creatitis those cases in which the pancreas was so definitely enlarged that there could be no possible doubt but that the disease actually existed. Undoubtedly by a more careful examination of the urine and stool Mr. Robson and Mr. Cammidge have been able to make the diagnosis in cases we have heretofore overlooked.

DETECTION OF THE EMOTIONS BY THE GALVANOMETER.*

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In 1890 Tarchanoff published in *Pflüger's Archiv* a paper describing experiments with a galvanometer in series with the human body. Changes in the electromotive force with resulting deflection of the galvanometer occurred when the face, ears or feet were tickled, and when various sense organs were stimulated. He noticed that actual stimulation was not necessary; the effect would appear when the person merely imagined the irritations. He observed, moreover, that the recollection of any kind of strong emotion produced the same effect. Ordinary intellectual exercise had no effect unless it was accompanied by exertion. Expectant attention had, however, a marked effect—a fact explainable if we consider attention as one of the emotions. Tarchanoff believed that the current sent through the galvanometer was due to a secretory current of electricity produced by the action of the sweat glands.

This paper by Tarchanoff was really a model piece of investigation. I read it and admired it not long after it was published; but my work led along other lines and, like everybody else, I forgot all about it.

In 1897, Sticker, of Vienna, repeated Tarchanoff's work, and concluded that the current was due not to activity of the sweat glands but to changes in the capillary circulation. In 1892, Somner, of Giessen, made similar experiments, but came to no conclusion. In 1905 the fundamental fact was rediscovered by a Swiss electrical engineer, E. K. Miller. This started Veraguth and Jung, of Zürich, on similar lines. Extensive investigations were now undertaken by Dr. Jung in the Psychiatric Institute at Zürich. One of his papers has been published in the *Journal of Abnormal Psychology* (Boston), February, 1907. Peterson and Jung applied the method to normal persons, and to various forms of insanity, such as dementia præcox, hysteria and paranoia.

Professor Peterson and I are now at work with the method along several lines, of which I may mention the following: 1. The attempt to construct a self-registering instrument that shall be as complete and handy as a chronoscope. 2. To definitely settle what bodily changes produce the electrical effects. 3. To classify and analyze emotional persons. We do not, however, propose to touch the problem of the analysis of the emotions themselves. This must be the work of the laboratory psychologist who has plenty of time to deal with normal persons. Medical men have so much material with diseased and abnormal minds that we can work most profitably on the pathologic side.

The apparatus employed is a moderately sensitive galvanometer with two electrodes and a battery. The current is sent through the hands of the person tested.

When the hands are placed on the electrodes a small current passes through the body, and the galvanometer shows a deflection. The deflection can be seen by reflecting a beam of light on a screen. A sudden deep breath or a cough causes an increased deflection after a latent time of two to five seconds. Expectation of a pin prick, for example, causes a deflection. So does any real or imagined emotion. When I flash a light into the eyes of the person or make a threatening gesture, or act as if I am to stick a pin into him you notice that the spot of light moves distinctly. The same happens when I ask him questions that are likely to arouse emotions, such as, "Who is your worst enemy?" "Did you ever lose any money?" "Are you married?" You notice one defect of the method, namely, that it shows the presence of an emotion, but does not indicate what kind it is.

We have now to consider the problem of what causes the changes in the amount of current allowed to pass through the body. We would naturally think at first of vasomotor changes, as in blushing. When we blush the capillaries are dilated, the skin becomes more filled with fluid and its electrical resistance is, therefore, less. But, when the arms are bound with Esmarch bandages so that no blood flows through them, the result remains the same. Therefore, the cause does not lie in vasomotor changes.

We next think of involuntary muscular movements. But we can make fairly great changes of pressure on the electrodes without producing noticeable deflections. Moreover, the hands can be placed in vessels of water where small movements would have no effect; the emotional deflection remains the same.

We might suppose that the emotion produced an actual excretion of sweat on the skin, whereby the electrical resistance would be diminished. We all know how anxiety will cause the brow to perspire, and that horses sweat with terror. But this is ruled out by the experiments with water electrodes.

We finally come back to the original supposition of Tarchanoff, that the change is due to the activity in the sweat glands. This may occur in two ways. The increased activity may produce an increased quantity of liquid in the lower layers of the skin, whereby the electrical resistance is reduced. Or, since the increased activity must result in altered electromotive forces, these may vary the amount of the current flowing through the body. This is the theory of Tarchanoff. For my own part, I do not see why such electromotive forces always add themselves to the current sent through and never oppose it; that is, an emotion always increases the deflection, thereby showing that more current passes. We thus seem forced to the conclusion that the variations are in the electrical resistance.

Some people have objected to the sweat glands being dignified into organs of the emotions. But dignity does not exist for science. It has been shown that the sphincter of the bladder registers most delicately both intellectual and emotional activity, and that the digestive movements of the duodenum (as observed with x-rays) are violently affected by disagreeable emotions. The sweat glands are certainly worthy of attention.

I must not omit to point out the practical application of the method. Dr. Peterson and I use the apparatus almost daily in our medical practice. For the nervous patients who come to us it is just as necessary to know how emotional they are as it is for the general practitioner to know how high is the temperature in a case

* Address before the New York Academy of Sciences, Nov. 25, 1907.

of fever. Moreover, in many cases it is necessary to find out what experiences in the past or present life of the patient produce emotions. For this purpose the patient sits at ease, with hands on the electrodes. Various words are spoken, or topics of conversation are brought up; the galvanometer shows when a sensitive subject has been touched.

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PLAGUE AMONG RATS IN SAN FRANCISCO.

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The following notes on epizootic plague in rats are published in the belief that they may prove of interest to other workers.

It will be observed that the relative merits of the microscopic and naked-eye methods of detecting plague in rats have been thoroughly tested. Our data are drawn from the microscopic and anatomic appearances of 14,184 rodents examined between Sept. 13, 1907, and Jan. 14, 1908. We agree with the last Indian Commission¹ in their belief that the naked-eye method alone furnishes enough data to pass on a rat as being plague infected or not. Like them, however, we preferred to combine the two methods first in order to rule out any fallacies which might be introduced by unknown local conditions. So far no disease of rats has been encountered which could possibly cause confusion, with the exception of a few instances which will be cited below under "Diseases in Rats Resembling Plague."

METHODS OF EXAMINATION EMPLOYED.

The rats were brought daily from the various district headquarters and entered serially in a book, where notes were recorded concerning the address of the rat, its species, etc. After being tacked out on a shingle, each rat was completely dissected by Mr. A. Venzke, who gained a great experience in similar work under Dr. Currie, Public Health and Marine-Hospital Service, during the previous epidemic in San Francisco.

A smear from the spleen of each rat was examined microscopically, and whenever the anatomic conditions indicated, from the glands, liver, heart's blood, etc.²

Whenever suspicious bipolar staining bacilli were found their pathogenicity was tested by rubbing a bit of the tissue to be tested into a lightly scarified area (about an inch square) on the abdomen of a guinea-pig, rabbit or white rat. These animals have been named in the order in which they have proved most satisfactory. In addition, if the condition of the rat warranted, cultures from the spleen and heart's blood were made on +1 agar slants. On the death of the experimental animal, note was always made of a typical local reaction at the point of vaccination. However, this proved un-

necessary, for we have had no mortality from plague among our stock guinea-pigs, nor have we found fleas on them. The experimental animals have been kept throughout in screened jars.

Cultures obtained from the spleen and heart's blood of the rats, and from the experimental animals, were then further tested for the production of typical involution forms on salt agar. We have grown the cultures to be so tested for twenty-four or forty-eight hours at 37 degrees C. on +1 agar, containing 2 to 3.5 per cent. sodium chlorid.³

In a number of instances the cultures so tested have been retested for pathogenicity. We have not been able to test for the production of stellactites in oiled bouillon owing to the vibration of our laboratory building.

OBSERVATIONS IN DETAIL.

Bearing in mind the statement made by Hetch and Otto⁴ that in rats experimentally infected through the oral and intestinal mucosa, plague bacilli could be found in greater numbers in the liver than in the spleen, we examined smears from both these organs in a series of 1,200 rats. The results did not justify the additional labor. Anatomic conditions which would possibly indicate the natural occurrence of intestinal infection in rats have been encountered in only one instance:

No. 2816. *M. decumanus*; sick when caught; glands not enlarged; spleen enlarged and congested; right lung whitish, and contains calcareous particles; liver shows many pinpoint yellowish foci of necrosis. Typical bipolar staining bacilli were very much more numerous in the liver than in the spleen. A guinea-pig was inoculated subcutaneously with an emulsion of the liver on Oct. 16, 1907. Died on Oct. 18, 1907, with typical anatomic reaction at the point of inoculation, glands and spleen. Cultures from the guinea-pig proved to be *B. pestis*.

Table 1 will indicate the number and kinds of rodents examined between Sept. 13, 1907, and Jan. 14, 1908, and the per cent. found infected.

TABLE 1.				
Species. ⁵	Total No. Examined.	Species. Per Cent.	Total Infected.	Infected, Per Cent.
<i>Mus decumanus</i>	13,982	98.79	139	0.99
<i>M. rattus</i>	105	0.73	1	0.95
<i>M. r. alexandrinus</i>	51	0.35	2	3.84
<i>M. musculus</i>	16	0.11	0	0
Totals	14,184		142	

It is evident that the most common rat in San Francisco is *M. decumanus*, and that the greater number found infected are of this species.

3. We have noted that plague cultures will not give typical involution forms in twenty-four hours on 2 per cent. sodium chlorid agar under certain conditions. This is when the salts which precipitate out of bouillon on its cooling are filtered out before the addition of the agar. However, the presence of 3 per cent. sodium chlorid obviates this difficulty.

4. Klin. Jahrb., 1903, II, No. 3.

5. The following characters, somewhat roughly stated, will serve for the routine differentiation of these three species:

M. decumanus: The Norway rat. Often reaches a great size, tail about the same length or shorter than body, heavily built, coat of coarse gray hair, ears smaller in proportion to size than in the next two species.

M. rattus: Of more slender and delicate proportions than *M. decumanus*, tail about an inch longer than body, coat of fine grayish brown or brownish black hair.

M. rattus alexandrinus: The Egyptian roof rat or white bellied rat, resembles *M. rattus* in general appearance except that the hairy coat on the whole under surface of the body is pure white with sharply demarcated borders.

The Norway rat, according to D. S. Jordan (Manual of the Vertebrates of North America), was introduced into America about 1775, whence it has practically expelled *M. rattus*. The latter species is the ship rat, *par excellence*, though the other two species also occur on ships. Most of the *M. rattus* brought to us have come from ships or wharves, though a few have been caught a mile from the docks. A few young of the variety, *M. r. alexandrinus* have been caught a mile or so inland, showing that this variety probably breeds on shore to a small extent.

1. Jour. Hyg., 1907, vii, 324.

2. In our routine staining, we have found Wright's, Jenner's and the carbol-thionin stains very satisfactory, but prefer the following thionin-methylene blue combination, devised by R. A. Archibald, D.V.S. It stains almost instantaneously, either after or without fixation by heart.

Solution 1.		Solution 2.	
Thionin	5	Methylene blue	5
Phenol cryst.	25	Phenol cryst.	25
Formalin	1	Formalin	1
Water	100	Water	100

Dissolve for 24 hours; mix equal parts and filter.