a conduit 80 rods long.	None, . .	Jas. R. Nichols, . .	No, . . .	Cost, $170,973.66; water rights, $20,-001.39.
Milford Water Co., . . .	No, . . .	Other good sources including Mendon and North ponds.	None, . .	No, ...	No, . . .	About $170,000.
Northboro' Water Works, .	No, . . .	Rocky pond in Boylston, $1\frac{1}{2}$ miles from reservoir can be connected; also, Howard brook.	No, . . .	Dr. E. S. Wood; result favorable; no figures.	No, . . .	$58,150; water rights not settled.
Southbridge Water Supply Co.	- -	A lake, about 4 miles distant, could be connected with present reservoir at cost of about $10,000 or $12,000.	- -	No, ...	- -	$17,700; land damage, $587.

SPENCER WATER WORKS,	No,	Whittemore pond of similar extent to Shaw pond.	No,	Walter N. Barnes,	No,	$100,000; damages not settled; works incomplete.
UXBRIDGE WATER CO.,	No,	Other springs,	None,	No,	No,	$12,000; damages unsettled.
WEBSTER WATER CO.,	-	-	-	No record,	Black bass,	$20,000.
WESTBORO' WATER MILLS,	-	Jackstraw brook, ½ mile distant, contains 550 acres of water-shed, and could be connected by an open canal at small expense.	-	H. W. Vaughan, of Providence, R. I., in 1873; no record.	Pickerel,	$60,000; water rights, $8,254.49.
WORCESTER WATER WORKS,	No,	Kettle brook, in Leicester, could be connected with supply with water-shed of 3,500 acres; dividing ridge to be cut by an excavation 800 feet long.	None,	Analysis in 1863; no record.	Black bass and salmon by city and private parties.	$1,352,659.23.

Reports of Water Boards, Commissioners, &c. — Continued.

SUFFOLK COUNTY — CONTINUED.

1.	15.	16.	17.	18.	19.	20.	21.	22.
BOSTON WATER WORKS,	Storage capacity of Mystic water-shed can be increased at a large cost; a large area would be flowed and some small water-powers destroyed. The storage capacity of Sudbury river is to be increased gradually; ultimate cost may be $800,000; damage not estimated.	Yes,	†	‡	From Mystic lake, 6,574,000 gals., including the consumption of Somerville, Chelsea and Everett. Lake Cochituate, 10,778,000 gals. Sudbury river, 21,192,000 gals.	Not known,	Not known,	5 per cent.
CHELSEA WATER WORKS,*	- - -	- -	- -	- -	1,500,000 gals.,	- -	- -	- -

WORCESTER COUNTY — Continued.

Athol Water Co., . . .	Yes; without damage.	No, . .	– –	– –	200,000 gallons, .	– –	– –	None.
Clinton Water Works (not in operation at date of report).	Yes; no estimate.	No, . .	– –	– –	– – –	– –	– –	– –
Fitchburg Water Works, . .	Storage capacity can be increased by three reservoirs at a cost of $165,000; capacity, 500,000,000.	No, . .	– –	– –	– – –	30 p. c., .	415 gallons,	15 p. c.
Gardner Water Co., . . .	No, ...	– –	– –	– –	50,000 gallons, .	– –	– –	50 families.

* *Chelsea Water Works.* — The city of Chelsea is supplied with Mystic Lake water by a contract originally made with Charlestown in 1867.

† Discharge of sewage from several manufacturing establishments, mostly tanneries, into the tributaries of Mystic Lake. A large part of such sewage is conducted by a special sewer below the lake. *Lake Cochituate.* — Discharge of Pegan Brook in Natick, which receives the drainage of a large part of the town; total population of Natick, 8,600; shoe shops and miscellaneous manufactures. *Sudbury River.* — A sewer from the town of Westborough discharges into one of the tributaries; population, 5,300.

‡ In *Sudbury River.* — No apparent result. In *Mystic Lake.* — No apparent result since construction of Mystic Valley sewer. In *Lake Cochituate.* — Evident pollution of that part of the lake which receives the discharge of Pegan Brook.

Reports of Water Boards, Commissioners, &c. — Continued.

WORCESTER COUNTY — CONTINUED.

1.	15.	16.	17.	18.	19.	20.	21.	22.
LEOMINSTER WATER WORKS,	Can be doubled at a cost of $50,000; damage not over $10,000.	No,	- -	- -	Estimated at 800,000 gallons.	50 p. c.,	Estimated at 50 gals.	5 p. c.
MILFORD WATER CO.,	Dam can be raised 5 ft. for $1,000, and increase the capacity 75 per cent.	No,	No,	No,	100,000 gals.,	2-3ds,	No.,	Double.
NORTHBOROUGH WATER WORKS,	Can be doubled for $10,000.	No,	- -	- -	40,000 gallons.	-	200 gallons.	20 per cent.
SOUTHBRIDGE WATER SUPPLY, Co.	- - -	- -	- -	- -	- - -	- -	- -	50 per cent.

Spencer Water Co., . . .	Can be increased 25 per cent. for $10,000.	No, . .	- -	- -	*	*	*	*
Uxbridge Water Co., . . .	Can be increased at small expense.	- -	- -	- -	- -	- -	- -	Double.
Webster Water Co., . . .	- - -	- -	- -	- -	8,000 to 9,000 gals.,	65 per. ct., .	- -	15 per cent.
Westboro' Water Works, .	Doubled at a cost of $15,000 to $20,000, without damages.	- -	- -	- -	200,000 gals , .	50 per ct., .	100 gals., .	10 per cent.
Worcester Water Works, .	No, ...	- -	- -	- -	3,200,000 gals., .	- -	200 gals., .	- -

* Not in use yet.

Reports of Water Boards, Commissioners, &c. — Continued.

SUFFOLK COUNTY — CONCLUDED.

1.	23.	24.	25.	26.	27.	28.	29.
BOSTON WATER WORKS, . .	*Dwelling-Houses.* — Valued at less than $1,000, $6; for every additional $1,000 of valuation up to $25,000, $1; for every family more than one in a house, $2; water-closet or bath-tub, $5. Tenement-Houses, $3; and for each $100 or fraction of $100 rent above $300, 50 cts. *Stores and Offices.* — Sink or bowl, $5; each additional, $2.50; water-closet, $5; water-closet not self-closing, $10. Restaurants, saloons, photographers, &c., &c., according to amount used, $5 to $50. Hotels, each bed, $3. Bakeries, for each daily barrel of flour, per annum, $3. Private stables, $6; each horse over two, $2. Livery stables, each horse, $2. Omnibus stables, each horse, $1.50. Truckmen's stable, each horse, $1.25. Hose, according to area of land, $5 to $50. Cask of lime, 7 cts. Measured water, 100 gallons, 2 to 3 cts.	Mystic supply by gravity and then by pumping. Cochituate and Sudbury river by gravity and high service by pumping.	DEBT. — Cochituate, May 1, 1882, $11,631,273.98; Mystic, $1,127,000. Sinking fund, Cochituate, $2,282,299.86; Mystic, $468,263.51.	The sewers receiving the effluent water discharge their contents into the sea, or into the estuaries of various rivers.	Boston Harbor.	†	‡
CHELSEA WATER WORKS,* . .	- - -	Pump and reservoir.	Chelsea water debt, $200,000.	- -	- -	- -	- -

WORCESTER COUNTY — Continued.

Athol Water Co., . . .	– – –	Gravity, .	$60,000, . .	– –	Miller's river,	– –	– –
Clinton Water Works (not in operation at date of report).	One faucet, $6; each additional, $2; bath-tub or water-closet, $5; each additional, $3. *Boarding-Houses.* — One faucet, $10; each additional, $2.50. Stores, offices, etc., $6 and upward. *Stables.* — One horse, $5; each additional, $2; cask of lime, 6 cts. *Measured Water.* — Per 1,000 gallons, 15 to 25 cts.	Gravity, .	– –	No drainage, .	– –	– –	– –
Fitchburg Water Works, .	One faucet, $6; each additional, $2; bath-tub or water-closet, $5; each additional, $3; hopper-closet, $8. *Boarding-Houses.* — One faucet, $10; each additional, $2.50; stores, offices, etc., $6 and upward. *Stables.* — One horse, $5; each additional, $2; hose for windows, gardens, sidewalks, etc., $5; nozzle to be not over ¼ inch diameter, and time limited to ½ hour morning and evening. Cask of lime, 6 cts. *Measured Water.* — 15 to 25 cts. per 1,000 gallons.	Gravity, .	Debt, $400,000; sinking fund, $71,165.69.	Partly by sewers.	Nashua river,	– –	– –
Gardner Water Co., . . .	– – –	Pump and reservoir.	Debt, $60,000,	– –	Miller's river,	– –	– –

* *Chelsea Water Works.* — The city of Chelsea is supplied with Mystic Lake water by a contract originally made with Charlestown in 1867.

† Legislation enabling the city of Boston to effectually prevent adjoining towns from polluting its sources of supply.

‡ The expense would be large and cannot be estimated till a plan is decided upon. The burden of the expense should generally fall on the towns which are polluting the sources of supply.

Reports of Water Boards, Commissioners, &c. — Concluded.

WORCESTER COUNTY — CONCLUDED.

1.	23.	24.	25.	26.	27.	28.	29.
LEOMINSTER WATER WORKS,	One faucet, $6; each additional, $2; bath-tub or water-closet, $5; each additional, $2; stores, offices, etc., $6 and upwards. *Stables.* — One horse, $4; each additional, $2; cask of lime, 6 cts. *Measured Water.* — Per 1,000 gallons, 25 cts.	Gravity,	Debt, $150,000; no sinking fund.	By surface drainage, and partly by sewers.	Nashua river,	- -	- -
MILFORD WATER CO.,	- - - -	Direct pumping.	Debt, $60,000; Sinking fund, $1,000.	A few sewers, but no general system as yet.	Charles river,	- -	- -
NORTHBOROUGH WATER WORKS,	- - - -	Gravity,	Works incomplete and figures not given.	Cesspools and drains.	Assabet river,	- -	- -
SOUTHBRIDGE WATER SUPPLY CO.	One faucet, $6; each additional, $1; bath-tub, $3; each additional, $2; water-closet, $4; each additional, $2; hopper-closet, $6. *Boarding-Houses.* — One faucet, $8; each additional, $2. *Stables.* — One horse, $4; each	Gravity,	- -	- -	Quinabog river.	- -	- -

	additional, $2; cask of lime, 6 cts.; markets, shops and saloons, $4 to $50; fountains, $3 to $8.						
SPENCER WATER CO, . . .	Family $8; bath-tub, $3; water-closet, $3; stores and markets, $5 to $12. *Stables.*—One horse, $3; one cow, $2; Cask of lime, 5 cts. Measured water, per 1,000 gals., 30 cts.	Gravity, .	- -	- -	Seven Mile river.	- -	- -
UXBRIDGE WATER CO., . . .	From $6 to $24 per year, . .	Gravity, .	- -	- -	Mumford river.	- -	- -
WEBSTER WATER CO., . . .	- - - -	Reservoir, .	None, .	- -	French river,	- -	- -
WESTBORO' WATER WORKS, .	- - - -	Gravity, .	- -	- -	Sudbury river,	- -	- -
WORCESTER WATER WORKS, .	- - - -	Gravity, .	Revenue pays interest of debt; debt not stated.	Sewers, . .	Blackstone river.	- -	- -

RECAPITULATION.

1. With very few exceptions, companies and water boards have derived their names directly from the cities or towns in which they are located. This custom has the obvious advantage of fixing upon each organization a definite local status, which, in the matter of financial standing, has a decided advantage. One company has found it of sufficient importance to obtain a special act of legislature, whereby its name is changed from its ancient Indian title to that of the town in which the company is located.

Forty-four boards, so far as can be ascertained, are chosen by cities and towns as supervisors of their public water-supplies. The remaining twenty-seven organizations are private corporations mostly chartered under State laws.

Under existing laws many of these companies are empowered to transfer their rights to the various municipalities in which they are located, and hence the number of private companies will be lessened in the future.

2. The sources from which water-supplies are derived in Massachusetts may be classified as follows:

(*a.*) *Lakes, and large ponds or reservoirs, either natural or artificial.*—There are thirty-nine cities and towns using such sources for water-supply. Fortunately the Commonwealth is well supplied with ponds or lakes, quite uniformly distributed, a catalogue of which may be found in the Fourth Annual Report of the State Board of Health, p. 117.

In several instances artificial reservoirs have been made by constructing dams across small streams, either in meadows or in rocky gorges, as at Winchester, Arlington, Milford, and at Birch Pond Brook in Lynn. In some instances the area of natural ponds has been largely increased by dams, as at the Upper Mystic Lake of the Boston supply.

The water-supply of Boston belongs both to this class and to the following, its supply being derived in part from natural ponds and also from the Sudbury River by way of storage reservoirs.

(*b.*) *Rivers.* — Although several cities and towns having water-supplies are situated directly upon the banks of the two large rivers, the Connecticut and Merrimac, yet in one case only does a city or town take its entire supply directly from the river. The cities and towns along the banks of the Connecticut are nearly all supplied by gravitation, and obtain their water from elevated sources among the hills.

Two cities upon the Merrimac use the water of the river, partially through filtering galleries having direct connections with the river, which can be opened in cases of emergency.

(*c.*) *Brooks, springs, or small mountain streams not liable to pollution.* — Twenty cities or towns obtain their water from sources of this character, and with one exception the water thus supplied appears to be of excellent quality. In consequence of elevated source and remoteness from habitations they are not liable to contamination at present. Fourteen of these water-supplies are west of the Connecticut River.

(*d.*) *Filtering Galleries.* — Nine water-supplies, including the two named in class (*b.*), are furnished through the medium of filtering galleries, or wells, usually constructed along the banks of some stream or river, with an intervening bank of gravel or other filtering medium of variable thickness. One such filtering well is constructed upon the bank of a pond, whose waters are excessively foul from the sewage of several tanning establishments. The water, however, as received from the well is of unusual purity, the claim having been established, that the water of the well comes from the neighboring hill and not from the pond. A direct pipe leads to the pond, for use in case of necessity, but has never been used since its construction, ten years since.

(*e.*) In two towns the supply is obtained from tubular wells driven into the ground. These have thus far proved adequate to the demand made upon them for a sufficient supply of good water. The city of Lynn also derives a portion of its supply from a similar source.

3. The areas of water-sources may be found by reference to the tables. The supply of Fall River has the largest water-surface in the State, 5.43 square miles. The total area of Boston's supplies amounts to 1,700 acres, and that of

the town of Webster 1,280 acres. At the other extreme, some of the mountain springs used by the villages of Western Massachusetts have an area of but a few square feet.

4. The area of water-sheds also presents a wide range of variation in extent. The largest (that of the Merrimac River) includes one-third of the territory of New Hampshire, some 4,136 square miles. The smallest reported, that of Nantucket, a water-shed entirely of drift or alluvium, is estimated at 25 acres.

The tubular wells can hardly be said to have a water-shed, since they are not materially affected by extent of rainfall.

5. The location of water-sources, with their water-sheds, in the Western counties, especially in Berkshire, is much higher than the general level of the towns and villages supplied, and hence quite free from the ordinary sources of water-pollution. The water-sheds in that section of the State are mainly forest lands, underlaid with rocky foundation, the higher slopes being mostly uninhabited and uncultivated.

In the middle and especially in the Eastern counties the water-sheds are to a greater extent inhabited and also cultivated, and not unfrequently subjected to decidedly objectionable sources of pollution.

In Barnstable County, there are as yet no water-supplies, either public or private, the want of elevated sources rendering a supply by gravitation impossible for any town.

6 and 7. The estimated capacity of sources, by daily average flow, and by minimum flow may be ascertained by reference to the tables. The capacity of the Merrimac River is estimated at Lawrence as thirty-eight billions of gallons per day. That of the town of Kingston is ten thousand gallons. The minimum capacity is not so fully stated in the returns, but has a similarly wide range of variation.

8. The replies to question eight are mainly in the negative; the chief exceptions being the water-sheds of the Boston supply, that of the town of Woburn, and those of cities and towns upon the banks of the Charles River.

9. Water-sources are used jointly as supplies only in the more densely populated portions of the State. The city of Boston supplies several of its suburban cities and towns.

Lynn furnishes water to Swampscott and East Saugus. Salem supplies the town of Beverly. The towns of Medford and Melrose and the city of Malden are fortunate in obtaining a joint supply of good water by gravitation.

10. *Other available Sources of Supply.* — Massachusetts, as already shown in previous reports of the State Board of Health, has a multitude of lakes and ponds still unused for water-supply. Some have an area of several thousand acres, as in the great ponds of Middleborough.

A few returns have indicated such other available sources as are within a convenient distance of their present water-works.

11. Fortunately, the elevation of most of the water-supplies above the level of towns and villages, as well as their remoteness from them, gives them an immunity from pollution, either from dwellings or manufactories. The larger cities, and especially Boston, are constantly threatened with danger, to prevent which, more efficient legislation is imperative. In the case of one town having a water-supply for a portion of its inhabitants (Turner's Falls), the public sewers have their outlets into a marsh which has direct communication with the Connecticut River at a point a few rods only above the inlet pipe of the public water-supply.

12. Analyses of the water of the principal water-supplies have been frequently made, and in a few instances, when not stated in the returns, we have quoted such recent records as could be obtained in the files of this office.

In future triennial returns of this nature, the work would be simplified for the purpose of comparison, by a requirement that all chemists or analysts should conform to a standard form of analysis to be adopted by the Board.

It is especially desirable that the old, variable and inaccurate term "gallon" should give place to the more accurate and universally adopted form "parts per 100,000."

REPORTS OF WATER BOARDS, COMMISSIONERS, &c.

WATER ANALYSIS (IN PARTS PER 100,000.)

No.	LOCALITY.	Date of Collection and Analysis,	UNFILTERED.		FILTERED.		Chlorine.	RESIDUE.			Nitrates.	Hardness.	Remarks.
			Ammo.	Alb. Ammo.	Ammo.	Alb. Ammo.		Fixed.	Volatile.	Total.			
1	Taunton, filtering basin, .	1878,	.0088	.0099	–	–	–	3.80	1.80	5.60	–	–	Prof. W. R. Nichols.
2	Lawrence, above dam, . .	1877,	.0044	.0102	–	–	0.19	2.41	1.69	4.09	–	–	Prof. W. R. Nichols, average of 12 samples.
3	Lynn, Breed's pond, . .	– –	.006	.016	–	–	.49	2 88	.80	3.68	–	–	Prof. W. R. Nichols.
4	Lynn, Birch pond, . . .	– –	.007	.077	–	–	.75	4.16	6.16	10.32	–	–	– – –
5	Springfield Water Works, .	Sept.,1878,	0.0376	0.0795	0.0376	0.0326	–	4 12	4.24	8.36	–	–	Prof. W. R. Nichols.
6	Springfield Water Works, .	Nov , 1878,	0.0061	0.0323	0.0061	0.0317	–	2 04	2 76	4.80	–	–	– – –
7	Cambridge, Fresh pond, .	Aug., 1879,	.0010	0150	–	–	–	8.00	3.50	11.50	–	–	– – –
8	Cambridge, Little pond, .	Mar., 1879,	.0133	.0900	–	–	1.20	4 25	5.25	9.50	–	2½	Prof. S. P. Sharples.
9	Newton, ...	Aug., 1882,	.0026	.006	–	–	0.7	–	–	10.	–	3	A. Hudson.
10	Lowell, ...	1883,	.0033	.0110	–	–	–	–	–	–	–	–	W. P. Atwood.
11	Dedham, ...	– –	.0005	.0054	–	–	1.	8.80	1.60	10 40	–	2½	Prof. E. S. Wood.
12	Brockton, Salisbury brook, .	– –	.0030	.0104	–	–	.15	.66	1.41	2.07	–	–	Prof. W. R. Nichols.
13	Plymouth, Smith pond, . .	– –	.0077	.0171	–	–	.73	1.60	1.40	3 00	–	–	Prof. W. R. Nichols.
14	Plymouth, Pump Station pond,	– –	.0013	.0107	–	–	.80	1.56	1.00	2 56	–	–	– – –
15	Gardner, east shore of lake, .	– –	.0011	.0130	–	–	.20	1.60	1.00	2.60	–	½	State Board of Health.

16	Gardner, lower part of lake, .	– –	.0035	.0114	–	–	.18	4 80	4.30	9.10	–	1	State Board of Health.
17	Winchester, ...	1880,	.017	.009	–	–	.39	–	–	4.96	.003	–	Prof. W. R. Nichols.

(GRAINS PER GALLON.)

1	Attleboro' Water Works, .	July, 1875,	–	–	–	–	–	1.40	2.80	4 20	None.	–	Prof. Vaughan.
2	Fall River, Watuppa lakes, .	1870,	–	–	–	–	–	.96	.84	1.80	–	20.	Traces of chloride of sodium and sulphate of iron; no nitrates; no ammonia. Prof. Appleton.
3	New Bedford Water Works, .	– –	.0115	.0243	–	–	0.83	2.08	2.80	4.88	–	0.27	Hardness in equivalents of carbonate of lime. Prof. W. R. Nichols.
4	Newburyport Water Works, .	– –	.003	.0623	–	–	0.405	5.83	1.51	7.34	–	–	– – –
5	Westfield Water Works, .	July, 1874,	–	–	–	–	–	1.51	.23	1.74	–	–	– – –
6	Lowell Water Works, . .	– –	–	–	–	–	0,13	–	–	2.91	–	–	W. P. Atwood.
7	Woburn Water Works, . .	1873,	–	–	–	–	–	3 2	0.8	4.	–	–	Prof. C. T. Jackson.
8	Brookline Water Works, .	Oct., 1874,	–	–	–	–	–	2.33	0.35	2.68	–	0.58	Prof. W. R. Nichols.
9	Fitchburg Water Works, .	1873,	–	–	–	–	–	1.11	1.29	2.40	–	–	Prof. Jabez Fisher.
10	Leominster Water Works, .	– –	–	–	–	–	–	1.51	.87	2.58	–	–	Prof. J. R. Nichols.
11	Worcester Water Works, .	Dec., 1860,	–	–	–	–	–	1.57	.50	2.07	–	–	Prof. C. T. Jackson.

Reports of Water Boards Commissioners, &c. — Concluded.

WATER ANALYSIS (FRANKLAND'S METHOD)

[See Report of State Board of Health, Lunacy and Charity, 1880. Supplement on Public Health.]

No.	LOCALITY	Date of Collection and Analysis.	Ammonia.	Albuminoid Ammonia.	Organic Carbon.	Organic Nitrogen.	Sum of Organic Elements.	Ratio of Carbon to Nitrogen.	Total Solid Residue.
1	Boston Water, Mystic supply, mean of 39 samples, .	June, 1879, May, 1880, .	.012	.018	.392	.065	.457	6.	9.9
2	Boston Water, Cochituate, mean of 42 samples, .	June, 1879, May, 1880, .	-	-	.452	.051	.503	8.9	-
3	Winchester, ...	1880, . . .	-	-	.297	.034	.331	8.7	-

13. *Stocking of Water-Sources with Fish.* — Fifty-one returns give either a negative reply, or omit any reference to the subject. Twenty returns give an affirmative answer, and of this number, fourteen state the species of fish introduced, as follows: —

Black bass only	6
Bass and land-locked salmon	2
Land-locked salmon	1
German carp	1
Trout and white dace	1
Trout	2
Pickerel	1
Fish introduced but not specified	6

14 and 25. For the sake of convenience of comparison, these two series of replies are considered together.

Fifty-nine companies and boards, including those of all the largest cities and towns, give a total sum paid, as the cost of works, of $41,733,628.25; of which sum $950,818.76 was paid for water-rights, and land damages.

The same companies (except a very few whose debt could not be exactly estimated in consequence of incompleteness of works) return the sum of $27,435,573.98 as the total amount of their water debt, and $4,630,659.06 as the amount of their sinking funds.

15. *Capacity for Storage Increase.* — Forty-seven returns report a capacity for increase of storage, from a small increase up to double the present capacity, and at various estimates as to total cost from $300 to $800,000, the latter by the city of Boston.

Various schemes have been proposed to increase the storage capacity of the Boston supplies, and for present relief a large basin is being constructed on Cold Spring Brook in Ashland, with an estimated area of 270 acres, and a storage capacity of over one billion gallons, at a cost of about $700,000.

The remaining cities and towns give a negative reply to this question, or no answer.

16. *Discharge of Sewers or Drains into the Water-Sources of Parties making returns.* — Fifty-seven returns give a negative answer, or no answer. The remaining reply

in the affirmative, all being located in Eastern Massachusetts.

In the case of Lowell, the offending parties are all the cities and towns upon the Merrimac River above Lowell, and in the case of Lawrence the same cities and towns with the addition of Lowell.

The supply of Arlington receives the sewage to a slight extent of East Lexington. The supply of Cambridge receives that of Belmont. The supplies of Boston, Chelsea, Somerville and Everett are still polluted by sewage from the towns of Woburn, Winchester, Natick, Westborough, Ashland and Framingham. The supplies of the lower cities and towns along the Charles River are polluted by those at higher points upon the same stream.

17. *Population and Character of Manufactures of Towns polluting Sources.* — This question is answered by three parties only, replies not being necessary in the majority of cases. The population above Lawrence amounts to about 110,000, and the manufactures mainly those of cotton and woollen manufacture. The population of the towns polluting the supplies of the city of Boston number about 40,000, and the character of manufactures mainly those of tanning and of shoe manufacture.

18. *Apparent Results of Sewage.* — Replies are given by four parties only: Lawrence, Arlington, Waltham and Boston. Lawrence states, "Slight traces detected at Lawrence." Arlington replies, "No apparent results." Waltham replies, "Results not appreciable." Boston replies, "In Sudbury River and in Mystic Lake no apparent results at present." In Lake Cochituate, "Evident pollution of that part near the Pegan Brook outlet."

19. *The average Daily Consumption of Cities and Towns supplied.* — Replies are received from forty cities and towns, including all the larger cities, and giving a total of 69,139,435 gallons supplied daily to a population of 1,107,977 inhabitants, — an average per capita of 62.+ gallons to the population supplied. The average per capita to actual consumers or water-takers is larger, especially in small towns and places where the water-supply has been introduced for a short time only.

20. *The per centum of Water used by Families.* — Replies are given in twenty-seven returns, and range from thirty to ninety-eight per cent. The percentage used by families is usually high in agricultural and also in suburban communities, and low in manufacturing cities and towns.

21. *The average Consumption per Family per diem.*— This item also presents a wide range of variation, fifty gallons being the lowest amount reported per family, and eight hundred the largest. Replies were received in twenty-seven returns. The excessive amount of water used by families to whom it is supplied by gravitation is a matter of trivial consequence; but, in our large cities, to whose inhabitants the question of additional sources of water-supply is a constantly recurring and troublesome one, the prevention of waste is an imperative duty, and one which demands immediate and continuous attention.

22. *Estimated Increase of Demand required for the next year.* — Replies received in thirty-one returns. No answer in the remainder. Estimates vary from nothing to one hundred per cent., the largest increase estimated being chiefly in the case of new companies; while in the large cities, and in long-established water-supplies, a tolerably uniform increase of from five to ten per cent. annually is anticipated.

23. *Water-Rates.* — Schedules of water-rates have been received from forty-four returns. No answer from the remainder. Some of the smaller companies have no schedules of rates,.but simply charge a certain sum for each family, without regard to the number of its individual members, or to the number of faucets or other water-fixtures. Items relating to the principal sorts of fixtures only have been copied into the tables. The places and fixtures specified in the returns are mainly dwelling-houses, boarding-houses, hotels, restaurants, saloons, offices, stores, manufactories, fish and provision markets, railroad stations, private stables, livery, boarding and club stables, horse-car and omnibus stables, truck and team stables, bakeries, barber-shops, photograph-rooms, drug-stores, green-houses. Faucets: bath-tubs, water-closets (pan, hopper and self-closing or self-regulating), urinals, hose for washing carriages, watering streets

and gardens, fire-hydrants. Special rates are also made for each horse, cow, ox, or sheep (the latter per 100). Some companies furnish water according to the valuation of houses supplied. Measured water is furnished by supplies, especially in the cities and large towns, at variable rates, at from two and a half to fifty cents per 1,000 gallons, according to the amount used. As a matter pertaining to public health, the custom of offering a premium to the old and filthy style of water-closet fixture, known as the pan-closet, by means of a cheaper rate, is decidedly objectionable. Wherever any distinction is made, as a matter of economy in the use of water, this objection may be easily overcome by the use of the words, "water-closet, with self-regulating or self-closing fixture," in the schedule of water-rates.

24. *System of Distribution.* — Thirty-four returns report a water-supply by gravitation.

By a reservoir system,	12
By direct pumping,	4
By reservoir and direct pumping,	5
By a stand-pipe and pump,	2
By a stand-pipe, direct pumping and reservoir,	2
By gravitation and by pumping (the latter for high service only),	5

25. See Question 14.

26. *Disposition of Effluent Water.* — A few returns have evidently misconstrued the word *effluent* and applied it to the waste water flowing away from water-sources. Understanding it in its technical sense and applying it to the water after its use by the inhabitants of a city or town, in other words the water contaminated by sewage, a majority of the returns have replied as follows: —

Effluent water disposed of through sewers, in cities and towns, (These are mainly the largest cities of the Commonwealth.)	10
By sewers and cesspools,	16
By surface drainage, percolation and other means,	3
No sewers or drainage,	2
Wrong or doubtful answer,	5
No answer,	30

It has been an almost uniform custom among cities and towns, in their haste to introduce supplies of pure water for the use of their inhabitants, to neglect the providing of proper disposal of the sewage of their respective communities until they were compelled to make such provision as a means of public safety.

In one instance, however, this objectionable order of procedure has been reversed, the town of Nahant having completed a thorough and successful system of public sewage during the past year in anticipation of a future water-supply. Her example is worthy of imitation by the larger cities and towns of the Commonwealth.

27. *Final Disposition of Effluent Waters.* —

Into rivers or brooks, ...	45
Into the ocean, or harbors or bays, ...	7
Into ponds (chiefly), ...	4
No answer, ...	13

28. *What Protection against Impurity of Present Source not now provided is desired.* — Sixty-two returns either give no reply to this question or state that no additional protection is desirable. Nine returns specify certain measures which they deem necessary for the protection of water-supplies, the particulars being stated in the tabulated returns.

29. *What additional Expense is involved in such Protection, and to whom.* — Three returns only reply to this question.

THE SEWERAGE OF NAHANT.


TOWN OF NAHANT
OUTLET No 1
OUTLET No 2
OUTLET No 3
OUTLET No 4
OUTLET No 5
OUTLET No 6
OUTLET No 7
VERNON ST
CLIFF ROAD
WILLOW ROAD
WHARF RD
WHARF
CAREY ST
PLEASANT ST
CENTRAL ST
SUMMER ST
NAHANT ROAD
WINTER ST
OCEAN ST
VALLEY RD
POND ST
HIGH ST
SPRING ROAD
BEAR POND
FLASH ROAD
NAHANT ROAD

THE SEWERAGE OF NAHANT.

The little town of Nahant, one hundredth part the area of Plymouth, was considerably disturbed during the latter half of 1881, and the first half of 1882, by the appearance of typhoid fever in various parts of the town.

The questions then presented for solution were,—

1st. What was the cause of disease?

2d. What should be the remedy?

3d. How long would it take to give relief?

4th. What would it cost?

The disease being zymotic, the remedies suggested were largely those that would be prescribed by a Board of Health —cleaning of premises, securing better drainage, plumbing, etc., and removal of all decomposing matters; afterwards trying to better the quality of water, ice, milk, etc.

Without going into details that would prove but repetitions of what may be already fairly well known, the writer desires to call attention in as few words as possible to those portions of the work that may not be so well understood; viz., separate sewerage, and the apparent recovery of the soil after pollution.

The former of these two subjects is better understood, perhaps, than the latter, although still imperfectly known in this country.

The latter subject, so far as the writer's knowledge extends, has never been discussed in print before, and although isolated cases have been noticed where soil was recovered, to greater or less extent, yet it has apparently either been overlooked, or considered as of small moment.

It being determined to construct a system of sewers, the "separate" system was adopted, as less expensive and quicker to build. It was argued that if manholes were placed at all junctions, and changes of direction, whether vertical or horizontal, it would be comparatively easy to flush with water, or clean with rods, chains, brushes, etc. (See Figs. 1, 2 and 3.)

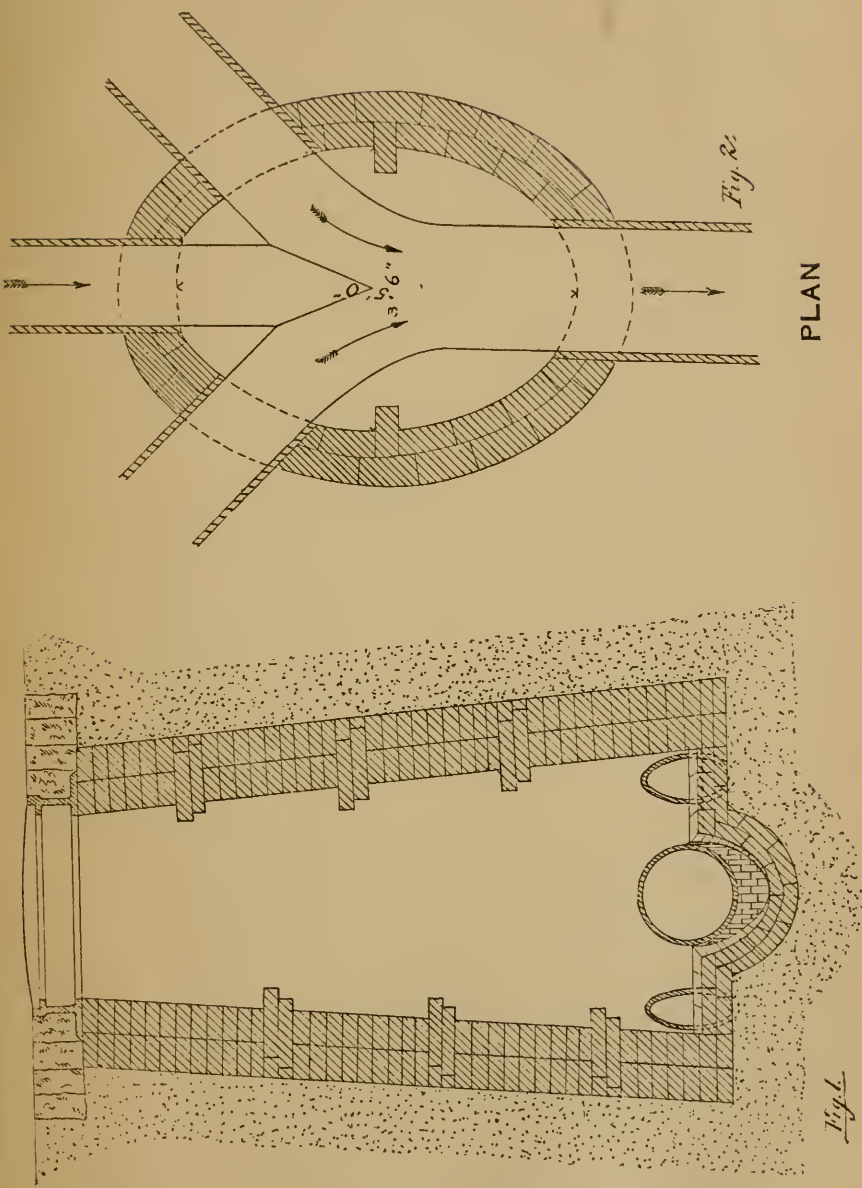
On questions relating not only to the preliminary selection of materials, but actual constructive work and maintenance, the writer borrowed freely on all sides, and though usually the methods heretofore employed by other engineers answered the purpose at Nahant, occasionally slight modifications and additions were made that seemed desirable.

Particularly was this the case with the apparatus for cleaning the sewers, and in the arrangement for the ventilation both of sewers and private drains.

The requisite capacities for the sewers were figured, on a basis of the area to be served, the proposed grade for each pipe, the velocity of flow of sewage, in every case, and the quantity of sewage that might be delivered at given points during those hours when plumbing would be in greatest use (between 8 and 10 A.M.). The sizes for pipes, thus determined by calculation, were doubled, so that when in maximum use they would run one-half full. Although many of the lateral sewers, figured on this basis and doubled, should have been four-inch pipes and not larger, the difficulty experienced in obtaining sufficient quantities of pipe of that size, straight enough to admit of inspection between manholes placed 250 feet apart, was so great, that six-inch pipe was selected as the minimum size.

Actually constructed, the sewers vary in size from six inches to eighteen inches in diameter, and are, so far as possible, laid with tight joints, excluding all ground and surface water. At the present time, the only water purposely admitted to any of the pipes, other than house sewage, is the rainfall from the roof of one school-house, that covers an area of 1,300 square feet. This was connected, as that part of the sewer was what is termed a "dead end" and received the sewage from one house only.

It is believed that the pipe system at Nahant represents to-day the only thorough system of separate sewers in this country. They certainly can be pointed to as the only system of separate sewers that are operated without public water of any description, and that in certain sections have



FLUSH TANK. MANHOLE.

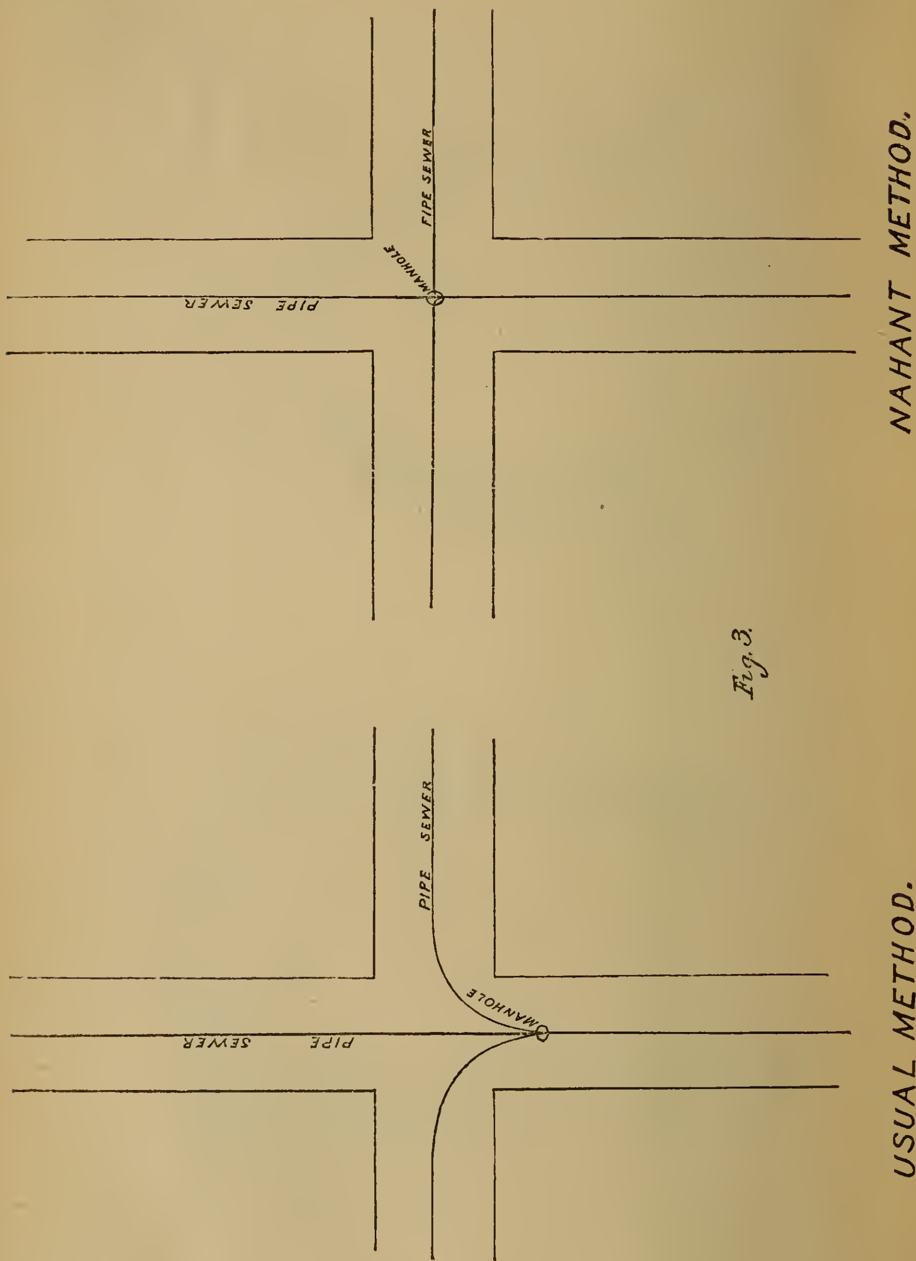

NAHANT METHOD.
PIPE SEWER
MANHOLE
PIPE SEWER
USUAL METHOD.
PIPE SEWER
MANHOLE
PIPE SEWER

Fig. 3.

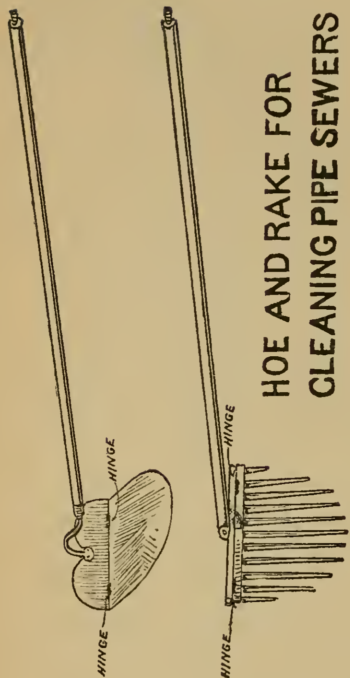
only a very limited supply of even well and cistern water. From their method of construction, however, as has been shown, every portion of the system is capable of being, and actually is, inspected periodically. Every length of pipe can be examined and cleaned, not only by flushing, but by scrubbing with wire brushes.

When it is desired to flush any line of pipe, a sand bag is used as a plug for the outlet of a manhole, which is then filled with salt water by the town water-cart,—rather a primitive fashion of procedure, but one that it was decided to adopt, temporarily, during the first season, or until it should be demonstrated by actual experiment where flush tanks should be located and what their size should be. As a rule, water enough is put into the manhole in question to make a solid water plug, as it were, for forty feet of the sewer, below the manhole.

The flushing by this crude method has been so successful, and has to be attended to so seldom, that it is quite possible the special flush tanks may be omitted entirely.

During construction, silt, in the form of fine sand and clay, found its way into some of the pipes, and upon completion of the work deposits were found in certain sections; in one case to a depth of over three inches, and very compact. The question of removal seemed quite a serious one; the more so, after repeated flushings had failed to carry off the obstruction.

After repeated experiment one of the two following courses was adopted in every case: a shingle with a lighted candle fastened upon it (see Fig. 4) was allowed to float down the pipe from a manhole, being controlled from the initial point by a string, so that it could be stopped when desired. An obstruction met could be located by measuring the length of the string. This being ascertained, a hoe or rake (see Fig. 5) was introduced on one end of a series of jointed rods (which when screwed together somewhat resemble a fishing pole), and the sand loosened and afterwards flushed off with water; or, a stout twine was attached to a wooden plug, which was floated down from one manhole to another, and to which, in turn, was fastened a small rope and a section of rather heavy iron chain, which latter could



HOE AND RAKE FOR CLEANING PIPE SEWERS

Fig. 5.

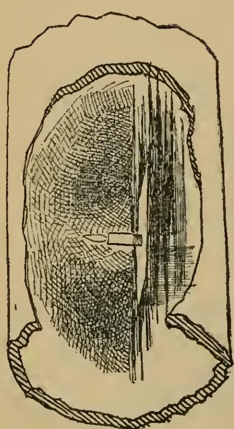
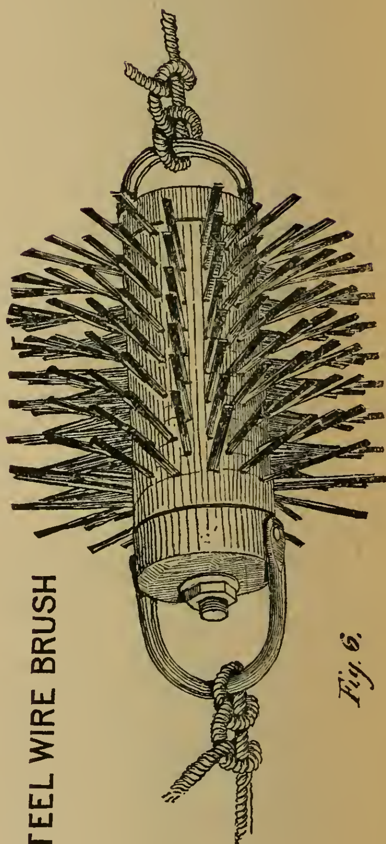


Fig. 4.



STEEL WIRE BRUSH

Fig. 6.

be dragged to and fro, until the whole mass of sediment was loosened.

These appliances, except the shingle and candle, are the ones ordinarily in use for pipe sewers, and were found tolerably satisfactory, though not wholly so. To meet the want still felt, circular brushes of various sizes that could be attached to a rope or a rod and then pulled or pushed through, were devised; at first, these were made of stiff bristles, but now are constructed of flat steel wires, fastened to a wooden core (see Fig. 6), and with the arrangements before mentioned appear to be sufficient for all purposes. After being once thoroughly cleaned, the question of keeping the sewers in that condition was much simplified.

Inspection now consists either in reflecting the sunlight through the sewer, from one manhole to another, by means of mirrors (see Fig. 7), which enable a very fair inspection without any flush whatever, or in the use of the shingle and candle before mentioned. If any foreign matter appears to be in the pipe, its position can be located (if the day be sunny) by counting the joints in the pipe, which can be seen by the mirrors above referred to, and the brush, chain, hoe or rake used, as may seem best.

The system, which is to-day nearly five miles in length, is intended to be thoroughly ventilated, and includes not only the public sewers, but all private drains below running traps.

The lower manhole on each trunk sewer is provided with a perforated cover, to relieve the other portions of the sewer from the pressure caused by heavy surf, and not, as has been suggested, as a fresh-air inlet, for, on the upper side of each manhole, is a flap valve or tide gate which would effectually prevent any such use being made of the perforated cover. The sewers and house connections above the last manhole on each trunk line (which manhole is intended for the purpose above described) are water-tight, so far as careful work can make them. House connections are entered in 4-inch Y pipes, and the ventilation for both sewer and house drain is provided for by a 4-inch pipe, connecting outside each and every house, extending from the main drain of each building just below the running trap, to some point above

Section of Manhole, showing method of inspection with mirror.

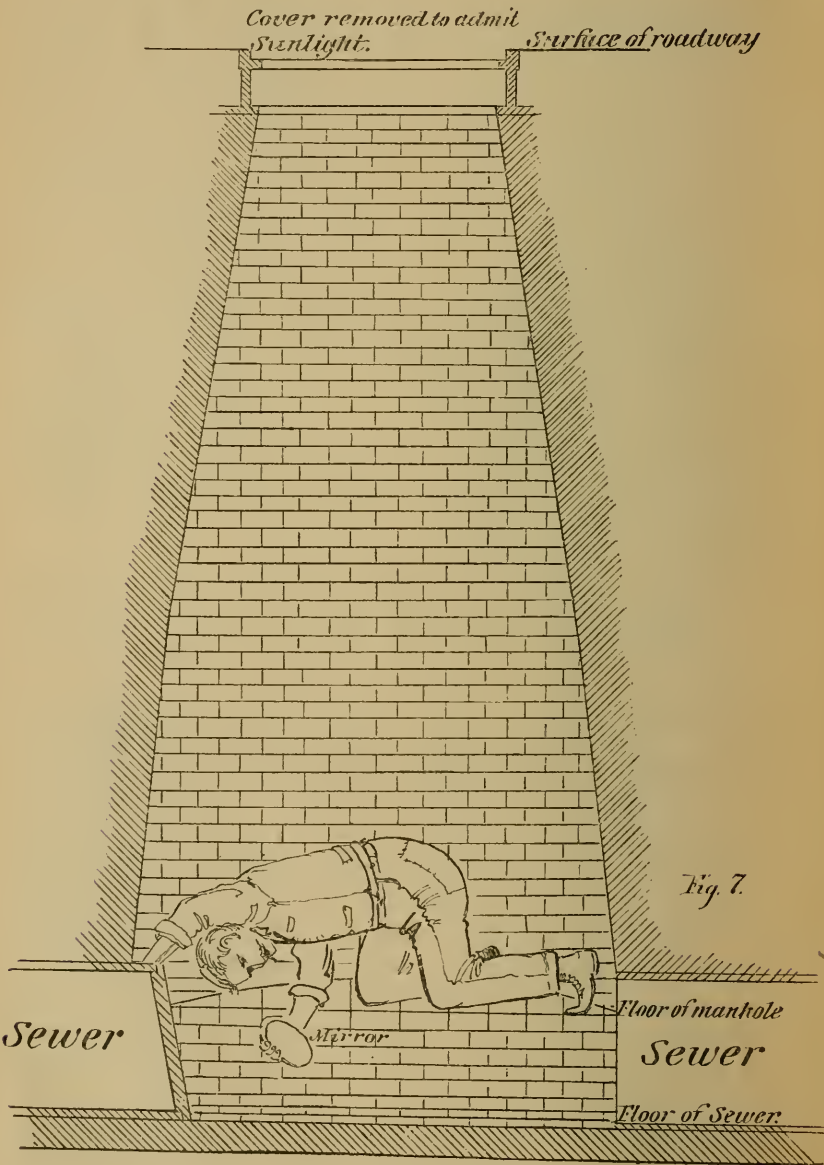
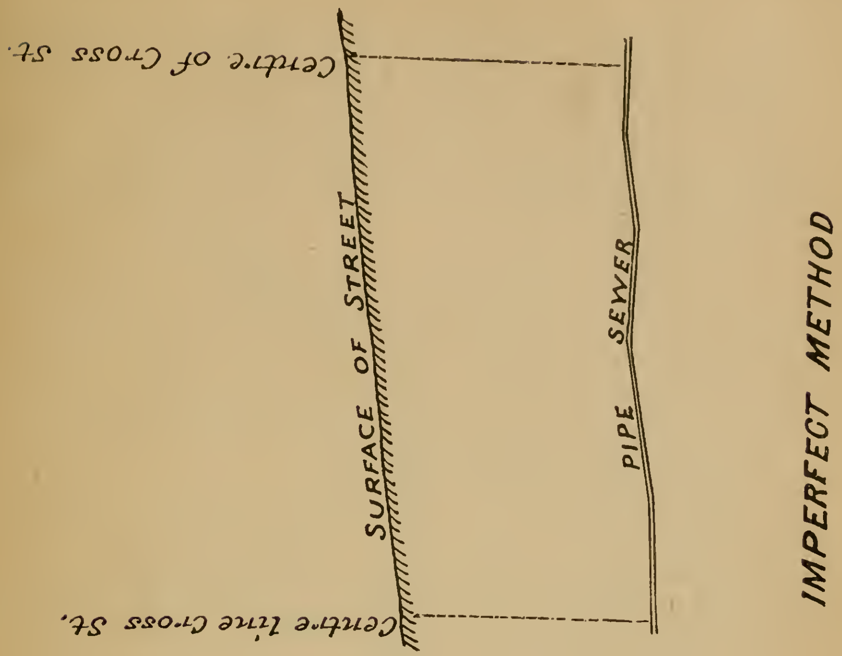
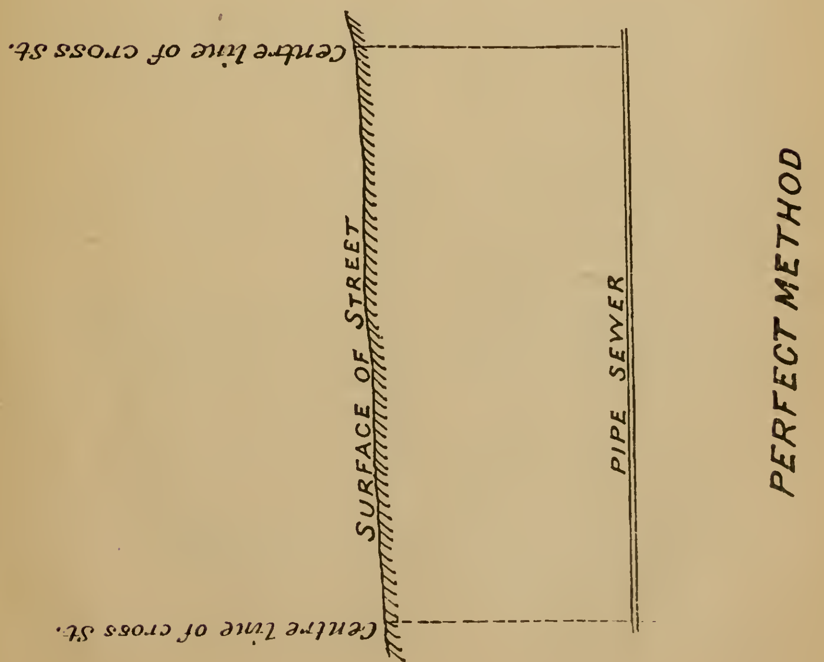


Fig. 7.


Centre of Cross St.
SURFACE OF STREET
PIPE SEWER
Centre line Cross St.
IMPERFECT METHOD


Centre line of cross St.
SURFACE OF STREET
PIPE SEWER
Centre line of cross St.
PERFECT METHOD

the chimneys. (See Fig. 8.) This provides not only for the ventilation of sewer and house drain (the latter is rarely ventilated between the running trap and the sewer, though apt to be fouler than any portion of the public sewer), but it also causes each house drain to ventilate its proportion of the system, and prevents the usual concentration of the gases at a few points.

All ventilation being above the top of the house, there is very small chance of annoyance from smell, and so far as known there has been none noticed at any point save slightly at the perforated manholes at the foot of the trunk lines, and in three instances from "puffing" of fresh-air inlets to house drains—both of which were disconnected from the sewer and drain ventilation referred to.

Many of the houses at Nahant being provided with privies instead of water closets, — and privies, too, of the poorest possible type, — the annexed cut was adopted (see Fig. 9), as being perhaps more easily attended to than any other, and at the same time capable of being used, but not abused.

Any privy whose contents are received in a leaking vault, is undesirable, and when such vault is, as is not uncommonly the case, used as general slop-hopper as well, and the soil in the immediate neighborhood drenched periodically with the family filth, it should always be viewed with distrust.

At such points as seemed permissible, the option was given between the tub set on the slanting asphalt floor, as shown, or a thoroughly cemented shallow vault into which no slops were to be thrown.

The foregoing rather brief description with the accompanying plates may be sufficient to show what was done at Nahant, to prevent further soil pollution. In addition to this, and at the same time, an investigation was constantly going on, to ascertain the amount of both soil and water pollution already existing, the general condition of individual premises, inside and out, with a view to determining what remedial measures should be applied, how and when.

A slight knowledge of the local geology of the peninsula may be of service in this connection.

The soil at Nahant varies in character much more than is

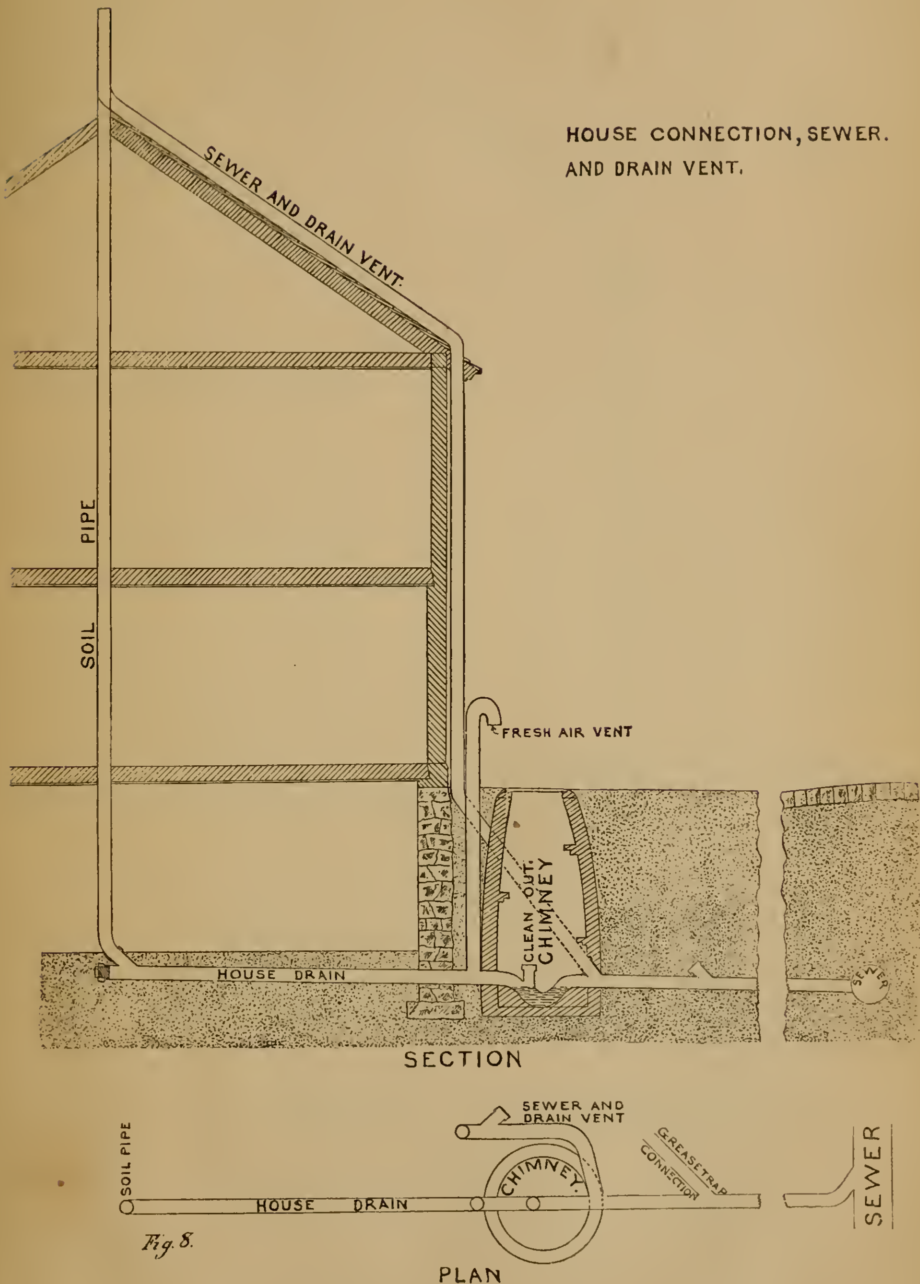
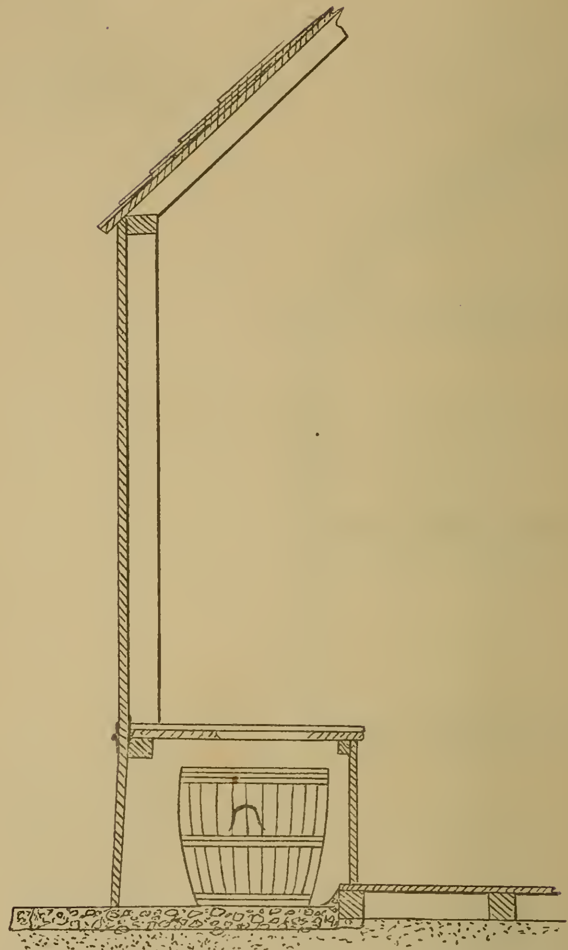

HOUSE CONNECTION, SEWER.
AND DRAIN VENT.
SEWER AND DRAIN VENT.
SOIL PIPE
FRESH AIR VENT
CLEAN OUT.
CHIMNEY
HOUSE DRAIN
SEWER
SECTION
SEWER AND DRAIN VENT
SOIL PIPE
HOUSE DRAIN
CHIMNEY.
GREASETRAP
CONNECTION
SEWER
PLAN

Fig. 8.



SECTION OF PRIVY.
Fig. 9.

generally supposed. Portions of the town show solid rock outcroppings; near by are deposits of fine white sand, fifty feet deep, or loose running gravel (drift) from twelve to thirty-five feet deep, and overlying the ledge, which still shows distinctly the grooves and markings of former glacial action. A little further on is found stiff bluish-green brick clay from twenty to sixty feet in depth, while the town gravel-pit at the west end exhibits a face of binding gravel of unusually good quality.

It being impossible to introduce public water on such short notice, the effort was made to remove all known sources of contamination, abolishing all cesspools and leaching vaults, draining marshes that smelled offensively, and, after removing all known causes of filth, to pump out and cleanse all wells and cisterns that afforded chemical or physical evidence of being tainted. There being hundreds of wells and cisterns used as drinking and cooking supplies, hundreds of chemical analyses were made, in the first instance to determine the general character of the water, and afterwards to ascertain what effect, if any, was produced (after removal of the supposed sources of trouble) by the pumping out and cleaning.

In many instances there was little or no improvement in the quality of the water, in others it was appreciably benefited, and occasionally, so far as could be ascertained chemically, waters were rendered entirely satisfactory, that were previously classed as decidedly injurious.

In the case of cistern water this might be expected in perhaps a majority of cases, and in a measure well water might show change for the better, though hardly to the extent indicated.

There being no public water during the season of 1882, most of the old wells and cisterns were of necessity depended upon for the major part of the drinking and cooking water, although many of the summer residents had spring water delivered periodically.

Of the wells and cisterns examined, nearly 60 per cent. contained water that was classed as undesirable (the proportion of wells and cisterns being about even).

Concisely speaking, there were 80 cases of typhoid fever during 1881, out of an estimated population of 1,500. In 1882 the summer population was probably not over 1,200, and the number of cases can perhaps be best reported in the language of the local board of health, just issued: "It is a source of gratification and pleasure to them (the Board) to be able to report that, notwithstanding the epidemic of typhoid fever that prevailed here in 1881, yet the vigorous correctionary measures adopted by the town, and carefully carried out, completely checked it, and not a single case of the fever has appeared here since, that could not be traced to some other locality, for its origin."

Another statement should be taken into consideration here, which may not be apparent to all, at first sight, but that has an important bearing; naturally, some of the houses where typhoid was present in 1881 were vacant during 1882, so that to understand the condition precisely, and compare them, those houses that were vacant in 1882 in which cases occurred during 1881 should be omitted. Instead of 80 cases, therefore, the total number of patients in 1881 should be considered as 61, sick in houses occupied either a portion or the whole of the season of 1882.

Six instances are shown below, three cisterns and three wells, all of which when first examined contained water that was undesirable to use.

Later, when such pumping and scrubbing out as was possible had been thoroughly attended to, fresh analyses were made, as indicated, and the waters were freely used during the season of 1882.

These samples have been selected, from many such, as showing, perhaps more markedly than any others, how it is sometimes possible for polluted water-supplies to recover, appreciably, in a short time, when the sources of pollution are removed.

Numbers of wells and cisterns did not recover, or show any marked signs of improvement that could be detected chemically, and though there are not enough examples on the whole list that occur in the same soil, and under sufficiently similar conditions, from which to draw general conclusions that can be considered as of very great value, yet it seems as if there was quite enough evidence to show that where isolated cases of typhoid occur that seem directly traceable to the drinking water, it is at times possible that the supply may be so improved by simple pumping out and cleaning as to become permissible in quality, and it is fair to infer from knowledge at hand that such pumping and cleaning may actually accomplish more than can be shown by any chemical work, as now done. Unless this last be true, or partially so, it appears scarcely possible that the condition of affairs at Nahant could have improved to such an extent in one season, one during which typhoid fever seemed more than usually prevalent elsewhere.

The first case is that of a well, the water from which is used in a house where fever was present in 1881. Sample taken in December, 1881: —

A.

Free ammonia,	0.0008
Albuminoid ammonia,	0.0070
Chlorine,	22.60
Fixed residue,	72.30
Volatile "	17.70
Total "	90.00
Hardness,	18°

The same well during the last of June, 1882, was as follows: —

B.

Free ammonia,	0.0027
Albuminoid ammonia,	0.0082
Chlorine,	10.60
Fixed residue,	41.70
Volatile "	9.70
Total "	51.40
Hardness,	13°

Of sample A the chemist reports, "A very suspicious water, on account of the large amount of chlorine, residue, nitrates, and high degree of hardness, although the soil appears at the present time to be acting as an efficient filter and oxidizer."

Of B the report is, "Suspicious on account of the large amount of nitrates, chlorine, residue and hardness. The small amount of the ammonias shows that the organic matter is at present being oxidized in passing through the soil."

The second case is that of a well in gravelly soil; water used in 1881 where there was fever in the house. Sample taken June, 1882:—

C.

Free ammonia,	0.0086
Albuminoid ammonia,	0.0202
Chlorine,	6.50
Fixed residue,	19.80
Volatile "	4.40
Total "	24.20
Hardness,	$2\frac{1}{2}°$

After cleaning, a sample was taken early in July:—

D.

Free ammonia,	0.0008
Albuminoid ammonia,	0.0138
Chlorine,	8 70
Fixed residue,	21.40
Volatile "	2.10
Total "	23.50
Hardness,	4°

A second cleaning was ordered, and a third sample taken the first of September:—

E.

Free ammonia,	0.0005
Albuminoid ammonia,	0.0100
Chlorine,	5.90
Fixed residue,	19 40
Volatile "	3.40
Total "	22.80
Hardness,	5°

Of C the report is, "There is too large an amount of organic matter present, as shown by the amount of both ammonias, the brown color and charring of the residue on ignition."

D is pronounced "a fair water, the albuminoid ammonia being just within the maximum normal; the yellowish tinge and the blackening of the residue upon ignition show rather too much vegetable matter."

When it comes to E, "There is no evidence of injurious contamination, and there is no reason for suspicion as to the future purity."

The third case of a well recovering (if this be the proper term to use) is one not over twenty feet deep and in a running gravel. Supposed source of defilement had existed not less than ten years. First sample taken in November, 1881.

F.

Free ammonia,	0.0040
Albuminoid ammonia,	0.0185
Chlorine,	5.40
Fixed residue,	10.50
Volatile "	6.00
Total "	16.50
Hardness,	–

The first of February, 1882 : —

G.

Free ammonia,	0.0019
Albuminoid ammonia,	0.0074
Chlorine,	5.70
Fixed residue,	14.70
Volatile "	2.90
Total "	17.60
Hardness,	2°

Early in April, 1882 : —

H.

Free ammonia,	0.0005
Albuminoid ammonia,	0.0078
Chlorine,	4.90
Fixed residue,	10.90
Volatile "	2.70
Total "	13.60
Hardness,	$1\frac{1}{2}$°

In July the same water was : —

I.

Free ammonia,	0.0000
Albuminoid ammonia,	0.0008
Chlorine,	6.60
Fixed residue,	28.90
Volatile "	11.30
Total "	38.20
Hardness,	4°

Early in October (after heavy rains): —

J.	
Free ammonia,	0.0038
Albuminoid ammonia,	0.0098
Chlorine,	5.80
Fixed residue,	12.50
Volatile "	5.00
Total "	17.50
Hardness,	3°

F is pronounced "unfit for use."

G: "I cannot tell whether this is a cistern or well-water. If a well-water, it is very soft and good, for Nahant water. If a cistern water it contains too much chlorine and solid matter."

H: "A very good water."

I: "An excellent water at the present time. The trace of nitrates, however, together with the considerable amount of residue, gives rise to a slight suspicion as to future purity."

J: "Still an excellent water."

This example is perhaps the most striking of the entire list, there being such a number of analyses. It is worthy of mention that after the first clearing out (after F and before G) nothing was done save to pump considerable quantities of water for use on the place, and so far as possible draw considerable volumes of water whenever opportunity afforded.

The first of the cisterns was tested first in Jan., 1882: —

K.	
Free ammonia,	0.0098
Albuminoid ammonia,	0.0178
Chlorine,	2.80
Fixed residue,	56.30
Volatile "	4.60
Total "	60.90
Hardness,	30°

In February: —

L.	
Free ammonia,	0 0013
Albuminoid ammonia,	0.0088
Chlorine,	1.60
Fixed residue,	8.30
Volatile "	1.40
Total "	9.70
Hardness,	3°

In April : —

M.	
Free ammonia,	0.0107
Albuminoid ammonia,	0.0088
Chlorine,	1.30
Fixed residue,	8.90
Volatile "	1.60
Total "	10.50
Hardness,	4½°

K is pronounced undesirable.

L shows "no evidence of injurious contamination. There is too much chlorine and residue for a cistern water unless located very near the salt water."

M is "slightly suspicious on account of the free ammonia, and if a cistern water, of the chlorine and residue."

Water from the second of the cisterns was used at a house where fatal cases of typhoid fever had occurred. Sample taken early in January, 1882.

N.	
Free ammonia,	0.0493
Albuminoid ammonia,	0.0144
Chlorine,	0.90
Fixed residue,	3.60
Volatile "	1.10
Total "	4.70
Hardness,	1½°

The next one taken in May, 1882 (after heavy rains) : —

O.	
Free ammonia,	0.0152
Albuminoid ammonia,	0.0098
Chlorine,	1.70
Fixed residue,	3.30
Volatile "	2.90
Total "	6.20
Hardness,	1°

The comments on the first one, N, are "Probably a cistern water, and a very suspicious one on account of the very large amount of free ammonia together with the large amount of chlorine. The albuminoid is about the extreme limit."

On O the report is, "Without knowing anything about the surroundings of this water, I should pronounce it suspicious or even bad, but I think fresh rainwater, collected about the beginning of an easterly storm at Nahant, might have this composition." (The sample *was* collected just after a heavy easterly storm.)

The third instance is a cistern the water from which was used in a house where very severe typhoid occurred. The first sample was taken just before the first of November, 1881.

P.

Free ammonia,	0.0195
Albuminoid ammonia,	0.0530
Chlorine,	0.7
Fixed residue,	11.00
Volatile "	10.00
Total "	21.00
Hardness,	–

And a fortnight later:—

Q.

Free ammonia,	0.0750
Albuminoid ammonia,	0.0085
Chlorine,	.20
Fixed residue,	3.00
Volatile "	2.00
Total "	5.00
Hardness,	–

P is pronounced "foul and unfit for use on account of its large charge of carbonaceous or vegetable organic matters. . . . It should be called highly dangerous."

Q: "This water is from a sound and clean cistern. The proportion of free ammonia is high . . . and may be accounted for by the entry of recent heavy rains into the cistern, or by the condensation of ammoniacal vapors on the roof from neighboring flues. A satisfactory water."

While the conclusions, as to soil recovery, may be derived from insufficient premises, perhaps calling attention to the subject may lead to a discovery of facts warranting systematic research in this direction that may be of great sanitary value.

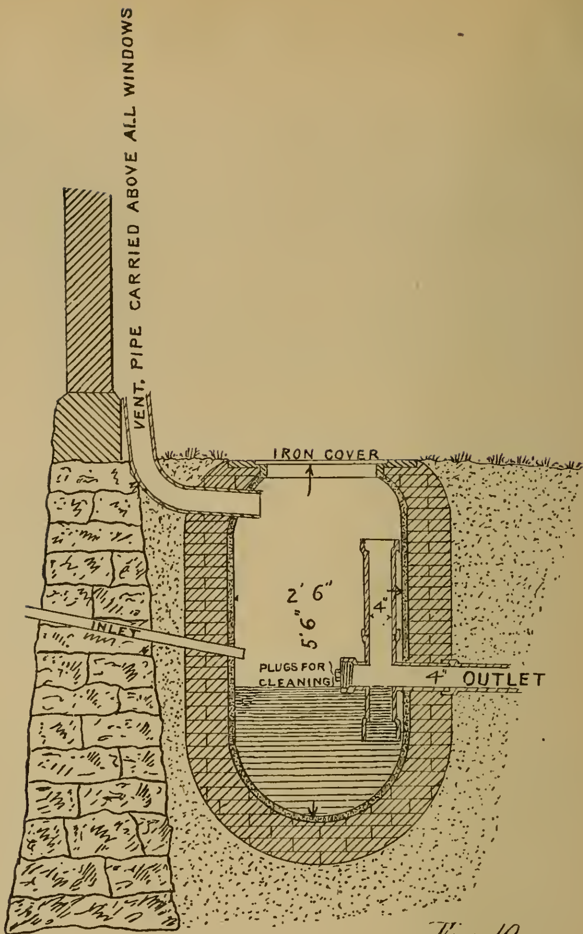


Fig. 10.

SECTION OF GREASE-TRAP

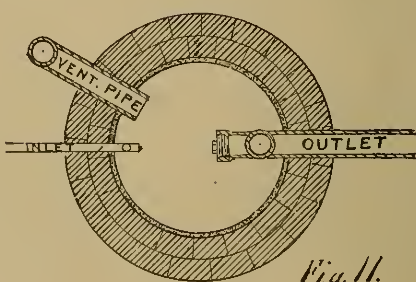


Fig. 11.

PLAN

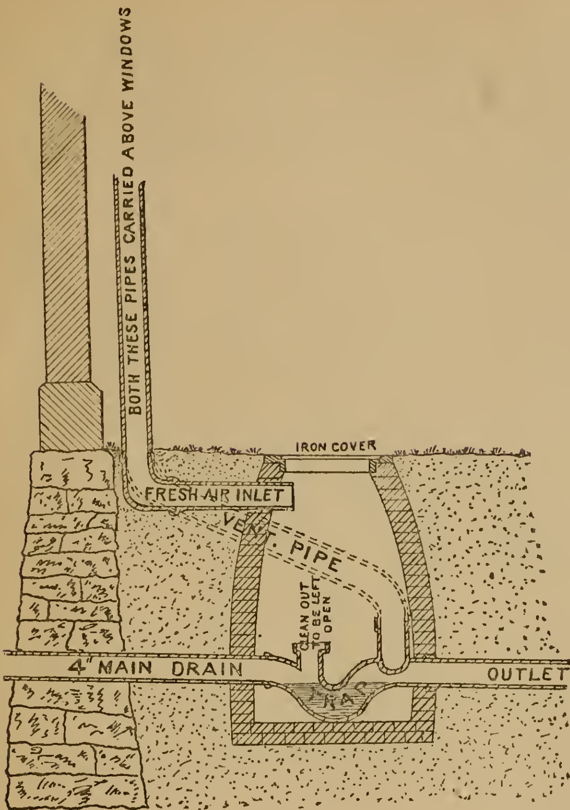


Fig. 12.

SECTION SHOWING TRAP, VENTILATING PIPE, &c.

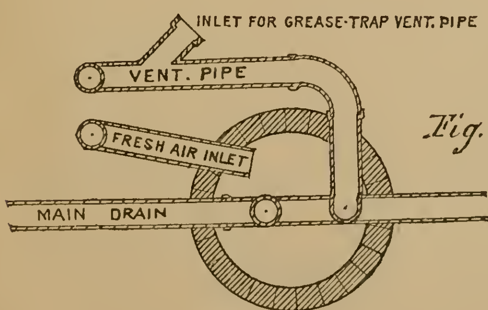


Fig. 13.

PLAN

Ground was broken for the sewers Feb. 16, 1882, and all work on them was finished July, 1882, although some of the private connections were not done till after that date.

The estimated cost of the work was $52,000; the actual cost, including a number of items not originally estimated upon, was $51,785.77.

The question has been frequently asked, "With the knowledge gained from the work done, what changes would be advised, was it to be repeated elsewhere?" A difficult question to answer, as no two places are similarly situated, either geographically, sanitarily, financially, or any other way. It may be sufficient to say, that some of the details of the house connections, such as grease-traps, cesspools (Figs. 10, 11, 12 and 13), and fresh-air inlets, would probably be somewhat differently arranged, and the former built of cast-iron rather than brick, while the general features of the plan would remain unchanged.

INDEX.

INDEX.

Accidental adulteration, 17.
Accommodation in vision, 106,
Accum on bread adulteration, 22.
Adulteration of food and drugs, statutes relating to, xv.
Adulteration of food, 3; English laws, 5; Massachusetts laws, 5; experts, 5; extent of, 6; English Society of Analysts, 6; The Analyst, 6, 9, 25; comparative adulteration, 7; butter, 7, 25; milk, 7, 39; groceries, 7, 9; bread and flour, 7, 10; drugs, 7, 9; wines, beer, and spirits, 7; water, 7; per cent. of adulteration, 8; sugar, 10; bicarbonate of soda, 10; cream of tartar, 10; baking powders, 10; knowledge required, 11; food analyst, 11; argols, 11; obtaining samples, 12; local inspectors, 12; possession with intent to sell, 12; purchase of samples, 13; milk inspectors, 13; treatment of samples, 14; books in court, 15; interpretation of results of analysis, 15; classification of adulterations, deleterious, fraudulent, and accidental, 16, 17; articles liable to adulteration, 19; arrow-root, 20; brandy, 21; bread, 22; butter, 25; oleomargarine, 27; canned goods, 31; cheese, 31; cheese poisoning, 32; confectionery, 33; poisonous colors in, 33; coffee, 34; cocoa and chocolate, 35; flour, 36; ginger, 37; honey, 37; lard, 38; mustard, 38; cayenne pepper, 39; horse radish, 39; fruit jellies, 39; milk, 39; analyses of, 40, 41; specific gravity of, 43; creamometer, 44; total solids, 46; fat, 47; sugar in, 47; certificate of analysis, 50; skim-milk, 51; buttermilk, 52; cream, 53; lime juice, 55; meat, 55; oatmeal, 56; buckwheat, 56; pickles, 56; preserved fruits, 57; pepper, 57; rum, 57; sugar, 58; glucose, 59; molasses and syrups, 63; spices, 64; tea, 65; vinegar, 65; wine, 66; preparation of wine for export, 68; specific gravity of, 70; cream of tartar, 71; bicarbonate of soda, 73; baking powders, 74; tinware, 74; poisonous glazing, 75; poisonous papers, 75; apparatus required, 75; microscope, 76; polariscope, 76; balance for weighing, 79; weights, 79; platinum, 79; beakers, 80; watch-glasses, 80; gas-lamps, 80; water-baths, 81; air-baths, 81; pipettes, 81; burets, 81; flasks, 81; measuring-jars, 81; re-agents, 82; samples, 82; bibliography, 83.
Agawam water company, 164–170.
Allen, A. H., on cream of tartar, 71.
Alum in pickles, 57.
Amherst water company, 165–171.
Amount of water in butter, 26.
Amount of curd in butter, 26.
Anæsthetic leprosy, 125.
Analysis of milk, 43.
Analysis of milk to be sworn to, 50.
Analysis of Nahant waters, 241.
Analysis of water supplies, 215, 218.
Analyst, The, 6, 9, 25, 71.
Aniline colors in candy, 33.
Annatto, 28.
Annattoine, 54.
Apparatus for cleaning sewers, 228.
Areas or water-sources, 213.
Areas of water-sheds, 214.

Argols, 11.
Arlington water works, 172-184.
Arrowroot, 20.
Articles liable to adulteration, 19.
Ash of butter, 26.
Ash of flour, 37.
Ash of wine, 67.
Ashley water works, 148-154.
Astigmatism, 108.
Athol water company, 197-209.
Attleborough water works, 148-154.
Average daily consumption of water, 220.
Average daily consumption of water per family, 221.

Bacillus of leprosy, 132.
Baking-powders, 10, 74.
Beer, 70.
Belfield, Dr., on bacillus of leprosy, 132.
Berkshire County water reports, 148-154.
Beverly water works, 156-162.
Bibliography of food adulteration, 83.
Bibliography of leprosy, 133.
Bicarbonate of soda, 10, 73.
Bitartrate of potash, 11.
Blanks for analysis, 50.
Blyth, J. W., on mustard, 38.
Bolley's manual on coloring matters, 33.
Books in court, 15.
Boston board of health, food adulteration, 9.
Boston water works, 196-208.
Bouchardat on vinegar, 54.
Brains in milk, 53.
Brandy, 21.
Bread, 9, 10, 22.
Bristol County water reports, 148-155.
British law as to vinegar, 65.
Brockton water works, 188-194.
Brookline water works, 188-194.
Brooks, springs, and small streams, 213.
Brown, J. C., on polarization, 37.
Brown sugar, 58.
Buckwheat, 56.
Burnt sugar, 54.
Butter, 7, 25.
Buttermilk, 53.

Calculations of amount of pure milk, 49.
Cambridge water works, 172-184.
Candy, 16, 32.
Canned vegetables and meats, 30.
Capacity for water storage, 219.
Capacity of sewers at Nahant, 228.
Capacity of water sources, 214.
Caramel, 21.
Carbonic-acid water, 9.
Carrot-juice as coloring-matter, 28.
Casamajor on glucose, 60.
Causes of impaired vision, 110.

Cayenne pepper, 18, 37, 39.
Chalk in milk, 54.
Champagne, 69.
Characteristics of types modified by wages of type-setters, 100.
Cheese, 31.
Cheese-poisoning, 32.
Chefus-nut, 35.
Chelsea water works, 196–208.
Cheshire water company, 148–154.
Chiccory, 35.
China clay, 4, 20, 33.
Chocolate, 35.
Cider vinegar, 65.
Classification of adulterations, 16.
Clerget on glucose, 61.
Clinton water company, 197–209.
Cocoa, 36.
Coffee, 17, 34.
Cohn, Dr., on nearsightedness in scholars, 91, 108.
Color-names, lack of knowledge of, 117.
Color-sense, and its defects, 115.
Coloring-matter in butter, 28.
Coloring-matter in milk, 54.
Coloring-matter in mustard, 38.
Commercial fertilizers, xii.
Comparative adulteration, 7.
Concord water works, 172–184.
Contagion of leprosy, 127.
Copper in canned goods, 31.
Copper in pickles, 57.
Cost of sewers at Nahant, 248.
Cotton-seed oil, 31.
Cream, 53.
Creamometer, 44.
Cream of tartar, 9, 10, 71.

Danger of blindness, 105.
Danvers water works, 156–162.
Dedham water company, 188–194.
Defective school-houses, a cause of myopia, 91.
Deleterious adulteration, 16.
Determination of sugar in milk, 48.
Donders, Prof., on hypermetropia, 105.
Drugs, 7.
Drugs, food and, adulteration of, statutes relating to, xv.
Dry-earth closets, 236.
Dupee and Wanklyn, bread analysis, 24, 25.
Dust, dirt, and foul air injurious to eyes, 111.

Effluent water, its disposal, 222, 223.
English analysts, 40.
English analysts, society of, 6, 42.
English laws, 5.
Engraving from photographs, 115.
Essence of coffee, 35.
Essex County water reports, 156.
Etiology of leprosy, 126.
Everett water works, 173–185.

Microscope, its use in analysis, 11, 65.
Middlesex County water reports, 172.
Milford water company, 198–210.
Milk, 7, 39; milk analysis, 50; milk-cans, 41; milk inspectors, 13; milk-sugar, 47, 48; specific gravity of, 43; Massachusetts standard, 41; lactometer, 43; total solids, 46; fat, 47; skim-milk, 51; buttermilk, 52; cream, 53; adulterations of, 54.
Mitchell on bread adulteration, 22.
Molasses, 63.
Montague water company (Turner's Falls,) 157–163.
Mustard, 17, 38.
Myopia, 90, 91.

Nahant, sewerage of, xi, 227; typhoid fever in, 227; questions fòr solution, 227; sanitary improvements, 227; recovery of soils, 227; separate sewerage, 228; man-holes, 227; apparatus, 228; capacity of sewers, 228; size of pipes, 228; mode of flushing, 231; removal of obstructions, 231; inspection of sewers, 231; ventilation of, 233; pressure of surf, 233; dry-earth closets, 236; analysis of Nahant waters, 241; geology of Nahant, 239; difficulty in obtaining a water-supply, 239; well and cistern waters, 239; cost of sewerage at Nahant, 248.
Nantucket water company (Wannacomet,) 188-194.
Natick water company, 174–186.
Nearsightedness in scholars, 90.
New Bedford water works, 149–155.
Newburyport water company, 157–163.
New Brunswick, leprosy in, 124.
New Jersey, state inspection of food, 10, 25, 42.
Newton water works, 174–186.
New York city board of health, as to specific gravity of milk, 43, 42.
Norfolk County water reports, 188.
Normal eye needs glasses at age of forty-five to forty-eight, 109
North Adams water works, 148–154.
Northampton wâter works, 165–171.
Northborough water works, 198–210.

Oatmeal, 56.
Objections to use of lactometer, 44.
Obtaining samples, 12.
Oleomargarine, 27, 31.
Olive oil, 14.
Orange County lactometer, 43.

Package coffee, 34.
Peabody water works, 157–163.
Pease in coffee, 35.
Pepper, 57.
Pharmaceutical Association proceedings, 33.
Phosphate of lime, 10.
Photographs, engraving from, 115.
Pickles, 15, 56.
Pittsfield water works, 148–154.
Plastering of wine, 67.
Plymouth County water reports, 188.
Plymouth water works, 189–195.
Poisonous glazing on enamel, 75.
Poisonous papers, 75.
Poisonous paper wrappers, 33.
Poisonous pigments in candy, 33.

Polariscope, 33, 61.
Pollution of water supplies, 215, 219.
Port wine, 67.
Possession, with intent to sell, 12.
Preparation of wine for export, 68.
Present distribution of leprosy, 122.
Preserved fruits, 57.
Proposed changes in letters, 101.

Questions for solution at Nahant, 227.
Quevenne on bicarbonate of soda in milk, 54.

Recapitulation of water returns, 212.
Recovery of soils from pollution, 227.
Removal of obstructions in sewers, 231.
Responsibility of overseers as to eyesight of operatives, 112.
Reports of water companies and boards, 143.
Results of sewerage, 220.
Rice flour, 39.
Richards, Mrs., examination of groceries, 10, 66, 71.
Richmond water company, 148–154.
Rum, 57.

Sage cheese, 32.
Salad oil, 17.
Salem, case of leprosy in, 121.
Salem water works, 157–163.
Saleratus, 74.
Sanitary improvements at Nahant, 227.
School-books, defective, 93.
School furniture, defective, 92.
School-house investigation, 92.
School-hours, 102.
Separate sewerage, 228.
Sewerage of Nahant, xi, 227.
Sharples, S. P., article on food adulteration, 3
Sharples, S. P., analyses of milk, 41.
Sherry wine, 67.
Ship-bread, 39.
Size of letters, 98.
Size of sewer-pipes, 228.
Skim-milk, 51.
Skim-milk cheese, 32.
Soda water, 9.
Soleil-Dubosq, polariscope, 47.
Somerville water works.
Sources of water-supply, 212.
Southbridge water company, 198–210.
South Hadley water works, 165–171.
Specific gravity of milk, 40, 43.
Specific gravity of wines, 70.
Spencer water company, 199–211.
Spices, 64.
Springfield water works, 164–170.
Squinting children, 106.
Starch in chocolate, 35.
State board of health of Massachusetts, 10.
Statutes relating to food and drug adulteration, xv.

Stearine in lard, 38.
Stockbridge water compaay, 148–154.
Storm-water excluded from sewers at Nahant, 223.
"Strictly pure," 72.
Suffolk County water reports, 196.
Sugar, 10, 58; loaf, 58; granulated, 58; brown, 58; in milk, 42; in wine, 67
Sulphur precipitated, 9.
Surf, pressure of in sewers, remedied, 233.
Symptomatology of leprosy, 125.
Syphilis, relation to leprosy, 127.
Syrups, 17, 63.
Systems of water distribution, 222.

Teas, 18, 65.
Termination of letters, 97.
Terra alba, 20, 37.
Thickness of letters, 97.
Thudichum and Dupré on wine, 68.
Tinware, 74.
Topography of water-sources, 214.
Total solids in milk, 46.
Total solids in wine, 70.
Treatment of samples, 14.
Trichina spiralis, 56.
Tubercular leprosy, 125.
Tubular wells, 213,
Turmeric in ginger, 37.
Typhoid fever at Nahant, 227.
Typical forms of letters, 97.

Veal, law relating to, 55.
Vegetable colors in candy, 33.
Ventilation of sewers, 233.
Ventzke-Scheibler, polariscope, 47.
Vessels to be marked, 52.
Vinegar, 65.
Violet powder, 9.
Vision impaired in working classes, 90, 107.
Von Baumhauer, on total solids in milk, 46.

Waller on bread adulteration, 25.
Waltham milk, 41.
Wanklyn on total solids in milk, 47.
Wanklyn on cocoa and chocolate, 36.
Waste of eye-power, 111.
Water boards, companies, and commissioners of Massachusetts, reports of, 143; questions requiring answers, 146.
  Tabular statement, 148.
  Berkshire County, 148.
    Adams water company, 148–154.
    Ashley water works (Pittsfield), 148–154.
    Berkshire water company (Lee), 148-154.
    Cheshire water company, 148–154.
    Great Barrington water company, 148–154.
    Lenox water company, 148–154.
    North Adams fire district, 148–154.
    Richmond water company, 148–154.
    Stockbridge water company, 148–154.

Water boards, etc.:
Williamstown aqueduct company, 148–154
Bristol County, 148.
Attleborough water supply district, 148–154.
Fall River water works, 149–155.
New Bedford water works, 149–155.
Taunton water works, 149–155.
Essex County, 156.
Beverly water works, 156–162.
Danvers water works, 156–162.
Haverhill aqueduct company, 156–162.
Lawrence water works, 156–162.
Lynn water works, 156–162.
Newburyport water company, 157–163.
Peabody water works, 157–163.
Salem water works, 157–163.
Franklin County, 157.
Glen water company, Greenfield, 157–163.
Turner's Falls water company, Montague, 157–163.
Hampden County, 164.
Agawam water company, 164–170.
Chicopee water company, 164–170.
Holyoke water works, 164–170.
West Springfield aqueduct company, 164–170.
Springfield water works, 164–170.
Westfield water works, 165–171.
Hampshire County, 165.
Amherst water company, 165–171.
Northampton water works, 165–171.
South Hadley Falls water works, 165–171.
Middlesex County, 172.
Arlington water works, 172–184.
Cambridge water works, 172–184.
Concord water works, 172–184.
Everett water works, 173–185.
Lincoln water works, 173–185.
Lowell water works, 173–185.
Malden water works, 173–185.
Medford water works, 173–185.
Melrose water works, 174–186.
Natick water company, 174–186.
Newton water works, 174–186.
Somerville, Mystic water works, 174–186.
Waltham water works, 175–187.
Winchester, Highland water works, 175–187.
Woburn water works, 175–187.
Wayland water works, 175–187.
Nantucket County, 188.
Wannacomet water works (Nantucket), 188–194.
Norfolk County, 188.
Brookline water works, 188–194.
Dedham water company, 188–194.
Plymouth County, 188.
Brockton water works, 188–194.
Hingham water company, 189–195.
Kingston aqueduct association, 189–195.
Plymouth water works, 189–195.

Water boards, etc.:
Suffolk County, 196.
Boston water works, 196–208.
Chelsea water works, 196–208.
Worcester County, 197.
Athol water company, 197–209.
Clinton water works, 197–209.
Fitchburg water works, 197–209.
Gardner water company, 197–209.
Leominster water works, 198–210.
Milford water company, 198–210.
Northborough water works, 198–210.
Southbridge water supply company, 198–210.
Spencer water company, 199–211.
Uxbridge water company, 199–211.
Webster water company, 199–211.
Westborough water works, 199–211.
Worcester water works, 199–211.
Recapitulation of water returns, 212; sources of supply, 212; lakes and large ponds, 212; rivers, 212; brooks, springs or small streams, 213; filtering galleries, 213; tubular wells, 213; areas of water-sheds, 214; topography of sources, 214; capacity of sources, 214; joint supplies, 214; other available sources, 215; pollution of supplies, 215, 219; analysis of waters, 215–219; fish, 219; finances, 219; capacity for storage, 219; results of sewage, 220; average daily consumption of water, 220; per cent. used by families, 221; estimated increase of demand, 221; water-rates, 221; systems of distribution, 222; disposition of effluent water, 222; protection desirable, 223; expense involved, 223.
Water in butter, 26.
Wax, 37.
Weight of bread, 22.
Well and cistern waters at Nahant, 239.
Whiskey vinegar, 65.
White wine vinegar, 66.
White, Dr. J. C., on contagion of leprosy, 127.
Wigner on food adulteration, 7.
Wine, 66.
Wines, beer and spirits, 7.
Wood-cutting and engraving, 113.