rate points so well as on the left side. When salt or sugar is placed on the two sides of the tongue, he observes that the sensation of taste is less acute on the right side. So little, however, is the patient incommoded by these various symptoms, that he denied their existence until minute examination proved them to be present. He has quite recovered his cheerfulness.

The result of the operation has satisfied me that the incision which I have employed is suitable for cases in which it is necessary to obtain free access to the parts at the back of the mouth, whether for ligature of a wounded carotid, or for the removal of a growth in the palate or back part of the upper or lower jaw, or fauces and tongue. The closure of the larynx in the manner described leaves the operator free to work in the enormous gap made by the incision; and hæmorrhage ceases to be so serious a complication as it otherwise is when a growth of any considerable bulk is being excised from the regions referred to.

October 1878. There has been no recurrence of the tumour; the patient is quite well and comfortable, and the scar is entirely concealed by the hair.

THE PURIFICATION OF WATER BY FILTRATION.

By J. LANE NOTTER, B.A., M.D., F.C.S.,

Surgeon-Major and Assistant Professor of Military Hygiene, Army Medical School, Netley.

THE subject which I have the honour to bring before you is one of the most interesting, and at the same time the most complex, on which I could address you. It is, indeed, surrounded with difficulties; and I am certain I need offer no apology for submitting for discussion a theme concerning which, I regret to say, there is much ignorance and misapprehension.

In dealing with my subject, my first object is to point out, in as plain language as possible, what is the nature of the substances we have to determine and eliminate if necessary, how this work may be accomplished, and what forces are expended in the process.

As you are all aware, pure water can only be found in the chemist's laboratory; absolutely pure water, containing only oxygen and hydrogen, it is almost impossible to produce. In the ordinary acceptance of the term, pure water does not require filtration; it should be free from suspended matter, and free from colour; water rendered impure by the admixture of fecal matters, or such substances as are known to be positively injurious, should be rejected at once. We need this process only when the water presents impurities the cause of which is suspected, but the consequences of using such uncertain. Now these latter are generally classed under the head of "organic matter"—a most comprehensive term, and which I maintain has been the cause of no small amount of confusion and clashing of opinions. And this brings me back to chemical contagia, a paper on which subject I had the honour of reading before this Association in Manchester last year.

In dealing with the complex quantity "organic matter", we are after all only adopting another phrase for contagium; for, unless this organic matter contains the spore or germ of a specific disease, it is at once conceded that it will not produce it; at least, such is the belief in the germ-theory of disease. It does not appear to me there has been, in connection with this subject, a proper study of the nature of the work a purifier has to perform. In endeavouring to eliminate specific germs, the special conditions under which they are produced must be considered, and these are evidently due to the intervention of something differing from those forces which we handle in our laboratories, as chemists. The chemical manifestations of the vital force in cellular organisms is lost sight of, and we appear to forget that many important conditions are developed by this vital force alone. It would perhaps be better to say that the change which takes place is due not so much to vital chemical force as to some special catalytic action exercised among the ultimate particles of the products originating in the nutritive processes of the organisms.

In my former paper, in discussing the spore-theory of disease, I endeavoured to show we had at least two things to consider: A. The organisms themselves; and B. The morbid products of their nutritive processes; and more recent observations have led me to think that this latter is by far the greater enemy of the two with which we have to contend. We know, for example, that cane-sugar, before it undergoes alcoholic fermentation, is hydrated, and thus split up, as occurs if acids are added, into two opposite glucoses: the ordinary glucose or grape-sugar, which causes the plane of polarisation to turn to the right, and lævulose or uncrystallisable sugar. This change was at first thought

to be due to the acid, but M. Berthelot showed that the active agent is a soluble, neutral, nitrogenous principle, *excreted* by the ferment, to which we can attribute no organisation, but which is directly derived from a living organism possessing the remarkable power of altering cane-sugar in a few moments, possibly by catalytic action, as no change appears to happen to itself.

We have here, then, two principles; viz., the cell itself, and the excreted product; and to this latter the force is due. Now, without such an exposition, it might be thought the force originally existed in the cell or organism, which would absorb all attention and divert it from the recognition of the ultimate source of disease or contagium, properly so called. The soluble ferments are derived directly from the living organisms in the midst of which they originate, nor can their specific character be transmitted to any artificial organic substance. I quote, as all important, the results of M. Bert's experiments, which prove that the action of chemical agents on soluble ferments is not quite to be compared with that exerted on organic ferments, for compressed oxygen destroys the organic ferments, while soluble ferments are not modified in their activity by it.

Again, every germ immersed in a liquid medium would attract to itself whatever may happen to be held in solution suitable for its nutrition; and this again, in due time, is broken down and cast off as effete matter, in which, after changes may take place. We have, then, in the generic term "organic matter" the following distinct products: A. The spore, or germ, or organism; B. The dissolved organic matter, ready to decompose and eliminate gaseous impurities, forming the pabulum of A; C. The morbid material resulting from its nutrition; D. Further morbid matter, originating probably by catalytic action in C. If, then, C and D are the real morbid matter, may they not be sometimes administered without A? We might then have cases (of enteric fever, say), giving all the symptoms, but without power of transmission; the subjective result to the patient might be the same, but the objective result with reference to other persons would be different. Again, perhaps a severe and a mild case might differ in this way: a severe case has A as well as B and C; in addition to the direct action of B and C, there may be progressive production of fresh B and C by the agency of A; A may also multiply itself, and thus the case would become objectively dangerous. A mild case, again, might suffer only from the direct effects of B or C, but the absence of A would make the manufacture of a further dose impossible, the case would also be objectively harmless from the absence of A. In this way some anomalies may be explained. This theory will account for Arnold Hillier's failure to discover any organisms and to attribute to chemical results changes which up to the present were only produced by living organisms. Arnold Hillier, it will be remembered, has recently extracted an albuminous body from putrid meat, in which he failed to discover any germ, but after the ordinary period of incubation, the rabbit into whose veins he had injected the extract died of intense blood-poisoning. At the same time, it must not be forgotten that the highest power of the microscope would fail to detect the gonidia of even the smaller algæ should their refractive index only equal that of water.

But organic matter is not confined exclusively to the animal world; we have vegetable organisms also to deal with. As a fact, no natural water—whether lake or river—is free from vegetable growth; microscopic examination reveals to us animal and vegetable life in abundance—rotifera and infusoria, oscillatoriaceæ and desmidiaceæ, the amber-tinted diatomaceæ, and mineral matters of various hue. Nor is it desirable that water should be altogether bereft of life. Some of the most impure waters I have ever analysed showed no trace of animal or vegetable life. It would seem as if the impurities were fatal, even to vegetable existence. Algæ alive and fresh, exhibiting a rich colour, are an evidence, I think, of wholesome water. It is only when these organisms undergo decay, which, as a rule, mostly takes place in the service-pipes in large towns, that it becomes unsuited for use. Light and high temperature appear to be the two great agents necessary for the development and growth of these algæ; and be it remembered, ordinary filtration through sand will not remove the spore or germ of plants; so that, under favourable conditions, filtered water, if kept, may be again liable to vegetable growth.

In the time placed at my disposal, I am unable to do more than briefly consider the organic impurities in water; and as these are by far the most important, I shall discuss filtration solely in reference to them, and dismiss from my paper all effect produced on mineral matters or on metals. These I hope to treat of at some future time. To repeat, organic matter may be suspended or dissolved. Filtration, in its simplest form, is only a mechanical process. It arrests the suspended particles which are in the liquid, and allows this latter to pass through. We have frequent examples of this in the large filter beds constructed by public companies, which are generally made of sand and gravel in

alternate layers. Its action may be said to be two-fold: it arrests at once the larger particles on its surface, while the smaller ones, by the force of adhesion to the sand and gravel, are separated. On the dissolved impurities, it has little action; when first used, a certain quantity of air is present within the pores and interstices of the sand, and this has some slight effect on oxidising a small quantity of the dissolved organic matter. Whether the amount of oxygen present in natural water plays any part in this oxidising power is an undetermined point. Gérardins evidently attaches great importance to it, and has suggested the amount of oxygen present should be taken as the index of purity or otherwise. It certainly would appear to have some effect. Both have often a perceptible influence in reducing the organic impurity, but the power is within very narrow limits, and uncertain and inefficient as a means of purifying polluted water. Wherever there is a public supply, the company should be compelled by law to deliver potable water fit for domestic use. At present, this is far from being the case; and the ordinary householder is obliged to submit the water he uses to the action of a purifying agent.

The success of a filter may be said to depend: 1. On the quantity and quality of the water passing through it; 2. On the character and suitability of the filtering media; 3. The form in which the organic matter exists; 4. The filter must be capable of being easily cleaned or the filtering material readily renewed, and its legitimate work will largely depend on this latter, for be it remembered no filter is self-cleaning. Charcoal, both animal and vegetable, is perhaps the most commonly used material for domestic filters. Animal charcoal is by far the most efficient, and the experiments I have made show that fragments are better than compressed blocks. Filtering through charcoal is generally supposed to rid water of organic matter; this is not the case, it simply changes the form of the organic matter to such an one as to render it innocuous. Animal charcoal has the property of condensing gases within its pores; in some cases, it is enabled to take up nearly its own weight of them. It greedily absorbs oxygen from the atmosphere, and this being in a condensed form, it is ready to oxidise any oxidisable organic matter with which it comes in contact. Charcoal simply changes the character of the organic matter; the compound undergoes no elimination, it is simply split up into its original form.

In the *Sanitary Record* of October 1876, I published the results of a series of experiments with albumen dissolved in distilled water, and passed through a silicated carbon filter. First, a known quantity of decomposing albumen was passed through, and it was found that 95 per cent. of the total amount was changed during filtration. Fresh albumen was next tried, and was found to be nearly unaltered by contact with the oxygen in charcoal; and it was not until decomposition had set in that the filter did its work. This fact is of great importance, as it distinctly shows that living or fresh organic matter is unaltered by filtering through charcoal.

The following results were obtained by experimenting many times on a large number of filters at Netley.

Filtration through Finely Granular Animal Charcoal.—The albumenoid ammonia is diminished 100 per cent., the whole being removed. The free ammonia is not increased (none in original). The organic oxygen is diminished 71 per cent.; the volatile solids 33 per cent. One of these filters experimented on was a metallic one. The water was allowed to remain in it for three weeks, when it was examined and found to contain zinc in large quantity, evidently dislodged from the galvanised coating of the iron. The total solids were more than doubled. On testing for free and albumenoid ammonia, the following results were found.

	Original Water.	After	After 3 Weeks
	Parts per 1,000,000.	Filtration.	in Filter.
Free ammonia ..	Nil.	Nil.	1.3824
Albumenoid ammonia ..	0.2152	Nil.	0.1440

The water had thus taken back from the charcoal about two-thirds of the albumenoid ammonia, and had also absorbed a large amount of free ammonia.

Filtration through a Silicated Carbon Filter.—There is an increase in the mineral matter; the albumenoid ammonia is only diminished 6 per cent.; the free ammonia is unaltered; the organic oxygen is diminished 39 per cent. The conclusion we arrived at was that a loose material was better than a solid block for filtering purposes, and that, in the case of charcoal, a certain amount of compression is necessary, as the results were not the same when similar charcoal was placed in funnels and the water passed through them. Treated in the same manner as the granular charcoal, the results were:

	Original Water.	After Filtration.	Aft. 3 Weeks in Filter.
	Parts per 1,000,000.	Parts per 1,000,000.	Parts per 1,000,000.
Ammonia, free..	Nil.	Nil.	0.0800
Ammonia, albumenoid ..	0.2152	0.2023	0.1420

The water had taken up a small quantity of free ammonia, but appears to have diminished its albumenoid by longer contact with the filtering media.

Spongy Iron Filter.—This, treated similarly, gives the following results.

	Original Water.	After Filtration.	Aft. 3 Weeks in Filter.
	Parts per 1,000,000.	Parts per 1,000,000.	Parts per 1,000,000.
Free ammonia ..	Nil.	Nil.	Nil.
Albumenoid ammonia ..	0.2152	0.0720	Nil.

The water has taken up nothing from the filtering material, but has got entirely rid of its albumenoid ammonia by prolonged exposure to the filtering medium.

A further series of experiments to test the keeping power of water passed through various filtering media.—A sample was placed in a stoppered bottle, and in a bottle unstoppered. After a considerable number of days had elapsed, they were carefully examined. The original water contained very little sediment, and showed none on being kept.

1. **Granular Charcoal Filter.**—In both the stoppered and unstoppered bottles, a reddish yellow deposit showed itself, which under the microscope appeared to be granular, with numbers of moving particles—the sphærobacteria of Cohn.

2. **Silicated Carbon Filter.**—No trace of sediment in stoppered bottle; a little in the open sample, containing a few micrococci and one or two infusoria.

3. **Spongy Iron Filter.**—There is no trace of sediment or organisms of any kind. With reference to spongy iron as a filtering medium, we found that its action on hard water was much more satisfactory than on soft waters. Iron is exceedingly soluble in soft water, and the action of the prepared sand in removing the iron is not nearly so effective as when hard waters were used, as these latter take up a smaller percentage of iron.

From the foregoing experiments we may, I think, adduce the following facts:

1. Filtration through sand is simply mechanical for the most part, and not to be depended on as a purifier.

2. Water may be purified by animal charcoal to a large extent; that its action is extremely rapid on decomposed organic matter; that fresh organic matter passes through unchanged; and that water should on no account be stored after filtration, as this matter subsequently decomposes, giving rise to low organisms. It is advisable not to leave the water in contact with the animal charcoal for a lengthened period, as it again takes up impurities from the medium.

3. That spongy iron is undoubtedly the best filtering material. Its action is not so rapid as charcoal, but there is no danger in prolonging the contact with the water. As far as my experiments go, it is the only safe filtering medium we have at present. It appears to act on all organic matter, whether fresh or decomposed, whereas charcoal acts more as a dialyser when colloidal substances are fresh and in a state of extreme dilution, and are certain to decompose after filtration.

One feature of filtering through charcoal must not be lost sight of: that charcoal becomes exhausted of its oxygen, and that foul gases held in solution by the water may replace it. Its action is limited, and it requires constant attention. I regret time will not permit me to enter more fully into this subject; I trust, however, the few facts I have submitted may not have been uninteresting or unimportant.

ASTHENOPHIA OCCURRING IN WOMEN ABOUT THE CLIMACTERIC PERIOD.

BY CHARLES HIGGINS, F.R.C.S.,

Ophthalmic Assistant Surgeon to Guy's Hospital; Lecturer on Ophthalmology at Guy's Hospital Medical School; etc.

CASE I.—Mrs. J., aged 46. May, 1875. The eyes had been irritable and painful at times, and there had been inability to do near work for about a year. No assistance had been obtained by use of glasses. Both eyes were myopic, $\frac{1}{20}$; v. = $\frac{2}{30}$. The ophthalmoscope showed hyperæmia of the optic discs and retina. Menstruation was extremely irregular, and at times excessive. She was ordered to use —20 for distance and writing; to rest the eyes as much as possible; and to use no glasses for reading, etc.; to bathe with cold decoction of poppy-heads and iced water occasionally. This patient continued under observation, but the condition of the eyes remained the same for the next two years. Recovery has since taken place, and menstruation has ceased, or nearly so.

CASE II.—Mrs. B., aged 44. August, 1875. The eyes had become extremely irritable, and so painful at times that near work was impos-