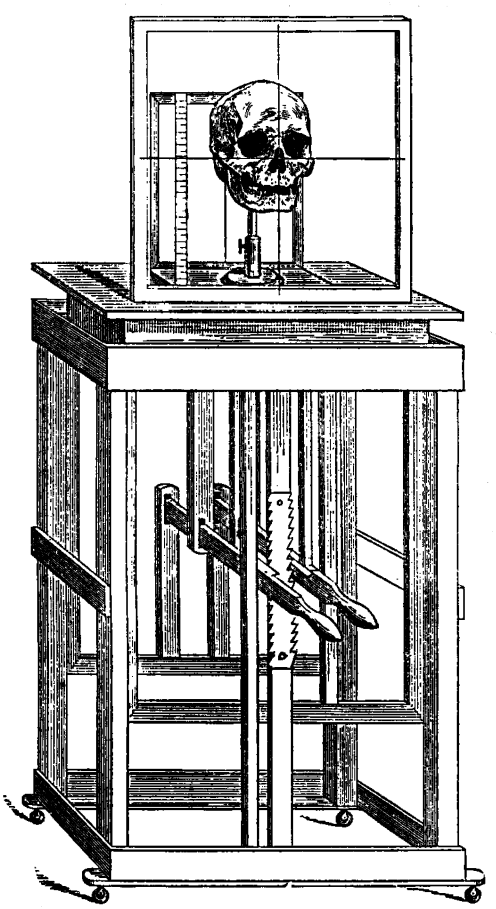
ments d'anthropologie générale' (Paris, 1885), states that the chief difficulties with water are: first, that the water, wetting the sides of the measuring-glass, rises on it, and makes it impossible for the observer to read correctly; and, second, that the water penetrates to the sinuses and vacuoles of the skull, and returns, when the skull is drained, to augment unduly the water belonging to the cavity proper. The experiments of Dr. Matthews indicated that the greatest source of uncertainty lay in the fact that the skull, when moistened, increases rapidly in cubic capacity. His method is as follows:—



ELEVATING-TABLE, CRANIOPHORE, AND CROSS-LINE FRAME FOR ADJUSTING SKULLS IN COMPOSITE PHOTOGRAPHY.

After recording the weight of the skull, it is varnished inside with thin shellac varnish, applied by means of a reversible spray apparatus. Artificial or accidental orifices are closed with India-rubber adhesive plaster. The foramina and fossae are filled with putty. The skull is wrapped in a coating of putty an inch or more in thickness, which renders it water-tight. It is filled with water by special apparatus in forty-five seconds, and emptied in fifteen seconds. The rapidity of this manipulation, in conjunction with the varnishing, prevents soaking into the sinuses, and the undue measurement of water which does not pertain to the cranial cavity. The water is poured into a measuring-glass of two thousand cubic centimetres capacity, and lycopodium is scattered on the water to define the true surface. The putty is taken from the skull: the latter is cleaned, and placed in a dry, warm apartment, until by slow evaporation it has been reduced to its former weight, and consequently to its former capacity. Then it is measured a second time to verify the results of the first measurement. The author did not claim rapidity as an advantage of the system, but believed that it removed to a great extent the effect of varying muscular effort, which was such a disturbing factor in other methods. "With the most important operations, the unchangeable element of time takes the place of the fickle element of vital force."

Although the method is new, and still susceptible of improvement, it is thought that the results as shown in the following table have not been excelled.

Comparative measurements of varnished and unvarnished skulls.

	Museum number of skull.	Unvarnished.			Varnished.			Date of measurement.	
		First measurement.	Second measurement.	Difference.	First measurement.	Second measurement.	Difference.		
		c.c.	c.c.		c.c.	c.c.			
1	199	1,400	1,390	10	1,400	1,400	–	March 26	April 2
2	359	1,450	1,445	5	1,450	1,450	–	" 23	" 3
3	362	1,275	1,270	5	1,270	1,265	5	" 26	" 2
4	373	1,455	1,455	–	1,450	1,450	–	" 24	" 2
5	375	1,305	1,305	–	1,300	1,300	–	" 24	" 3
6	481	1,455	1,455	–	1,445	1,445	–	" 24	" 2
7	1,516	1,160	1,155	5	1,160	1,160	–	" 23	" 3
8	1,914	1,285	1,280	5	1,285	1,285	–	" 27	" 3
9	1,915	1,450	1,440	10	1,440	1,435	5	" 21	" 2
10	2,034	1,200	1,195	5	1,190	1,190	–	" 26	" 2
	Sum of	differ	ence.	45	. .	. .	10		

Average variation in unvarnished skulls . . . . . 4.5 c.c.
Average variation in varnished skulls . . . . . 1.0 c.c.

THE CULTIVATION OF MICROBES.[1]

IT is possible to obtain a perfectly sterile liquid (that is to say, one deprived of all living germs) by one of four methods:—

1. Filtering through some material whose meshes are sufficiently fine to arrest the smallest organisms. The only material really practicable for this purpose is the unglazed porcelain used by Pasteur and Chamberland.

2. Obtaining the liquid directly from the internal organs of one of the superior animals; the digestive tract being considered, for this purpose, an *external* organ. Pasteur's experiments have shown that the

[1] Abridged from an article by Dr. HERMANN FOL of the University of Geneva, in *La Nature*.

tissues of such animals are the most perfect filters known, neither permitting the entrance, nor tolerating the existence, of any foreign material, unless the tissues are diseased.

3. Sufficiently prolonged exposure to a temperature of at least 110° C. This is the lowest necessary for the destruction of spores, although 80° C. is sufficient to kill bacteria in the growing condition. The length of the exposure must not be less than an hour: the longer the time beyond this, the greater the security.

4. Intermittent heating, invented by Tyndall, and much used in Germany. This consists in making the spores germinate, in order to kill the full-grown bacteria at 80° C. For this purpose, the vessels containing the fluid to be sterilized are kept at 20°–30° C. to favor the growth of the spores, and are every day raised to 80° C. for one hour, to destroy such bacteria as have become fully developed. This method takes much time, and its results are always uncertain. [This is the French point of view, but must not be accepted as that of the best authorities. — ED.]

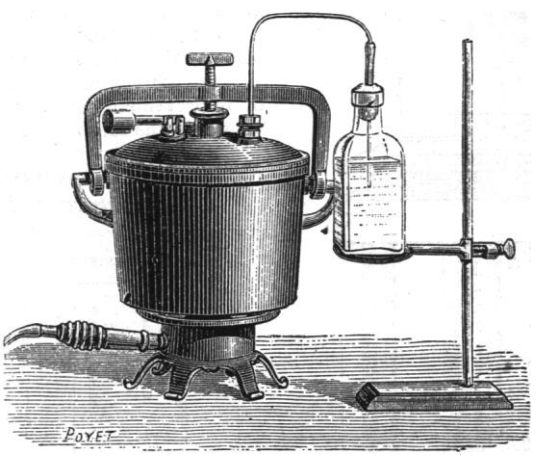


FIG. 1. — PAPIN'S POT, WITH THREE OPENINGS.

Of all these methods, the third, that of destroying the germs once for all, is the one giving the greatest security and ease of manipulation. It has but one fault, that of coagulating all albuminous substances which can be solidified at the temperature of boiling water. [This fault is a very great one, and at once excludes the use of blood-serum as a culture-medium. — ED.]

The latest and best method for employing this process is as follows: The first thing is to close the vessels meant to contain the sterilized liquids with stoppers permeable to air. The method of doing this will be described later. The flasks are then kept at a temperature of 160° C. for at least three hours. If the temperature be higher, sterilization will occur sooner, but the cotton stoppers will be charred. The furnace in which this sterilization is done should be double-walled, but its form is unimportant. The flasks should be allowed to cool slowly to prevent breakage; and, as the rarefied air contracts, the air which enters is well filtered by the cotton plug.

The second step consists in preparing the sterilized liquid, and introducing it into the flasks. The *bouillon* of Miguel is the best we know of, and is this: Take of lean meat (beef) one kilogram, and boil it in four litres of water for five hours; skim it, and let it stand over night in a cool place; then take off the fat, and neutralize the fluid with caustic soda; filter, put in water up to four litres, and boil for ten minutes.

Prolong this second boiling to an hour, and do it in a Papin's pot, at 110° C., after putting in forty grams of common salt. Then the liquid, cooled, and passed through a double filter, is again placed in the Papin's pot for three hours, which completes the sterilization. Instead of this natural *bouillon*, the following may be used: —

	Grams.
Peptone (chemically pure)	5
Basic phosph. soda	10
Ammon. muriat.	5
Liebig's extract	5
Cane-sugar	20
Cooking-salt	3
Water	1,000

Boil, filter, and sterilize as above. The result depends upon the quality of the peptone. If a nutrient gelatine be desired, put from twenty-five to thirty grams of pure colorless gelatine into either of the above fluids before the last filtering. This last should then be done through a hot filter. The other manipulations are the same, except that the sterilization must not be prolonged more than an hour; for, if it is, the gelatine loses its power of solidifying. Agar-agar may be used instead of gelatine, and remains solid at 30° C. It is only partially dissolved in boiling water, but is completely so at the end of an hour at 110° C. in Papin's pot. Filter hot, and again sterilize at 100°

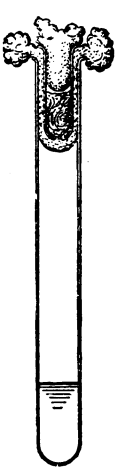


FIG. 2. — PRESERVATION TUBE.

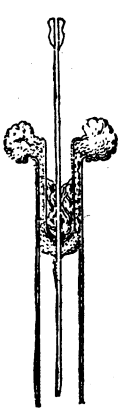


FIG. 3. — STOPPER OF PRESERVATION TUBE, WITH TROCAR POINT.

—120° C. Agar-agar will stand any amount of prolonged heat.

The pot in which the sterilization is done has three openings (fig. 1). One is for the safety-valve; the second, for the thermometer, has a tube closed at the bottom to prevent pressure upon this instrument; and the third is conical, closed with a cork kept in place by a handle and thumb-screw. A metallic tube,

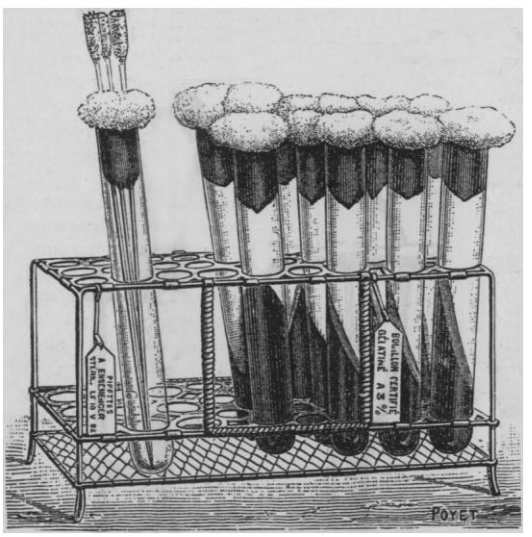


Fig. 4.—Rack for preservation tubes.

bent twice, passes into the chamber. The free end is connected by rubber tubing, kept closed by a spring, to a short metal tube with a trocar point, and an opening near the extremity in the side.

After the fluid has been sufficiently sterilized, upon introducing the bent tube into the upper part of the chamber, and opening the spring, the vapor is forced out. Allow it to run for a few moments, heat the trocar end of the tube, work this through the cotton stopper of a sterilized flask, and the nutrient fluid will be gradually passed over into the flask.

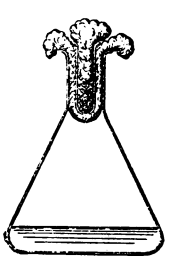


Fig. 5. — Conical culture-flask.

To obviate the difficulties in the way of piercing the ordinary cotton plug with safety, small test-tubes with a flaring mouth, and a hole in the bottom, are placed in the mouths of the flasks, with cotton outside and flax at their bottoms. Above the flax is a plug of cotton (fig. 2). The trocar point can be easily forced through the flax and the thin layer of cotton underneath, if the upper plug be removed (fig. 3); and this method seems to offer the easiest and most certain manner of filling the flasks or other vessels. For cultures, I prefer test-tubes placed in racks of iron wire (fig. 4), or conical flasks with flat bottoms (fig. 5).

Accidental contamination is the one thing to be avoided in these proceedings, which is attained by heating every thing used for sowing, etc., to 300° C.; the objection to this being the difficulty of getting the instruments cool enough not to destroy the germs which we wish to use, and at the same time not cool enough to take in impurities. Manual dexterity teaches much, but more vigorous measures are better still.

I first sterilize all my instruments in test-tubes with flax stoppers, through which they pass. Such are glass pipettes, pointed, with an opening at the

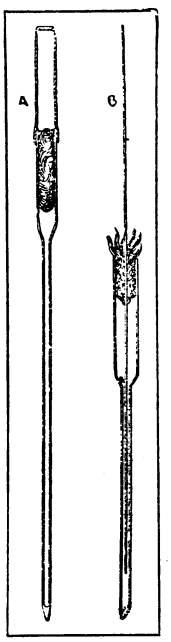


Fig. 6. — Pipette and platinum needle.

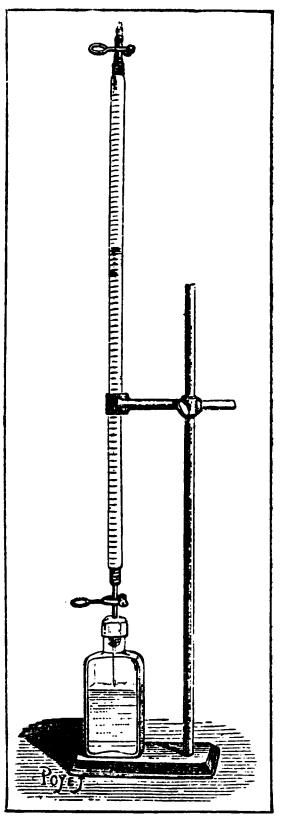


Fig. 7.—Graduated burette.

side, and plugged at the other end with cotton-wool or flax (fig. 6, *A*). When in use, this end has a rubber cup over it, by means of which the fluid may be drawn up or expelled. For more solid materials, I use knitting-needles, or platinum wire in straight tubes with open bevelled ends (fig. 6, *B*), and, for sowing, push the point of the needle through the open end of the tube. In transferring a pure culture from one flask to another, these means are sufficient; but, with mixed cultures, separation of the various forms must be accomplished, which may be done by culture fluids or nutrient gelatine.

For fractional cultures in liquids, the principal

instrument needed is a round burette, tapering at both ends, and graduated so that the mark 100 is exactly at the lower orifice, and the mark 0 a few centimetres below the upper (fig. 7). On each extremity is placed a rubber tube closed by a spring. Before using, I disinfect the apparatus by passing sulphurous acid through it, and then attaching it to a Papin's pot filled with water at 110° C. for an hour. In fifteen minutes all trace of the sulphurous acid has disappeared, both rubber tubes are closed, their ends plugged with sterilized flax, and the burette left to cool. In cooling, a perfect vacuum is produced in the tube. I affix to the lower rubber tube a pointed canula, sterilized *at the time* by a current of steam or the flame, introduce it into a flask of *bouillon* kept for three or four weeks at 30° C. (to prove its complete sterilization), open the lower spring, and the burette is filled immediately: the fluid is allowed to rest at the mark 0.

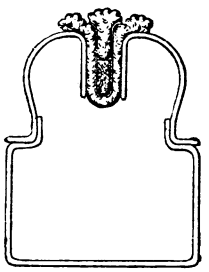


FIG. 8. — GLASS CULTURE-FLASK.

The apparatus being thus prepared, a very dilute portion of the fluid, or a small piece of the substance containing the organisms to be separated, is introduced at the top of the burette. The dilution must be great; for the contents of the burette can only be

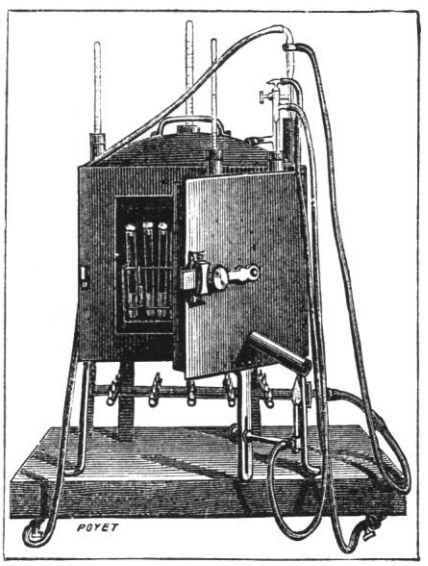


FIG. 9. — WIESNEGG STOVE.

distributed among twenty-five tubes, and more than two-thirds of these tubes must become inoculated in order to the success of the experiment. If it be desired to determine the number of germs in a given specimen of water, put a very minute quantity into the burette filled with sterilized *bouillon;* mix the two thoroughly, thus obtaining an equal distribution of the germs; introduce the canula of the burette, immediately after heating, through the plug of a sterilized tube; allow four cubic centimetres of the fluid to flow from the burette; and so on for twenty-five tubes.

If all the tubes become cloudy, it is because the amount of water used was too great; and this amount must be reduced until only a portion of the tubes show any sign of life. With water full of bacteria,

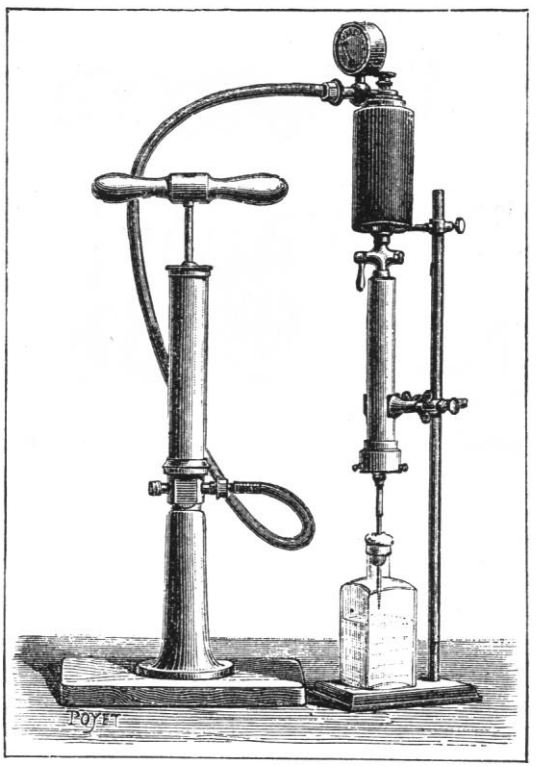


FIG. 10. — CHAMBERLAND'S FILTER.

the quantity to be used is too small for exact measurement; and then two burettes are used, the one full of water, and the other of *bouillon.* A drop of the suspected water is placed in the first, and then this dilution is used with the *bouillon*, as before. A simple arithmetical calculation then gives the approximate number of germs in a given quantity of water.

The first experiments of Pasteur and Tyndall were imperfect in method; Miguel used a flock of cotton in a glass tube, through which he filtered the air, and then washed the cotton in sterilized *bouillon:* my improvement is to substitute a powder, soluble in the nutrient fluid, for the cotton; and for this purpose I use common salt, well sterilized. This salt may be turned into the burette, and the calculation made as before.

The results obtained by fractional culture are at the

best but approximate; but even these are better than the results from cultures scattered over gelatine surfaces. This method, however, is good as a preliminary, and is in brief as follows: A definite quantity of the suspected water is placed in a measure of nutrient gelatine; this is softened by heat, and the two are thoroughly mixed; and the gelatine is then allowed to harden in a test-tube, or in such a flask as is shown in the figure (fig. 8). The flat, thin surface thus obtained makes it more easy to count the colonies which will appear in a few days. For air-germs, the soluble powder spoken of above is the material to be placed in the nutrient gelatine.

The objections to the method are, that many species of bacteria develop very slowly at the temperature of the air and in a solid medium, and are obscured by other more rapidly growing colonies. The same objections hold in separating the germs in any pathological process.

The method of fractional sterilization used by the Germans is only useful where egg-albumen, or other substances coagulable by heat, are to be employed for culture-media. For this purpose I use a furnace (fig. 9) designed by myself, and manufactured for me by Mr. Wiesnegg. It serves its purpose well, and is much better than that of Koch. It is of double-walled copper, the intervening space being filled with water. This space has openings for thermometer and regulator. The door is double-walled, filled with water, and has its special heater, and it is kept at exactly 75° C. Tubes containing the material to be sterilized are placed in this furnace for one hour daily to kill the full-grown bacteria, and during the rest of the time are kept at 35° C. to favor the growth of the spores. In ten or twelve days the greater part of the tubes will be found to be fully sterilized.

Far better than this is the method of filtering through a substance sufficiently fine to retain all germs, successful results having been long obtained by Pasteur by filtering through plaster. Chamberland's method through porcelain is, however, the best (fig. 10), and is perfectly satisfactory provided the porcelain tube is good. This latter is difficult to obtain. Diluted egg-albumen and blood-serum may be easily filtered in this way, although slowly, under a pressure of from two to three atmospheres. Great care must, of course, be taken, to prevent the contamination of the material after it leaves the canula.

This method of sterilization is peculiarly appropriate for certain animal fluids whose chemical composition is changed by heat, but which it may be necessary to employ as culture-media for certain forms of bacteria.

TRANSPORTATION OF PETROLEUM TO THE SEABOARD.[1]

THE interest in the late project for forcing water for army purposes over the broken and elevated country between Suakin and Berber by means of pipes has called attention to the extent, importance, and utility of the pipe-lines in our own country, which convey the crude petroleum of the region lying between the Alleghanies and Lake Erie to the shores of that lake and the Atlantic seaboard.

The exploitation of these regions by means of artesian wells began about twenty-six years ago. By June, 1862, 495 wells had been sunk near Titusville, and the daily output was nearly 6,000 barrels, selling at the wells at from $4 to $6 a barrel. But as the production increased with rapid strides, the market-price fell with a corresponding rapidity, making the transportation charges to New-York City a considerable proportion of the total cost.

The question of reducing these enormous transportation charges was first broached, apparently, in 1864, when a writer in the *North American* of Philadelphia outlined a scheme for laying a pipe-line down the Allegheny River to Pittsburgh.

Originally the oil was carried in 40 and 42 gallon barrels, made of oak, and hooped with iron: afterward tank-cars were introduced. These were at first ordinary flat cars, upon which were placed two wooden tanks, shaped like tubs, each holding about 2,000 gallons. On the rivers, bulk-barges were also, after a time, introduced on the Ohio and Allegheny. At first these were rude affairs, and often of inadequate strength; but, as now built, they are 130 by 22 by 16 feet in their general dimensions, and divided into eight compartments, with water-tight bulk-heads. They hold about 2,200 barrels. In 1871 iron tank-cars superseded those of wood, with tanks of varying sizes, ranging from 3,856 to 5,000 gallons each. These tanks were cylinders 24 feet 6 inches long and 66 inches in diameter, and weighed about 4,500 pounds.

Among the very first, if not the first, pipe-lines laid, was one put down between the Sherman well and the railway terminus on the Miller farm. It was about 3 miles long, and designed by a Mr. Hutchinson: he had an exaggerated idea of the pressure to be exercised, and at intervals of 50 to 100 feet he set up air-chambers 10 inches in diameter. The weak point in this line, however, proved to be the joints. The pipes were of cast-iron; and the joint leakage was so great, that little if any oil ever reached the end of the line, and the scheme was abandoned in despair.

In October, 1865, the Oil transportation company completed and tested a pipe-line 32,000 feet long. Three pumps were used upon it, — two at Pithole, and one at Little Pithole. The first plans to extend such lines to the seaboard seem to have been made in 1876, when the pipe-line owners held a meeting to organize a pipe-line company for this purpose; but the scheme was never carried out. In January, 1878, the Producers' union organized for a similar seaboard line, and laid pipes; but they never reached the sea, stopping their line at Tamanend, Penn. About four years ago the National transit company was organized, and succeeded to the properties of the American transit company. Its lines, illustrated on the accompanying map, were completed in 1880–

[1] Abstract of an article in the *Engineering news* of last week, from advance sheets furnished by the courtesy of the editor.