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

* Read at the Annual Meeting of the Yorkshire Branch, British Medical Association, Harrogate, 1905.

or one of mixed races its practical utility is much more evident. In India, for example, where its value was first proved, Sir William Herschel, finding that in the Courts false personation was prevalent, introduced into Bengal, some eight years ago, the use of finger impressions, and insisted on executants of documents affixing their finger impressions in the register of admissions. Pensioners having died, their friends or relatives had personated them, and continued to draw allowances which should have lapsed with the death of the person to whom they were originally granted. All military and civil pensioners are now required to give their finger impressions, and this precaution is effective against fraud. Impersonation in competitive examinations for Government appointments has been almost entirely stopped by this method. In the opium departments, where large money advances are made from Government to cultivators, the possibility of disowning the mark made by an illiterate, or the signature by one who could write, is obviated by registering the finger-prints at the time of the loan. All emigrants under the Emigrants Act are required also to be registered, and all Government servants who are not gazetted are now required to leave their *sign digital* in this manner. Medical certificates are invariably supplemented by a thumb impression, and they have been used for plague prevention.

Its value to insurance companies has not yet been adequately realized, especially in countries where, owing to the tropical climate, bodies are buried or burnt almost as soon as death occurs. There is no doubt that the impression of the finger of a dead person taken before decomposition sets in would fix his identity in a most convincing way if at any previous time the deceased had been required to give an impression of the same finger.

Its value as a means of authenticating testamentary dispositions cannot be over-estimated.

It has been especially useful in India, as no objection can be raised to it on the ground of religion, caste, rank in society, or sex, so there is no prejudice to be overcome in adopting it. In cases of sudden death or accident to a person in a place where he is unknown, the constant and gruesome supply of "unknowns" in all large cities, whether from accident, murder, or suicide, would become much smaller were finger-prints recorded.

To establish claim to money or property (especially when in a foreign country), to authenticate passports (especially in time of war), to detect rogues, to recognize deserters re-enlisting *et hoc genus omne*, the best method of registering individuals up to the present was that introduced by M. Alphonse Bertillon of Paris, who relied on five measurements, namely—the greatest head length, head breadth, foot length, cubit, and length of the middle finger, but like all anthropometrical methods the personal equation of the observer so modified its value that a more certain method was desirable. And the singular merit of finger-prints, in that they are self-signatures, free from all possibilities of error in observation and fault in recording, that they apply throughout life, combined with the simplicity of the methods adopted, gives us a system which answers all requirements and affords an incomparably surer criterion of identity than any other bodily feature.

When we look at the hand of a man there are to be found various lines, ridges, and creases, and these occur at all ages from infancy to senility, the most prominent of which are the flexure creases, which are of only of interest to students of palmistry and Bond Street charlatans. The less conspicuous but more numerous lines are the papillary ridges which appear over the whole surface, giving it an appearance that might be likened to the ripples on

water or sand. There is no absolute connexion between these two classes of marks, the directions of the creases not determining the course of the ridges. These ridges are studded with microscopic pores—the mouths of the ducts of the sweat glands—and their office is to raise the mouths of the ducts so as to facilitate the discharge of perspiration, and also in some way the sense of touch, as they are found on the prehensile portion on the tails of monkeys. These papillary ridges show in the hands of an infant and in a labourer's whose hands have become hardened by the use of his tools. Injuries do not necessarily obliterate the ridges, but of course a cicatrix will do so, which in an impression shows like a thin white space somewhat similar to a crease (see Fig. 1). During life the ridges persist, and from a large number of observations it is stated that there is no change between birth and death, and there seems to be no more constant feature than these ridges in all the details of anthropometric data. The hand of time, with its growth and decay, can alter the expression, the gestures, the handwriting beyond recognition; even the eye colour may alter in years; the quantity and quality of teeth and hair also fade by degree and become beautifully less; but these hitherto neglected and minute ridges, as far as we know, maintain their characteristics throughout life, and are only destroyed by decomposition. They are found legible on the paws of stuffed monkeys and on Egyptian mummies.

While it has been recognized for centuries that finger tips might have some value as a personal record, it has only been within the last few years that they have been

given any real value as a scientific test of individuality. In 1823 Professor Purkinje of Breslau read a thesis on finger impressions, which he divided into nine standard types. Berwick, the reviver of wood engraving in England, appears also to have been struck with the delicacy of the lineations, for he made engravings on wood of a couple of his fingers which he used as designs for his illustrated works.

Fig. 1.—An arch (magnified), showing the cicatrix (A) of an old cut.

Fig. 2.—A loop (magnified).

Fig. 3.—A whorl (magnified).

Mr. Francis Galton has, however, done the giant's work in proving the value of these signs and their persistence; he divided them into three main types—arches, loops, and whorls (see Figs. 1, 2, and 3). The almost inconceivable variety of the patterns present, which a slight examination of a number of digits will easily make apparent, has until lately prevented the easy classification of so great a multiformity.

Mr. Henry, an Indian Inspector-General of Police, introduced a system of classification into four varieties—namely, the three of Mr. Galton's suggestions and a fourth class of composite forms—and this method enables them to be indexed for universal application.

The simplicity of the process of recording finger-prints is one of its chief attractions, as it entails neither undressing of the patient nor discomfort beyond the soiling of the digits. The apparatus is very easily obtained, and consists of (1) specially prepared printer's ink; (2) a small roller for spreading the ink; (3) a slab of glass, polished copper or porcelain on which the ink must be rolled out into as thin a film as possible; (4) the paper or card on which the prints are taken, this not to be too highly glazed; (5) a solution of washing soda to remove the ink from the fingers.

The ink, roller, and slab must be kept scrupulously clean and free from dust, hairs or grit. To take a plain impression as shown in Fig. 4 I press my finger lightly on the inked slab and then on the receiving surface, and imprint the design as from a stamp, which in this case happens to be a whorl.

Another more useful form is the rolled impression, which has the advantage of showing a much greater sur-

face and a larger number of points for comparison. To take a rolled impression, the finger is laid on one side and rolled over to the other, so that the plane of the nail is at right angles to the plane of the slab at the commencement and termination of the inking, and if the finger lay on the ulnar side to begin, the movement ended when it lay on the radial edge. The same rotation of the inked finger imprints the design, which by its greater breadth gives the Brodingnagian impression. I may here show you a very simple method of obtaining a print which may be

Fig. 4.—(a) Plain impression, (b) rolled impression (magnified).

photographed and thus preserved. If our President (Dr. Gordon Black) will kindly press his finger on this clean card—there is, as you see, no visible result. I now dust over the card a little powdered plumbago, which adheres to the lines of invisible perspiration and enables us to see most clearly the patterns of his papillary folds, and you will observe that the thumb shows an exceedingly complicated design known as a twined loop, which I may state is rather an uncommon type.

All impressions may be arranged under one of four types, namely, arches, loops, whorls, and composites. Arches are subdivided into arches and tented arches. Clear definitions demarcate arches from tented arches and both from loops. Loops may be either ulnar or radial, and are further differentiated from each other by ridge counting and by their ridge characteristics. Whorls are single or double cored. Impressions of this type differ conspicuously from each other owing to the innumerable varieties of pattern they present, but further demarcation is provided by ridge tracing. Composites include central pockets, lateral pockets, twinned loops, and accidentals. In impressions there are fixed points known as the inner and outer terminus, whose correct position is readily found, and they serve many useful purposes, including ridge counting, ridge tracing, and orientation of pattern. When finger-prints are required as evidence in a law court it is necessary that they be enlarged, and such enlargement to be admissible must be proved in the manner laid down by the law of evidence, the provisions of which should be consulted by medical men concerned in conducting cases in which finger-prints are exhibits.

The registration system adopted by the Government consists of rolled impressions of the digits in their natural order of thumb, index, middle, ring, and little finger, those of the right hand being in line above and immediately below them the impressions of the corresponding digits of the left hand. At the bottom of the slip the plain impressions of the index, middle, and ring fingers of both hands are taken. In round numbers, about 5 per cent. of impressions are arches, 60 per cent. loops, and 35 per cent. whorls and composites, the proportion varying in several digits. The possible arrangements give a clue to the method of classification which is of a numerical nature, each finger impression having a certain numerical value, the largest of which can total 32; and in this manner the figure value of each impression is registered, and can, by one expert in the art, be readily compared with any other so classified. The official description of such an impression would be, for example:

No. $\frac{13}{18} \frac{11}{10}$ (10), or No. $\frac{26}{2} \frac{0}{10}$ (10).

This classification takes a little practice to understand. The Government report to the Secretary of State spoke

very well of its practical value, as it could be used readily and with sufficient accuracy by police officers or prison warders of ordinary intelligence, was of such a nature that in the case of an old offender giving a false name his record might be found with certainty, that when the case had been found among the classified descriptions it was convincing evidence of identity.

The slight cost of apparatus, and the fact that skilled work is transferred to the central or classification bureau, the rapidity of the process, and the certainty of the results, are all strongly in its favour.

It has been suggested that it would be applicable in hospitals and asylums, and will no doubt be found to have uses in almost every branch of human intercourse. I am able to show you here practical result from this locality. Some little time ago a burglar broke into a house and ransacked the premises. On the return of the inhabitants the unwelcome visit was very apparent, but no trace could be found that would lead to the identification of the criminal. One of the Bradford detectives, however, feeling confident that some sign would be left behind, went up and discovered on a small wooden medicine chest the impression of a thumb. This chest, no doubt, had been opened under the delusion that it contained money, and the impression left, as you can see from the photograph (Fig. 5), was close to the head of a small screw used to fix

Fig. 5.—Finger impression found on box (magnified). Impression of prisoner's middle finger, right hand (magnified).

the lid to the sides. By photographing and enlarging this impression it was found to correspond very closely with that of a man well known to the police. On comparing his finger impressions with that found on the box, perfect similarity of the papillary ridges was discovered, and at the present time he is accepting the hospitality of His Majesty in Armley Gaol.

I could, if time would allow, give you many instances in which the police have been enabled to identify criminals and further the ends of justice. In one case the results of indiscriminate thirst served to curtail the liberty of a man who broke into a club in this town; after rifling the cash box, he regaled himself with bottled beer, which he drank out of the neck of the bottle, dispensing with the usual tumbler, and left on the neck and sides of the bottle impressions of his somewhat grimy fingers. In spite of the difficulty of photographing such an impression on glass, a very respectable print was taken which served to weave a net round this thirsty night bird.

In India I was brought in contact with a remarkable case which led to the recognition of the value of this method of personal identification. In 1898, at Jalpaiguri, on the Bhutan frontier, the manager of a tea garden was found lying on his bed with his throat cut, his dispatch box and safe having been rifled and several hundred rupees carried away. The deceased Scotchman had a reputation of being a very severe task master, and suspicion fell upon his cook, upon whose clothes some blood stains were found, also upon the relatives of a woman with whom the murdered man had a liaison, and against a wandering gang of Kabulis of criminal propensities who had encamped recently in that neighbourhood. There was also a suggestion raised that the deceased man had an enemy in the person of an ex-servant whom he had caused to be imprisoned for theft. The inquiries of the police, however, failed to incriminate any of the suspected persons, and it was ascertained that the ex-servant had been released from gaol some weeks before,

but no one could say that he had been seen again in the district. The cook's statement that the bloodstains on his clothing were from a pigeon's blood which he had killed for his master's dinner was confirmed by the analyst's report. Fortunately, among the papers found in the dispatch box was a calendar in book form printed in the Bengali characters, with an outside cover of a light blue paper, which is usually found on native-printed books. On this cover were noticed two thin brown smudges, which, under a magnifying-glass, were recognized as impressions of one of the digits of some person's right hand. In the Central Office of the Bengali police the finger impressions of all persons convicted of certain offences are classified and registered, and the impression on the calendar, when compared, was found to correspond exactly to the right thumb impression of Kangali Charan, the ex-servant above referred to. In consequence he was arrested some hundreds of miles away and brought to Calcutta, where his right thumb impression was again taken and corroborative evidence collected. The chemical examiner to the Government certified that the brown marks on the cover of the calendar were mammalian blood, the inference being that the actual murderer or some associate had knocked his blood-stained thumb against the calendar when rummaging amongst the papers in the dispatch box for the key of the safe; and the accused person was committed to stand his trial charged with murder and theft, and finally convicted, but in the absence of direct evidence to the deed being committed, capital sentence was not carried out. Since then, however, a special law has been passed by the Indian Council admitting the evidence of experts on finger-print identification in courts of justice.

SERUMTHERAPY BY THE MOUTH.*

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FOR eight years I have been using by the mouth serums, both normal and the product of immunity, with remarkable results. Their action thus used is neither antitoxic nor antibacterial. The theory which best explains their action is that of tissue resistance. That is, that along with antitoxic and antibacterial resistance to infection, or alone when those other elements are absent, there is produced an increased resistance in the tissues to the pathogenic action upon them of the organisms present; that this produces what may be called a sterile soil without harmfully affecting the organisms themselves. This is present in active immunity, and can be transferred to the patient as passive immunity by the oral use of the serum in regular doses.

This tissue tone constitutes initial resistance to infection, and varies in man and animals; in the latter both as species and individuals. It may be defined as the capacity of the tissues to carry on their functions unimpaired in the presence of infection. This is health. Disease occurs when the tissues are impaired in their functions, and recovery when their resistance has been so restored that they are once more capable of carrying on their normal functions even though the organisms are still present. The presence and vitality of the organisms in typhoid and pneumonia when the patients are afebrile and convalescent can be rationally explained on such grounds. The tissue resistance has been raised to such a degree that the organisms are incapable of further affecting them. The organisms themselves having no suitable soil for their action are readily eliminated.

The oral use of normal plasma† of the horse, sheep, and ox in doses of one drachm four times a day in non-microbial cases of function deficient through lack of nutrition produces a restoration of function by removing the lowered nutrition. A favourable class of case for this is lactation deficient in quantity or quality, or both, in a debilitated patient. The restoration of the patient's nutrition by the renewal of her appetite, digestion and assimilation

of food leads to a perfectly normal lactation which may be maintained by a continued use of the plasma as required.

The same result is obtained by injections where function is deficient through lack of nutrition due to microbic action on the various tissues involved.

The reaction leading to restored function is obtained in the presence of those infections to which the animal itself is refractory, but in no other infection. Thus the serum of the horse and sheep, of the greatest service in tubercle, are valueless in influenza, the animals themselves being as susceptible to that infection as man. Ox plasma is of the greatest service in influenza, as the animal is extremely resistant to that infection. Thus, only in those infections to which the animal is itself refractory is the reaction obtained. Hence it is concluded that by this method of use the natural resistance of the animal to infection is being transferred to the patient.

The results cannot be due to the albumin in the serum, as no albumin could have any such effect, even if absorbed. In my opinion the results are due to the action of certain elements in the serum elaborated for the energizing of the tissue nerve centres, and these elements being probably of glandular origin, are readily absorbed and produce in the patient the reactions for which they were intended in the animal. Thyroid and suprarenal gland by the mouth have the same easy absorption, and produce their characteristic physiological effects in the patient exactly in the same way.

These are the elements in the serum which will be developed to meet the action of the organisms on the tissues, and on their presence and power will its defence depend.

Antidiphtherial Serum.—In diphtheria there is present a paralytic agent acting mainly on the involuntary muscular system, and to resist that muscle depressant there is developed a muscle recuperative element in the serum available by its oral use. There is also a proteolytic agent causing the production of digestive action and leading to the formation of albumoses and other products of digestion, and to meet this there is produced in the serum an antiproteolytic power also available by oral use of the serum. In diphtheria the concurrent use of the serum by the mouth in doses of 1 drachm with the hypodermic injection materially assists the recuperative powers of the patient, and leads to a rapid and complete recovery when given in time.‡

The recuperative action on the involuntary muscle is obtained in shock from traumata, haemorrhage, etc., where the cause is non-microbial. It is also obtained in the presence of the staphylococcus, streptococcus, and *Bacillus coli communis*. By its action on the voluntary muscle the vasomotor tone is restored to normal, and inflammation is thus very directly treated, and on Nature's own lines.

The proteolytic action of the staphylococcus and the *Bacillus coli communis* is directly combated by the antiproteolytic element in the serum and by the conjoint action of this and the recuperative power of the serum the pathogenic action of these organisms on the tissues is specifically antagonized. That these elements have no antitoxic or antibacterial or other harmful effect on the organisms present is shown by a prompt relapse should the treatment be discontinued before the patient has thoroughly recovered. Where required there is also produced a marked leucocytosis, which is probably more clearly apparent from the restored vasomotor tone causing the reduction of surrounding inflammation, and thus concentrating the phagocytes on the focus of the disease. In the stage of inflammation before death of tissue and pus formation, the proper use of antidiphtherial serum should promptly arrest the process. In the stage of loculation its use should maintain the general tissue tone, prevent metastasis, and more rapidly mature the loculation. After evacuation it should rapidly clear up the cavity, promptly reduce the pus formation, and promote the rapid convalescence of the patient.

All of these it has done in an experience of eight years.§

* Read before the Chelsea Division of the Metropolitan Counties Branch of the British Medical Association.

† Messrs. Allen and Hanburys supply the normal plasma in their Bynin series as byno-plasma, a palatable preparation, without suggestion of blood, and which preserves the plasma sweet while in use. The dose is half an ounce.

‡ Messrs. Parke, Davis, and Co. have been preparing for me for years a low-potency antidiphtheric serum specially made for oral use. The dose is one drachm, generally four times a day, but in acute cases twice as frequently.

§ Messrs. Baillière, Tindall and Cox have nearly ready for publishing a work on this subject, giving 275 cases of its use in the various conditions in which it has been found serviceable, as well as a fuller explanation of the principles suggested as explanations of the facts.