characteristic, but does not commit us to a theory as to its pathological effects.

THE MICROCOCCUS CATARRHALIS.

Gram negative cocci were observed in ten out of the twenty-one cases—that is, 48 per cent. These had the characteristics of the *Micrococcus catarrhalis* as described by Gordon.¹¹ In the two cases in which a pure culture was obtained I passed the organism through the carbohydrate media, the results agreeing with those given by Dr. Gordon,¹¹ and also with the reactions given by a laboratory culture which he kindly sent me; these results are shown in Table IV.

TABLE IV.

	Gram.	Glucose.		Lactose.		Saccharose.		Maltose.		Litmus Milk.		Potato.
		3	7	3	7	3	7	3	7	acid	clot	
Case XV, T ₁ a ₁	±	—	—	—	—	—	—	—	—	—	—	—
„ XVI, N ₁ a ₁₁	—	—	—	—	—	—	—	—	—	—	—	+
Dr. Gordon's specimen	—	—	—	—	—	—	—	—	—	—	—	—

Dr. Gordon states that these reactions are sufficient to differentiate the *M. catarrhalis* from all other cocci. It is a somewhat large coccus. It grows rather more slowly than the diphtheroid bacilli, and its growth on ordinary media is uncertain. On nasgar it gives in two or three days a vigorous growth consisting of well defined, discrete, round colonies, yellowish-white in colour. Under a low power of the microscope the edges of the colonies are seen to be even and well-defined, and not thinned at the periphery. On gelatine at 22° C. I obtained a fairly good growth in one case, but in the other and in the laboratory culture it failed to grow. On ordinary agar at 37° C. it was sometimes possible to obtain a growth, when inoculated from a pure culture, but if mixed with more vigorous organisms, such as staphylococci or diphtheroids, it is usually overgrown by them. Hence the need for a medium such as nasgar, which encourages its growth.

Fig. 8 shows the microscopic appearance of a three-day culture of *M. catarrhalis*.

Fig. 8.—*Micrococcus catarrhalis*, stained carbol-fuchsin. × 1,000 diameters.

CONCLUSIONS.

1. Both diphtheroid bacilli and the *Micrococcus catarrhalis* were present in my series of cases, but Pfeiffer's bacillus was present only in such small numbers as to be negligible.

2. Other organisms were present in much the same proportion as in normal throats and noses.

3. The diphtheroid organism present conformed to the description given by Cautley³ of the bacillus discovered by him in 7 out of 8 cases of common cold, and confirmed by Gordon⁴ and Prosser White.⁵

4. The diphtheroid bacillus isolated gave reactions in carbohydrate media which serve to differentiate it from diphtheria on the one hand and xerosis and Hofmann on the other.

5. The question of the exact symptoms, if any, caused by the diphtheroid bacillus and the *Micrococcus catarrhalis* respectively cannot be said to be settled. In view of the fact that nasal discharge was not a prominent feature of my series of cases, it seems likely that the diphtheroid organisms are rather a cause of a painful sore throat, with headache, malaise, and muscular pains, irritable cough,

and scanty viscid expectoration. Whether they cause coryza—a cold in the head—is at least open to question, especially in view of the presence of *M. catarrhalis* in nearly half my cases.

6. It seems therefore best to give a name such as *Bacillus septus*, which does not assume a knowledge of the pathological significance of the organism, or to refer to it as "Cautley's bacillus."

7. Its occurrence in as many as 95 per cent. of cases nevertheless makes it almost certain that it is of importance in the etiology of a common cold.

I hope to carry out further investigations on this subject, and trust that it will receive both from bacteriologists and clinicians more attention than in the past. In view of the recent work on diphtheroid organisms in general paralysis of the insane, I cannot help feeling that we are on the eve of a great advance in our knowledge of the pathology of some obscure diseases. Possibly even the common cold, neglected and despised, may be found to have a place in the etiology of some serious diseases, hitherto unexplained.

[P.S.—I should like to thank Mr. Edmund Spitta (joint author of Slater and Spitta's *Atlas of Bacteriology*) for his kindness in taking the beautiful high power photomicrographs which illustrate this paper, Figs. 4, 5, 6, 7, and 8.]

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THE DIFFUSION OF RED BLOOD CORPUSCLES THROUGH SOLID NUTRIENT AGAR.

BY SURGEON H. C. ROSS, R.N.

WHEN blood is planted on the surface of some solid agar in a tube a remarkable diffusion of the red corpuscles takes place under certain conditions, appearing as an opaque cloud descending from the drop of blood placed originally in the tube. This diffusion appeared to me so interesting that I was led to investigate it further; to make a series of experiments in the endeavour to elucidate the conditions under which it takes place, and to record some measurements under the different circumstances.

If an ordinary sterile tube of nutrient agar is taken and a drop of blood is placed on the surface of the slope, coagulation will occur in the usual way, and the drop will remain clearly defined, showing bright red against the yellow tinge of the medium. Provided the surface of the agar has not been injured by the platinum loop or other instrument used for inoculating the tube the blood will remain on the surface, and will not soak in at ordinary temperatures, no matter how long the tube is kept. When the blood has coagulated the tube may be inverted or placed in any position without the blood running, as the clot adheres to the smooth surface of the agar.

CONDITIONS UNDER WHICH THE RED CORPUSCLES ARE DIFFUSED.

If a tube containing the sloped agar with a drop of blood implanted on it be incubated at 42° C. a curious change takes place. This begins to make its appearance in about twelve hours. The original drop of blood on the surface looks just the same; but it will appear as if some of the blood was extending downwards from it into the substance of the medium, a red cloud, thick and opaque, spreading in a semicircle from the drop and getting

thinner as it extends. This cloud is shown by the microscope to consist of entire red corpuscles, diffusing through the solid medium. The longer the tube is kept in the incubator the greater the depth the cloud attains, until a certain limit is reached, when the diffusion stops.

The phenomenon takes place very slowly at a temperature of 37° C. and rapidly at 60° C. At 35° C. no diffusion occurs, even if the tube be incubated for a fortnight; but from 37° C. upwards to the melting point of the agar a very marked diffusion occurs. Gravity does not affect it. Two tubes were prepared and placed side by side in the incubator, one being inverted; the diffusion occurred with equal rapidity in both.

The time the blood has been removed from the body does not appear to affect the diffusion. A tube was inoculated with blood and kept at the room temperature for six weeks without showing any signs of diffusion. It was then incubated, with the result that the cells diffused in the usual way. The quantity of blood planted on a given area of surface of the agar appears to govern the extent of the diffusion. The median basilic vein of a man's arm was tapped and an agar slope was covered with a thick film of blood. A control tube had a small drop of blood placed on the slope. In the control tube the drop of blood ceased to diffuse in twenty-four hours, whereas in the other tube diffusion did not cease for a week, when the agar looked like a mass of solid blood.

Blood can be raised to a temperature of 50° C., and then planted without preventing the diffusion.

Mixing the blood with water prevents diffusion of the cells owing to their rupture; but the haemoglobin will diffuse, colouring the agar a deep claret colour. This coloration is entirely different from the appearance given by the corpuscles when diffusing unbroken.

A good way to demonstrate the phenomenon is to take a sterile agar tube in which the agar has been sloped, and to plant out a large drop of blood from the pricked finger with a sterile platinum loop. The tube should then be incubated at a temperature of about 42° C. for forty-eight hours. The position of the tube is immaterial. When it is taken out of the incubator the cloud is noticeably spreading into the agar away from the drop on the surface. The tube should then be broken and the solid agar removed if possible without breaking. With a platinum loop a minute portion can be extracted from that part of the agar which is immediately below the original drop of blood. Care must be taken not to let the upper or smooth sloped surface be touched by the wire, or it may be contaminated with cells from the original drop of blood. For the same reason the sloped surface should not be wounded, although the particle to be examined should come from as near it as possible. This particle will be a red colour and opaque, quite different in appearance from the rest of the transparent medium. It can then be placed on a slide, and gently pressed out with a coverslip.

On examining it with a low power, the red cells can usually be made out, provided it has been taken from near the surface; but if it is derived from near the advancing edge of the cloud, nothing but large granules will be seen. The cells, tending to become degenerate, appear separated from one another, and in fact they look as if they had been carefully embedded in the agar one by one. It is rare to find two cells together, they all seem to be an equal distance apart. On examining them with a higher power, using a strong light, they appear rounded and granular, the granules being of different sizes. The further from the original drop of blood the specimen is taken, the fewer cells appear, and their place seems to be taken by large granules which will not stain by any ordinary aniline dye.

A METHOD OF WATCHING THE DIFFUSION MICROSCOPICALLY.

This necessitates a warm stage that will maintain a fairly accurate temperature for many hours at a stretch. I used one of my own design, which roughly consists of a small electric resistance enclosed in ebonite of such a shape that it will rest on top of a microscope slide. The actual wire of the resistance is separated from the slide by mica. There is a square gap in the ebonite box for the specimen and objective of the microscope. This warm stage, or rather slide warmer, is in series with a Nernst lamp, which admits 1 ampère of current to it. The heat

generated by this warm stage is great, and will raise the temperature to 60° C. in a room with a temperature of about 65° F. To maintain the temperature of the slide at as near 39° C. as possible, I have designed a special slide fitted with a thermostat. This slide contains along one border a coherer of brass filings embedded in wax, which is a perfect conductor of electricity up to about 40° C., when it decoheres. On cooling to 37° C. the filings again cohere and their conductivity is re-established. The coherer in the slide is connected by wires to two terminals on the warm stage which keep the warm stage in place, and which are in their turn connected with a relay and two cells all in series. The decohesion of the filings causes the relay to short circuit the main current to the warm stage, and the cohesion of the filings opens the current to it. In this way the current to the warm stage is alternately being made and broken by the coherer, maintaining the slide at a temperature varying between 37° and 40° C. These slides are very fairly accurate, and last for many hours.

Procedure.

Some agar is melted, and a drop of it poured on to the centre of a coherer slide so as to form a thin film when it sets. The lateral portions of the film are removed with a knife to accommodate the warm stage. A shallow groove, $\frac{1}{4}$ in. long, is made transversely in the agar, care being taken that it is not deep enough actually to pierce it. The groove is best made with the elbow of a wire bent at an angle of 45 degrees. A similar film is then made on a coverslip, and, when set, the centre portion is removed with a sharp knife so as to leave a ring of agar round the edge.

The smallest possible drop of blood is placed in the groove without letting any cells flow over the edges, and the coverslip is placed in position on top of the groove in such a way that there is no agar actually on top of it, though it exists all round. If by accident the coverslip touches the groove it will be emptied of blood by capillarity. The warm stage is then slipped on and the coherer wires connected to it, and the slide and stage are then carried bodily to the microscope and focussed. Until the agar has settled down a little it is as well not to use a higher power than a $\frac{3}{4}$ in. After a little time $\frac{1}{4}$ in. may be used. The groove appears to have an irregular outline, and that part should be chosen where it is fairly straight and where there are plenty of cells in apposition to it.

The cells look as if they were in layers superimposed one on top of the other, and the depth of these layers can be gauged by careful focussing. A deep layer should be watched. At first there are streams in the blood, and the corpuscles will flow with the current; it is noticeable that the leucocytes tend to adhere to the agar. After an hour or two the cells will show a tendency to become elongated with their long axis at right angles to the edge of the groove, and the border of the mass of blood will become more and more irregular. Slowly parts of the edge are protruded, and there appears to be a steady advance of the whole of the layer of corpuscles. As they advance they separate one from another and become smaller and smaller, becoming all the while more and more degenerate and granular. Ultimately they become so small that they appear as granules. No leucocytes or blood plates can be seen in the advancing edge.

An Endeavour to ascertain the Fate of the Leucocytes and Blood Plates.

As repeated examination of the agar with blood diffusing through it has not revealed any signs of the leucocytes or blood plates, I have endeavoured to find out what becomes of them. The procedure was practically the same as before, except that the agar had been previously mixed when melted with an equal volume of polychrome methylene-blue, and that there was no groove made in the film. A drop of blood was placed on the surface and a ringed coverslip applied. As the coverslip did not touch the drop anywhere it retained its original dimensions. The leucocytes take up the stain from the agar, their granules staining red.* The red corpuscles become a homogeneous mass and slowly appear to go out of focus. The leucocytes, on the other hand, seem to remain in focus and to become greatly enlarged with their

* I am indebted to my brother, Professor R. Ross, for suggesting this method.

granules collected at their edges. Ultimately they rupture and atrophy, the granules separating and giving up their stain.

This giving up of the stain after about six hours is a curious phenomenon, and I think that some of the non-staining granules found in the diffusing blood are derived from this source.

The blood plates are more difficult to follow owing to the difficulty of using an immersion lens, and to the fact that they will not take up the stain from the agar so well as the leucocytes do. Some of them can be seen remaining for a time on the surface, and from the close resemblance to these bodies of some of the granules seen in the advancing edge of the diffusing blood I am inclined to think that they diffuse with the red cells.

THE EFFECT OF CERTAIN GASES ON THE DIFFUSION.

Some vapours modify the diffusion to a large extent. In making these experiments the procedure was the same throughout, tubes being used having as nearly as possible the same calibre; they were partially filled with agar, the surface of which was transverse to the tube, not sloped. The same quantity of blood was placed in each, and a control tube was incubated alongside them. The woollen plug was soaked in the volatile fluid to be tested, and the tube incubated, a rubber cap being previously fitted over the mouth of it.

Formic aldehyde caused the haemoglobin to diffuse at ordinary room temperatures, and prevented the corpuscles from diffusing at any higher temperature. Ammonia had the same effect.

Chloroform and ether caused a diffusion of haemoglobin at any temperature up to 37° C., then after that a very rapid and marked diffusion of the corpuscles took place, a diffusion which was far more rapid than if the blood had been exposed only to the air.

Attempts to produce diffusion of the cells in blood serum and gelatin have so far failed.

MEASUREMENTS.

Since the amount of blood on a given area of agar surface influences the extent of the diffusion, the same methods were used in all these experiments.

Test tubes were procured possessing as far as possible the same calibre—15 mm., which gives a sectional area of 1.76 sq. cm. To cover this area completely sufficient blood was drawn into a capillary pipette, which was then marked. As this quantity was too small to measure accurately, the pipette was filled up to the mark with mercury, which was then weighed, and the volume of blood calculated by means of the specific gravity; roughly it is 208 cub. mm. This volume I call one unit. The agar was obtained from one source, and aseptic precautions were taken to prevent contamination. Four tubes were numbered A, B, C, D; the first two had one unit planted in them, the others two units, and all were incubated at 42° C.

In twenty-four hours all showed the same amount of diffusion, and in forty-eight hours tubes A and C were broken and the extent of the diffusion measured by callipers.

A had stopped diffusion and measured 3 mm.

C measured about 4 mm.

In seventy-two hours B and D were removed and measured; B showed 3 mm. and D 6 mm.

From this I gather that the extent of the diffusion of cells and granules depends on the amount of blood planted on a given area of agar surface at a certain temperature.

Two more tubes, one containing one unit and the other two, were incubated as before. The first reached its limit in forty-eight hours, the second in seventy-two, as in the previous experiment. They were left in the incubator for another week, the temperature for the last twelve hours being raised to 60° C. The diffusion was then measured and found to be the same—that is, 3 mm. and 6 mm. respectively. From this I deduce that the cells will diffuse up to a certain distance from the original drop of blood and then stop, and that prolonged incubation, even at a higher temperature, will not make them progress beyond this point. I have never seen the mass of diffusing cells become separated from the surface of the agar.

Measurements.—Two tubes, one containing one unit and the other two, incubated at 37° C., did not show any signs of diffusion that could be seen by the naked eye until forty-eight hours had elapsed; in seventy-two hours the diffusion had reached its limit in the one-unit tube, and in about one hundred hours in the other. This last measurement is only approximate, owing to evaporation. At 60° C. the one-unit

tube diffused to its limit of 3 mm. in four hours. The other in about seven hours had reached its limit of 6 mm.

By making measurements in the presence of chloroform and ether I found that the rapidity in the case of these two vapours is about the same. At 37° C. one unit reached its limit of 3 mm. in twenty hours, and at 60° C. in about half an hour.

These vapours, then, cause a great increase in the rapidity of the diffusion, but do not affect its extent.

From the foregoing experiments it appears that the diffusion is a purely mechanical one, and that, with the possible exception of the blood plate, it is only the erythrocyte that will diffuse entire through the agar.

This phenomenon is not confined to human blood, for I have repeated some of the experiments with that of birds; but as far as I can make out it will not take place in other commonly-used culture materials.

NOTE BY PROFESSOR R. ROSS, F.R.S., C.B.,

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It may be advisable to add that preparations demonstrating this curious phenomenon have been carefully examined by me and shown to a number of friends. The diffused corpuscles lie deep in the solid agar, at a considerable distance from the surface on which they were originally placed, and have an appearance under the microscope suggestive of strawberries in aspic. I can find no signs of tracks along the paths which must have been traversed by the corpuscles in their singular progress through the apparently solid medium. Dr. B. Moore, Professor of Bio-chemistry of this University, thinks that the phenomenon is probably one of colloidal adsorption. So far as I can ascertain it has not been described before, and may have been overlooked owing to the fact that blood streaks on agar are not often incubated at over 42° C.

PERSONAL IDENTIFICATION BY MEANS OF FINGER-PRINT IMPRESSIONS.*

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THE certain identification of individuals is a subject that has always been of practical value and interest to the medical profession.

The famous Tichborne trial and the recent wrongful imprisonment of Mr. Louis Beck distinctly demonstrate the difficulties of definite knowledge in this direction; and show that we have not, until recently, advanced greatly beyond the time when Ulysses, returning home from his twice ten-year wanderings, was greeted by his faithful hound Argus but unrecognized by his wife Penelope, or his son, and only when his old nurse Euryclea was washing his feet did she learn that her foster-son and master had returned, by seeing the scar on his knee left by a wound from a boar's tusk sustained in early manhood; for deep tattoo marks and scars are very reliable evidence of identity.

The remarkable variety of the lines present on the hands and fingers has been recognized for long, especially in the East—the Babus in India call the finger impressions "Tip-sahi"; and some will remember how, in Kipling's book *Kim*, the Indian spy Mahbub seals his authority by "wetting his thumb on a cake of india-ink, and dabbing the impression on a piece of soft native paper. From Balkh to Bombay men knew that rough-ridged print with the diagonal scar running across it."

The employment of finger-prints among the various nations is partly superstitious and partly ceremonial, as Mr. Francis Galton has pointed out. Such customs as the touching of a seal or wafer by the executant of a deed who declares with a finger touching the seal "this to be my act and deed," and a modern witness who when sworn must hold the Bible in the right hand and kiss it, are relics of the superstitious idea that the personal contact between the individual and document has some mysterious efficacy, the ceremonial being a formal act the performance of which can be proved by witnesses.

The practical value of any method of certain identification of individuals is so wide-reaching, that I need only mention a few of its uses. Among an illiterate population

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