

are most suggestive, in the posterior scapular or mid-axillary line. If no pus is located it may be inserted in the space above and below up to the upper margin of dullness and as low as the costal margin. This is repeated until all the spaces over the dull area have been explored in the nipple, mid-axillary, and posterior scapular lines. It is often difficult to determine whether the point of the needle is above or below the diaphragm; if the blood which is drawn back into the barrel of the syringe is bright and frothy it certainly comes from the lung, though darker blood may come either from the liver or from compressed lung. Again, a sense of resistance is experienced as the diaphragm is pierced, and the exposed part of the needle or the syringe will, as pointed out by Fürbringer, move with respiration when the needle has passed through the muscle. I have not noticed that temporary inflammatory paralysis of the muscle has vitiated this sign, but this possibility must be borne in mind.

May we not assume that even under normal conditions a needle passed into the lower four spaces to the extent of 3 inches passes through the diaphragm, and when this is raised the subphrenic space will be reached by such a needle even two spaces higher? When clear or turbid is withdrawn at one depth and pus still further in, the diagnosis is clear. I have no experience of any danger through injury to vessels or viscera or risk of carrying infection from the chest to the abdomen by this means. If clear fluid is drawn from the chest alone, this is aspirated by gravity through a long fine tube. If nothing is withdrawn the patient is returned to bed; if pus is found the needle is left in situ and another needle introduced into the space below; if pus is found there the first needle is withdrawn, cleansed, and inserted into a still lower space. The rib to be resected will be that below the lowest space in which pus was found. In any case this must not be higher than the eighth, as above this level it is difficult to shut off the pleura by suturing the diaphragm to the chest wall.

#### GENERAL OUTLINES OF OPERATION.

Usually there is a positive indication for preference of a particular route, but if none exist the posterior transpleural thoracic route should be chosen. By considerable practice during the war very many surgeons learnt of the value of this route in abdomino-thoracic surgery. In this instance it will be assumed that pus has been found below the diaphragm, and that the needle is still in position. At least 3 inches of the rib below the space in which the needle has been inserted is resected and the diaphragm is incised, but not cut completely through for the same extent. The upper edge of the incision into the diaphragm is then carefully sutured with a continuous catgut stitch to the upper margin of the wound through the parietal pleura and intercostals so as to shut off the pleura; then the abscess may be incised freely and a large rubber tube inserted. In spite of the above precaution on at least two occasions a secondary infection of the pleura, necessitating drainage through the same wound, has ensued in my hands. If pus has been located either by incision or with a needle through the front of the chest or the anterior abdominal wall it is best to establish counter-drainage in the loin at the most convenient spot.

#### CONCLUSION.

It may be often that the diagnosis of subphrenic abscess is not definitely settled until pus is found and drained. As I pointed out in the case of Captain R., even then one may be in error as to the relation of the abscess to the diaphragm. If an abscess is found and drained below the diaphragm it may be difficult to be sure that it is not within the liver and that one is, in fact, draining an amoebic liver abscess. Again, the needle may enter one of the multiple abscesses which occur in suppurative pylephlebitis, but in the stage of this disease in which abscesses of any size exist the patient is much more ill, rigors are common, and jaundice is present in its later stages. A suppurating hydatid cyst may give rise to the same signs, but its nature will at once be recognised as soon as the cyst is opened.

## THE VALUE OF THE QUASI-CONTINUOUS TEMPERATURE RECORD

IN THE EARLY DIAGNOSIS AND PROGNOSIS  
OF TUBERCULOSIS.

BY SIR GERMAN WOODHEAD, K.B.E., M.D., LL.D.,  
PROFESSOR OF PATHOLOGY, UNIVERSITY OF CAMBRIDGE;

AND

P. C. VARRIER-JONES, M.A. CAMB., M.R.C.S.,  
L.R.C.P. LOND.,

FOUNDATION SCHOLAR, ST. JOHN'S COLLEGE, CAMBRIDGE;  
TUBERCULOSIS OFFICER, CAMBRIDGE COUNTY COUNCIL.

REPORT TO THE MEDICAL RESEARCH COUNCIL.

SOME years ago,<sup>1</sup> supplementing the observations made by the late Professor Arthur Gamgee, we drew attention to the value of quasi-continuous (half-minute) temperature records in the study of tuberculosis and published a number of typical temperature charts taken from tuberculous patients. We had not then sufficient experience of these records to be able to determine their exact value as an aid to diagnosis and prognosis, but certain oft-recurring features appeared to us to be characteristic of the temperatures induced, not merely by the artificial introduction of tuberculin but also by the auto-inoculation that goes on during the progress of the disease in a consumptive patient. We have been able to follow up to Jan. 1st, 1921, the cases then described and have had the opportunity of noting not only which of them have done well but which of them, not responding to treatment, have gone steadily or intermittently from bad to worse. We have thus accumulated much information as to the value of these quasi-continuous temperature records *not only in diagnosis but in prognosis*. To the histories and temperature charts of the cases already recorded may now be added the experience gained from the study of a number of typical cases<sup>2</sup> which, of great interest in themselves, constitute a broader basis on which to found an opinion as to the value of the method.

#### *Features in the Record of Diagnostic Value.*

In our earlier paper in THE LANCET we called attention to the peculiar character of the auto-inoculation temperature curve, and pointed out how closely it corresponds to the post-tuberculin curve. Of its value as a diagnostic feature we had little doubt, and we were inclined to think that its value in prognosis might be almost as great, but for that opinion we had not, at the time, any very sound or sufficient basis. The features in these quasi-continuous records on which we laid stress as of diagnostic value were: (a) Somewhat sudden rise of the afternoon and evening temperature, not necessarily steady, but in jerks—temporary exacerbations—and with a general trend upwards; (b) continuation at a somewhat high level—above 99° F.—for 8 or 10 hours; (c) followed by a rapid fall, sometimes to a subnormal level; (d) during the whole day response of the temperature to agents inducing rise or fall—exercise, food, cold or warm drinks—much more readily and through a much wider range than in the healthy individual. A combination of certain of these features gave us (e) what we call a “plateau”—a long-continued temperature above 99°, commencing with a sudden rise and ending with a sudden and prolonged descent—which we considered to be diagnostic of tuberculosis; (f) elevations more or less marked on the plateau—these we compared to mountain peaks on a highland plateau. Before taking up the general consideration of the importance of these features it may be well to give an account of certain cases, the early histories of which have already been published, and of a number of other typical cases, the history of which affords corroborative evidence of the diagnostic and prognostic value of the quasi-continuous temperature record.

<sup>1</sup> THE LANCET, 1916, i., 495.

<sup>2</sup> In all over 200 of these quasi-continuous 12-, 24-, and 48-hour temperature records of 68 patients have been made and analysed.

CASE 1.—This patient<sup>3</sup> had been kept under observation from June 11th, 1914, until September in the following year. He had passed through a sanatorium, had then been placed under domiciliary treatment for a time, and allowed to do but a certain amount of work. Put on full work the patient at once began "to do badly," for though there were fewer signs of active disease than had been present when he first came under treatment he ceased to put on weight. In September the patient was still working full time, and by the ordinary methods of clinical investigation it would appear that he was holding his own, but from a study of the continuous temperature charts it was evident that the disease was progressing. These temperature curves, we now find, may be taken as representative of those obtained from some dozens of similar cases, and appear to be associated with a progressive tuberculous process. In Fig. 22 the effect of the tuberculous condition on the temperature is characteristic. A fever giving rise to a slightly convex temperature curve extends from late afternoon until 12 midnight or later. The diurnal range of variation is somewhat greater than normal, but here the rise is gradual, as is also the fall, though with this latter are associated fluctuations altogether absent from a normal temperature curve. These fluctuations appear to be due to the disturbed sleep of the patient during the earlier hours of the night. As the disease progresses there is marked alteration in the character of the curve and its diurnal variations. In place of the gradual ascent there is a sharp rise, followed at the end of the plateau by a still more rapid fall to the normal level. On the injection of a small therapeutic dose of tuberculin a "plateau" curve develops at once, the temperature remaining at or above 99°<sup>4</sup> for ten hours, though the greatest diurnal range is only 1°·3° (Fig. 23). Three weeks later, under similar conditions, a similar plateau (Fig. 24) is developed, and on the following day, though the plateau is still present, the diurnal range is 2°·3° (Fig. 25). All this was looked upon as indicating an unsatisfactory state of affairs as regards the progress of the disease. Four months later when, though the condition of the patient's lungs appeared to be satisfactory, he was found to be working too hard, the patient commenced to lose weight, his temperature curve became irregular and ran too high, and the exhibition of a therapeutic dose of tuberculin was followed by a definite "plateau" reaction.<sup>5</sup>

#### *Temperature Instability a Feature of Tuberculinisation.*

The instability or irregularity appears to be a marked feature of tuberculinisation, whether the result of auto-intoxication or artificially produced by "tuberculin." We have since noted that, in this as in other cases, as the disease progresses the "plateau" gradually becomes more and more characteristic, until finally we have a perfect reproduction of the curve—with its daily variations and its peaks—that results from the injection of tuberculin into a tuberculous subject, human or bovine. In the case under consideration, where from the temperature curve an unfavourable prognosis was given at a very early stage, the course of the disease was carefully observed until the final issue. Here not only was the plateau a more and more distinctive feature as the disease progressed, but finally a complete inverse temperature curve, a grave prognostic indication, was obtained some time before the patient died.

CASE 2 first came under observation in 1914.<sup>6</sup> The patient was at work in September and October, 1915, and temperature curves on which a steadily developing plateau was recorded were obtained at intervals.<sup>7</sup> Following the publication of this case several other curves were obtained, all of them, unfortunately, showing a progressive development of the plateau, with well-marked fluctuations, high peaks, and deep depressions. From these temperature indications an extremely unfavourable prognosis was argued. At that time there was neither hospital nor sanatorium accommodation sufficient for our Cambridge patients, and although the man was advised to cease work he would not or could not follow this advice, and the disease progressing he succumbed to a severe hæmorrhage some few weeks later.

CASE 5.<sup>8</sup>—The further study of another case (G. de R.) affords additional evidence of the prognostic value of the quasi-continuous temperature curve. With physical signs of tubercle in the apex of the right lung, and marked dullness and many crepitations at the left base, the patient was transferred to the colony at Little Abington. Up to November, 1915, living an open-air life, he put on weight, and the disease became quiescent; the sputum, large in amount and swarming with bacilli when the patient was first seen, steadily became less abundant, and finally was almost negligible in quantity. The note over both lungs improved; there was a gain of 3½ st. in weight and the chest measurement increased. When the patient was beginning to improve several continuous temperature records were obtained.<sup>9</sup> The temperature was then somewhat high, especially between 10 A.M. and 9 P.M., rising to 99°·5° at 6.15 P.M. and then falling steadily until the early morning, but was also very unstable, a glass of cold milk causing a rapid and definite depression. This patient was under continuous treatment at the colony for a period of two and a half years, some dozen records being taken during that period. He engaged in fairly strenuous work and his general condition remained so good that, at the end of the European war, on discharge from the colony he was able to return to Belgium, where he attempted to resume work. He found, however, that he was able to do a limited amount of work only, was easily fatigued, and soon broke down. He was then admitted to a French sanatorium, where, under treatment, he again improved

slightly. He has had several attacks of hæmoptysis, there is now marked loss of weight, and the disease is still progressing. The disease was undoubtedly retarded during his stay in the colony, but was immediately roused to activity on his return to normal life. While a refugee in Cambridgeshire he was kept under strict observation and during the whole time the disease continued to progress, though slowly. He was last heard from on Jan. 5th, 1921, when he was in fair health.

[Since the above was in type the expected announcement of the death of this patient has been received.]

#### *Plateau with Peaks and Depressions.*

The accompanying additional charts were taken from this case on Feb. 3rd and 4th, 1917. In the first (Fig. 1) the plateau is well developed, the temperature remaining at or near 100° from 3 o'clock in the afternoon until nearly 8 o'clock in the evening. There is then a gradual fall till 5 A.M., after which comes a steady rise. No very marked irregularities, peaks, or depressions appear in this record, though it is by no means so regular as a normal curve, seeming to be fairly easily affected by external influences. On the following day—at 2 P.M.—a minute dose (1/25,000 mg.) of bacillary emulsion was injected subcutaneously, and although the temperature rises no higher than on the previous day, the character of the curve is altered (Fig. 2). The plateau is more marked, the rise commencing at 2.30 P.M., and is maintained until 11 P.M., when a sudden fall is associated with a severe night sweat. Here almost the lowest point of the curve is reached between 1 and 2 A.M., after which comes a slight rise, but the lowest point (97°·6°) is reached at 6 A.M. Between 9 and 10 (owing to displacement of the thermometer before micturition the curve is interrupted between 7 and 8 o'clock) the temperature is again nearly 100°, and continues between 99° and 100° until 11 P.M. In this curve steep depressions and peaks are very prominent features, and although the rapid fall between 7 and 8 A.M. is probably due to slight displacement of the thermometer, the fall from the P.M. temperature and the rapid rise after the A.M. temperature are very characteristic of a somewhat active and progressive tuberculous process, that can be held in check or delayed only by the exercise of the greatest care.

CASE 6 (M. S.) was admitted to Bourn Colony, Nov. 16th, 1916, with a temperature of 103° F., pulse 100, marked breathlessness, and great loss of weight. The patient, an orderly at a military hospital, was one of six men who had slept in bunks in one small room.<sup>10</sup> During his stay at the colony the patient's condition improved considerably, the signs of actively progressing disease in the right upper lobe gradually subsided, and the man was placed upon graduated work. From time to time a slight rise in the evening temperature was determined by the ordinary mercurial thermometer. A quasi-continuous temperature record extending over 48 hours was taken only when there appeared to be some indication—slight rise in temperature or complaint of fatigue after work—that such was necessary. During the whole time this patient was under observation little clinical evidence as to the course of the disease could be obtained, the physical signs giving no indication of any increased activity. After admission the patient gained weight for a time, then his weight became, and remained, stationary for several months. After 12 months' treatment and training at the colony the patient was ordered to do some little light work on the land, partly with the object of ascertaining how far a patient in this condition could perform such work, and partly with a view to testing the efficiency of the system of the After-Care Association, and arrangements were made for the reception of the patient on a farm. Hours of work, which did not exceed six a day, were planned out and a start was made. For a time all went well. Clinically the patient's condition remained much the same, but gradually, as there was some loss of weight, it was concluded that there was extension of the disease and the patient was readmitted to the Papworth Colony, where more exact observations could be made and further temperature records taken.

The first of these temperature curves (Fig. 3), obtained six days after the return of the patient to the colony, at once afforded evidence that the disease was progressing. Early in the day the temperature rose to 99° and continued above that point for 12½ hours—to 10.15 P.M.; then followed a broken, irregular fall to 98° at 6.30. A second temperature curve (Fig. 4), taken 24 days later, was equally discouraging. The plateau, extending from 12.30 P.M. to 11.45 A.M., with a break of two hours, during which the temperature fell to 98°·7°, was imperfect, but the "toothed," "peaked," or "wavy" character of the curve was very marked. It was evident that here auto-inoculation was responsible for the "temperature," for when a minute dose of bacillary emulsion was injected no greater reaction was obtained, though the

<sup>3</sup> Figs. 22 to 25, loc. cit., pp. 496-497.

<sup>4</sup> All temperatures are "rectal," and are recorded in degrees Fahrenheit.

<sup>5</sup> Loc. cit., Fig. 26, p. 497.

<sup>6</sup> Loc. cit., p. 497.

<sup>7</sup> Loc. cit., Figs. 27, 28, 29, pp. 497-498.

<sup>8</sup> Loc. cit., p. 499.

<sup>9</sup> Loc. cit., Fig. 34, p. 499.

<sup>10</sup> Subsequently, though at different dates, all the other five were admitted to the colony, each with some evidence of tuberculous disease.

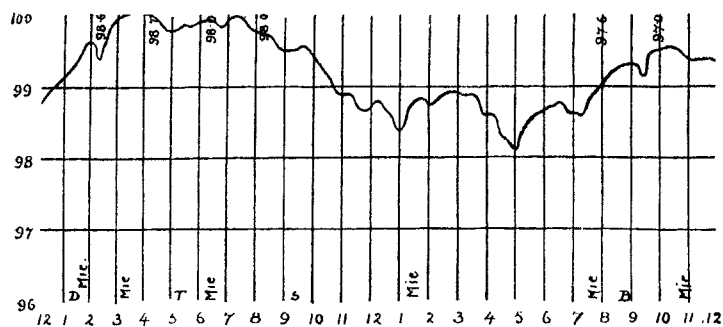


FIG. 1.—G. de R., aged 23. Record taken Feb. 3rd-4th, 1917. This shows a ten hour "plateau," with no well-marked peaks. The diurnal range of temperature is only  $2^{\circ}$ , but the curve indicates the presence of a somewhat active tuberculous process. This and the following quasi-continuous records are all taken with the thermometer in the rectum. The figures at the upper margin of the diagrams indicate the mouth temperatures. The temperatures are given from noon to noon in degrees Fahrenheit. B = breakfast; D = dinner; T = tea; S = supper; Mict = micturated.

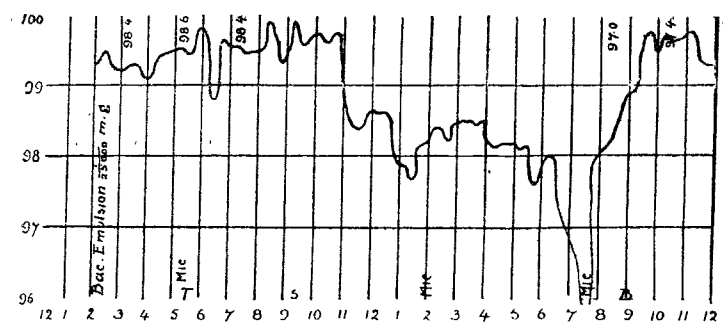


FIG. 2.—G. de R. Record taken Feb. 4th-5th, 1917, after the injection of 1/25,000 mg. bacillary emulsion. There is little alteration in the period over which the plateau extends, but the temperature is less stable, the peaks are more marked, and at the end of the plateau there is a sudden fall, synchronous with the development of a night sweat.

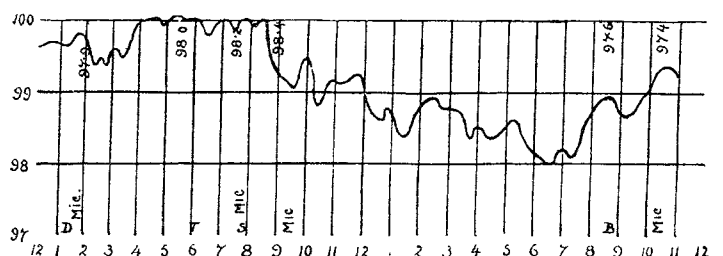


FIG. 3.—M. S., aged 18. Record made Jan. 25th-26th, 1917. Shows a plateau extending over a period of (more than) eight and a half hours. There is also some irregularity of the curve, but there are, as yet, no marked "peaks." The diurnal range is only  $2^{\circ}$  so long as the patient is confined to bed. The curve is that associated with a progressing tuberculosis and unfavourable prognosis.

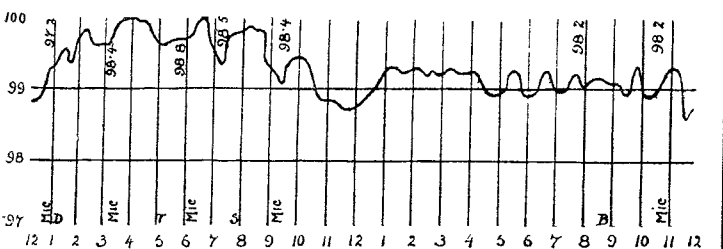


FIG. 4.—Another record from M. S. three weeks later, Feb. 19th-20th, 1917, in which the plateau is (eight and three-quarter hours) marked, peaks are more prominent, and the diurnal variation is only  $1.3^{\circ}$ , but the general level is very high. There is only slight remission during the night and morning hours.

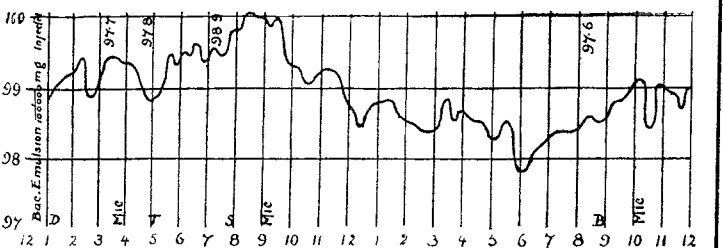


FIG. 5.—Another record from M. S. taken Feb. 20th-21st, 1917, after 24 hours' complete rest and the injection of 1/100,000 mg. bacillary emulsion. The plateau is still marked, though at two periods the temperature falls a couple of points below  $99^{\circ}$ . The diurnal variation is  $2.2^{\circ}$ . In all three records the minimal temperature is considerably higher than normal.

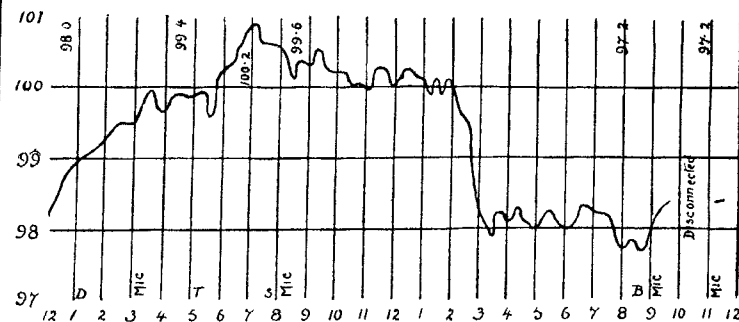


FIG. 6.—Another record from M. S. made on April 11th-12th. Here the disease is progressing rapidly, as evidenced by high temperature, broad plateau, well-marked peaks, and sudden fall where night sweat occurs. Disease very advanced and actively progressing. Diurnal variation  $3^{\circ}$ .

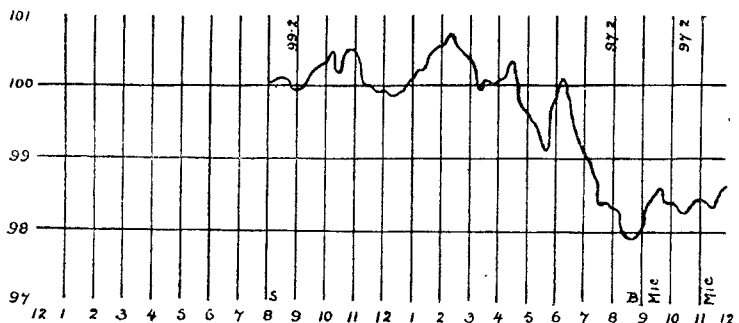


FIG. 7.—Record from M. S. made five days later, April 16th-17th, 1917, with plateau prolonged to later morning hours, well-marked peaks, and depressions and sudden fall, with late night sweat. Diurnal variation,  $2.9^{\circ}$ . Inverse temperature; patient nearing end.

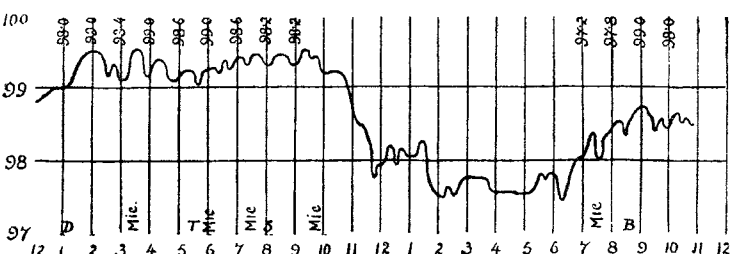


FIG. 8.—W. T., aged 15. Record made June 10th-11th, 1917. Plateau nine and a half hours, with well-marked peaks and rapid night-sweat fall. Diurnal variation  $2^{\circ}$ , and some instability throughout the day. Prognosis unfavourable.

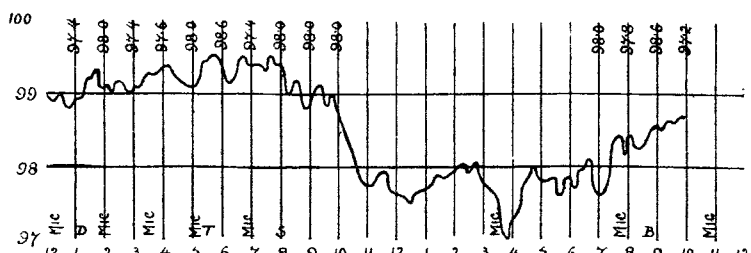


FIG. 9.—A second record from W. T., made June 13th-14th, 1917. Plateau seven hours, with night-sweat fall at 10 P.M. Curve very irregular throughout, easily affected. Diurnal range of variation  $2.5^{\circ}$ .

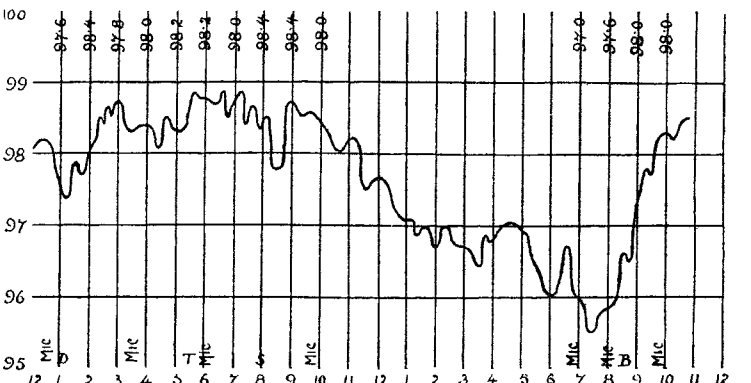


FIG. 10.—Another record from W. T., made June 21st-22nd, 1917. This curve is scarcely characteristic as regards the plateau, but it is so extremely irregular—i.e., is so easily affected by external influences, meals, micturition, &c., and the diurnal range is so great ( $3.3^{\circ}$ ), that without the plateau this curve must be looked upon as indicative of a progressing tuberculosis.

curve (Fig. 5) became slightly more irregular. The plateau in this instance extended over a period of 11 hours, after which the temperature fell slightly and irregularly from  $99^{\circ}3'$  at 11.15 P.M. to  $97^{\circ}8'$  at 6 A.M.

On April 11th-12th further evidence of the progressive nature of the disease was obtained (Fig. 6) in the plateau—on which well-marked peaks developed—followed by a rapid fall during a night sweat and an irregular line marking long continued low temperature. There is no rise between 3.30 and 9 A.M., probably because the patient is asleep. The plateau period (temperature above  $99^{\circ}$ ) lasts for 13 hours—1 P.M. to 2 A.M. The highest point is reached,  $100^{\circ}9'$ , at 7.15 P.M. The sudden fall from  $101^{\circ}1'$  to  $98^{\circ}9'$  between 2 and 3.3 A.M. is very typical of a night sweat fall. The whole curve is curiously toothed and the chart again resembles very closely that of a tuberculin reaction temperature of a bovine suffering from extensive progressive tuberculosis. On April 16th-17th, 1917, an "inverse" temperature (Fig. 7) makes its appearance. The patient's temperature was high,  $100^{\circ}$  at 8 P.M., when the tracing was commenced. The line followed a regular plateau course, at or above  $100^{\circ}$ , from 8 P.M. to 7 A.M., at 2.20 A.M. running up to  $100^{\circ}7'$ . At 6.15 A.M., after a "night sweat," there was a sudden fall to  $97^{\circ}9'$  between 8 and 9 A.M.; this was followed by a rise to  $99^{\circ}4'$  at 6 o'clock on the afternoon of the 17th.

*Temperature Record More Trustworthy than Signs and Symptoms.*

We are convinced from a study of the series of quasi-continuous temperature records here figured that considerably more reliance is to be placed on them than on physical signs and clinical symptoms however accurately noted and carefully interpreted. The instability of the temperature, especially when a plateau is developed must, apparently, be accepted as a reliable indication of increased activity of the disease, whether physical signs can be made out or not. These records, it is true, were made only after some special indication of the necessity for so doing had arisen, but in each instance the special curve appears to result from auto-intoxication or auto-inoculation. This, however, is exactly the factor we wish to determine, and here the records indicate most clearly the successive doses of tuberculin which the patient has, from time to time, administered to himself through the work or exercise prescribed for him. On readmission to the colony some improvement in the general condition of M. S. took place, but from such time onwards the clinical signs began to point to an extension of the disease, the temperature records continuing to substantiate our deductions from the clinical signs. Again and again "tuberculin temperatures" were recorded, highly irregular plateaus made their appearance and, finally, a true inverse temperature curve was obtained. The plateau had taken complete control of the range of temperature and, as in other fatal cases, gave an indication of the approach of the end, many weeks—nay months—before the final issue was determined, April 19th, 1919. The case is interesting from the fact that the period of observation extended throughout the whole course of the disease—some years; and also that quite early in the disease the character of the continuous temperature record enabled us to make not only a diagnosis as to the extent of the disease but to anticipate its probable course, for it has been found that in all records of a number of fatal cases of tuberculosis collected during the past eight years the persistence of a plateau temperature, especially when on this are superposed marked fluctuations, is a sure indication of active disease, whether this can be diagnosed by means of the stethoscope or not.

CASE 7 (W. T.) was admitted to Bourn Colony, May 11th, 1917, as an early "contact case" of pulmonary tuberculosis; not only has his mother since died from pulmonary tuberculosis, but a sister has recently succumbed to the same disease. In this patient the consumption early assumed a very virulent form, for although the activity of the process was retarded by rest and treatment—the patient gained  $17\frac{1}{2}$  lb. in 2½ months—the disease again began to progress as soon as the patient was allowed to work anything beyond very short hours. Temperature records were taken during the 2½ months between 11/5/17 and 31/8/17, at the time the patient was putting on weight. Eighteen months later, February, 1919, the patient died.

In Fig. 8 we have the first of a series of curves showing, in the continued and regular level of the "plateau" between 2 P.M. and 10 P.M., the effects of the auto-inoculation of the patient, followed by a steep fall of a degree and a half within two hours, after which, at 6.20 A.M., the lowest point is attained. A similar record was obtained three days later and again ten days later (Fig. 9). Instead of the usual diurnal variations, we have here a prolonged period during which the temperature remains at almost one level, broken only by sharp peaks and depressions such as are so commonly met with when tuberculin is injected into tuberculous cattle. The A.M. temperature usually falls (Fig. 10) and behaves very much as does the normal temperature, but in a record taken June 24th-25th the difference between the A.M. temperature and the P.M. temperature is less than normal (Fig. 11).

CASE N. was admitted to Bourn Colony on April 21st, 1917, with definite signs of extensive tuberculous disease of the lungs and peritoneum. The patient's whole physique was flabby and his general condition very poor. After keeping him under observation for a month it was decided, as accommodation was then limited, to discharge him from the colony, and on May 25th, 1917, he was sent home and placed under domiciliary treatment. He was dead within six months.

*Curve of Rapidly Progressing Tuberculosis.*

The temperature curves from this case are very characteristic and of great interest. Taken 12 and 13 days after admission, they indicate a rapidly progressing tuberculosis. Though the temperature only once reached  $100^{\circ}$ , the plateau (above  $99^{\circ}$ , Fig. 12) extended for 11 hours during the first 24 hours, May 3rd and 4th, and 8 hours on the following day. The temperature then fell to subnormal,  $96^{\circ}2'$  at 5.30 P.M. on the first day and  $96^{\circ}$  on the following day at 8.30. Here the plateau, the range of the diurnal variation,  $5^{\circ}8'$  on May 3rd-4th and  $3^{\circ}6'$  on May 4th-5th (Fig. 13), combined with the extreme irregularity of the curve left no doubt as to the active and progressive character of the tuberculous process.

CASE S. D. was admitted Dec. 23rd, 1916, in a very advanced stage of pulmonary tuberculosis, both lungs being considerably involved. So ill was the patient that he was confined to bed during the whole of his stay at the Bourn Colony, suffering from severe night sweats, commencing when the night temperatures were at the highest. He remained under observation in the colony for about a month only, and died shortly after discharge—Feb. 25th, 1917.

In the three records here given we have ample evidence of the extreme activity of the disease in its later stages—five or six weeks and then four weeks before the death of the patient. In Fig. 14 it is seen that the temperature rises rapidly, but very irregularly, from  $98^{\circ}4'$  at noon to  $100^{\circ}9'$  at 7.15 P.M. It then falls, with a severe "night sweat," to  $100^{\circ}$  at 9.30, from which point there is a steady rise to  $103^{\circ}7'$  at 4.30 A.M., giving a diurnal range of  $5^{\circ}3'$ , followed by a somewhat intermittent fall to  $99^{\circ}7'$  at 10.40 A.M. This complete inversion of the usual curve is, as already noted, very characteristic of the late stage of a rapidly progressing pulmonary tuberculosis. The second record (Fig. 15), made 11 days later, is especially interesting in that not only is there a high temperature, an irregular curve, a wide range, and a very rapid fall after a night sweat at 3 A.M., but a very high plateau (over  $102^{\circ}$ ) extending between the hours 2 P.M. and 5 A.M., apparently the result of severe auto-inoculation. The fall from the highest point of the plateau at 3 A.M. is both rapid and irregular. Here we have a semi-inverse temperature extending from  $101^{\circ}3'$  at 12 noon to  $103^{\circ}6'$  at 3 A.M. and falling with breaks to  $99^{\circ}3'$  at 11 A.M. On the following day a curve (Fig. 16) of a somewhat different type, but still very characteristic, is obtained. Commencing at  $98^{\circ}2'$  at 1 P.M. there is a continuous and regular rise to  $101^{\circ}5'$  at 6 P.M.; after this the rise becomes irregular, with marked dentations, until at 12.30 A.M. it reaches  $103^{\circ}6'$ . At 1.30 A.M. a night sweat commences and the temperature begins to fall, though slowly, reaching  $103^{\circ}$  at 2-4 A.M.,  $102^{\circ}2'$  at 5 A.M.,  $102^{\circ}$  at 7 A.M.,  $100^{\circ}3'$  at 9.30 A.M., and  $100^{\circ}$  at 12 noon. In  $12\frac{1}{2}$  hours there is a rise of  $5^{\circ}6'$ , followed by a fall of  $3^{\circ}8'$  in  $10\frac{1}{2}$  hours, the temperature remaining at or over  $100^{\circ}3'$  for a period of  $21\frac{1}{2}$  hours. This curve corresponds very closely to the post-tuberculin curve obtained from a calf in an advanced stage of tuberculosis.



CASE L. P. was admitted to Bourn Colony June 26th, 1916, as a case to be kept under observation. Two months previously he had suffered from a severe attack of influenza, but when admitted was quite convalescent. Owing, however, to the length of time that the influenza symptoms had persisted it was feared by his medical attendant that the patient might have developed pulmonary tuberculosis. During his stay at the colony he had no cough and no rise of temperature, though frequent records were taken. There was a gain of 9½ lb. weight, the patient reaching his normal weight in a very short time. He was able to do a full day's work without the slightest fatigue, and was soon discharged fit to continue his trade of cycle repairing. Since leaving the colony he has not had a day's illness, and at the present date (5/1/21) he is well and strong and doing a full day's work.

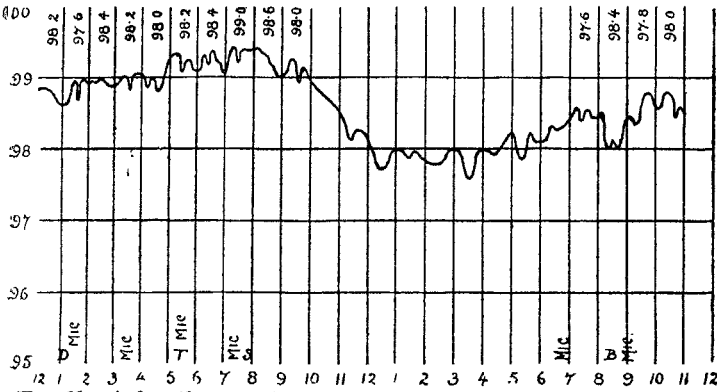


FIG. 11.—A fourth record from W. T., made June 24th–25th, 1917. Nine hours' plateau, with many peaks and depressions followed by a night-sweat fall. Diurnal range 1·8°, but high mean.

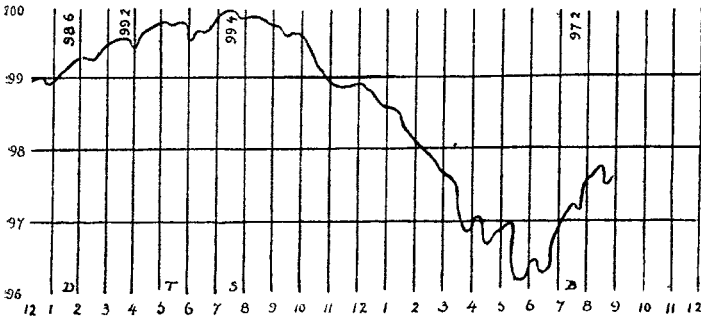


FIG. 12.—N., aged 20. Record made May 3rd–4th, 1917. Plateau eleven hours, but with no very marked peaks or depressions. The fall from 10 P.M. is very steady and regular until 3.30 A.M., when period of profound sleep is past. Diurnal range 3·8°. Prognosis very unfavourable.

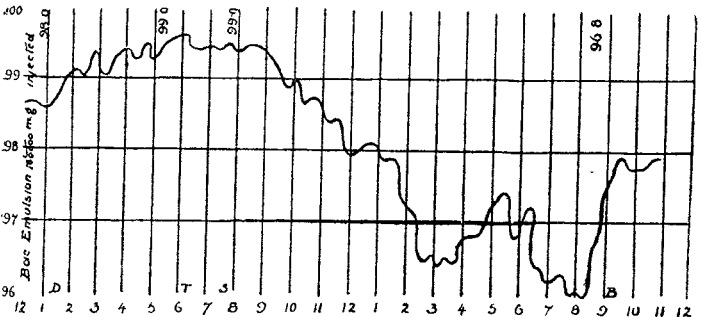


FIG. 13.—A second record from N., made May 4th–5th, 1917, after the injection 1/100,000 mg. bacillary emulsion. Seven and three-quarter hour plateau, irregular curve, early morning sweating, with rapid fall of temperature between 1.30 and 2.30 A.M. Diurnal range 3·6°. Here the natural tuberculinisation is so great that the addition of the comparatively small amount of bacillary emulsion affects the curve but slightly.

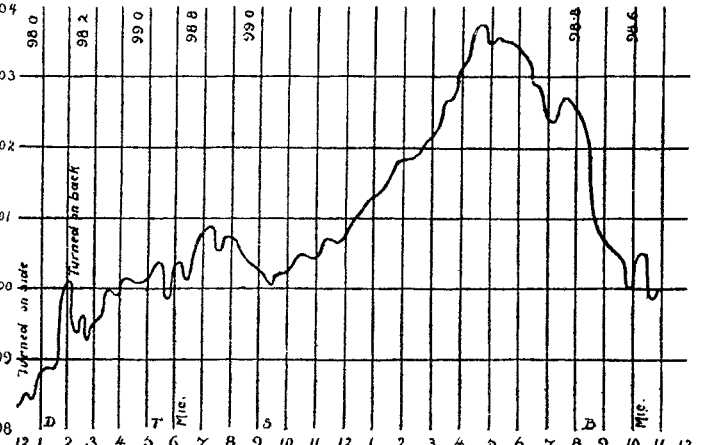


FIG. 14.—S. D., aged 25. Record made Feb. 2nd–3rd, 1917. Characteristic "inverse temperature." Prognosis very bad.

A Normal Temperature Record.

In the record (Fig. 17), taken from this patient at the Pathological Laboratories on June 20th, 1916, before he was admitted to Bourn, we have a characteristically normal temperature curve. There is no plateau and little irregularity of the curve, and although the diurnal range is nearly 2° it is obvious that no auto-inoculation effects are present. To further test the matter a diagnostic dose of bacillary emulsion was injected at 12 noon on June 21st. This gave rise to no

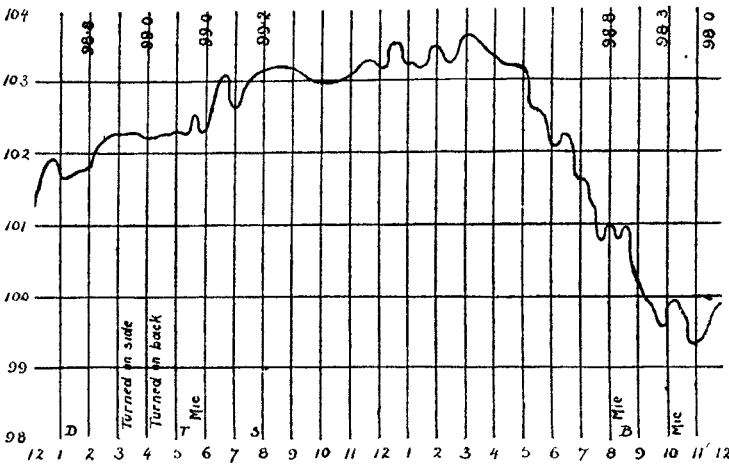


FIG. 15.—A second record from S. D. 11 days later, Feb. 13th–14th, 1917. Even though temperature runs between 99·3° to 103·6° during the 24 hours, the plateau, with peaks and depressions, still persists. The movement of the plateau to the right is here very characteristic of the "inverse" or "half inverse" temperature.

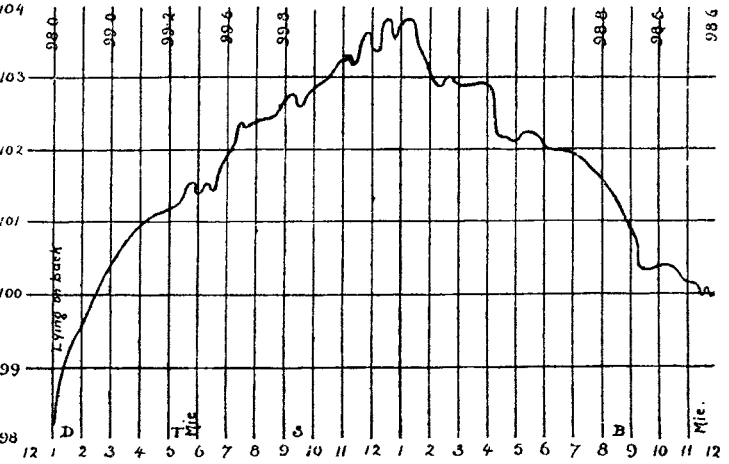


FIG. 16.—Another record from S. D. resembling very closely the post-tuberculin curve taken from a calf in a very advanced stage of tuberculosis. Diurnal range, peaks, and depressions well marked. Diurnal range 5·6°.

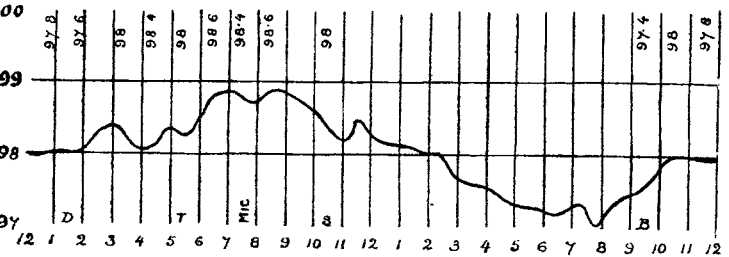


FIG. 17.—L. P. Admitted as doubtful case of post-influenzal tuberculosis (?) Record taken June 20th–21st, 1916. A "normal" temperature curve. Regular curve with normal diurnal range and variations with no exaggerated peaks or depressions. Diurnal range 1·8°.

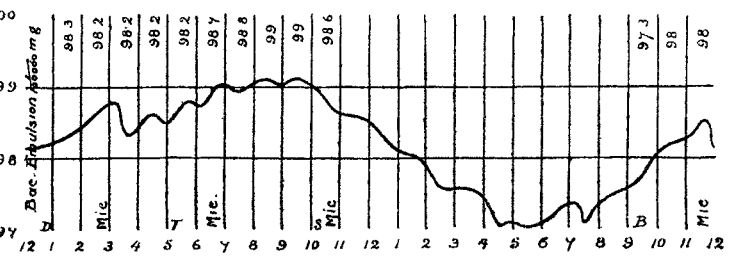


FIG. 18.—A "tuberculin" record from L. P. after a test injection of 1/100,000 mg. of bacterial emulsion. No plateau, merely a very slight and temporary rise of about three points. Still a "normal" curve in all respects. Diurnal range 2·1°. Diagnosis "non-tuberculous," afterwards confirmed.

plateau temperature (Fig. 18); the fall from the highest point at 9.30 to the lowest at 5.30 A.M. is well graded, the rise of the A.M. temperature is equally gradual and steady, and there is little or no exaggeration of the "teeth" of the curve, which, even after the injection, shows nothing but an immediate slight rise of  $0.3^{\circ}$ . The whole curve undoubtedly justifies a negative diagnosis—absence of any tuberculous process.

CASE K. S.—This patient, a scientific instrument maker, the brother of M. S. (Case 6), was examined in December, 1916, as a "contact" of his brother, for though he had not been working with him at the Military Hospital, he had shared a room with him at their own home. The general appearance of the patient was far from robust. He was thin and not well developed, his frame being considerably slighter though more wiry than that of his brother; indeed, he looked the more delicate of the two. He protested, however, that he was "quite well." In the chest there were no physical signs, and no definite evidence of pulmonary mischief. It was thought, however, that there was a suitable case for observation, especially as there was a strong probability that infection might have taken place. This, coupled with the delicate frame of the patient, made him a suitable subject for a control observation, and he was sent to the colony, where for  $5\frac{1}{2}$  months he was kept under close inspection in surroundings and under conditions similar to those in which his brother was living. Quasi-continuous temperature records were made at intervals. During the above period he gained  $16\frac{1}{2}$  lb. in weight, and at the end of it he returned to his work with the Cambridge Scientific Instrument Company, coming to the dispensary for examination from time to time. No signs of tuberculous disease have ever been found, and at the present date the man enjoys good health and is doing a full day's work.

On Jan. 23rd–24th, 1917, the temperature of the patient running about  $99^{\circ}$  from 12 noon until 7.15 P.M., a small dose (1/100,000 mg.) of bacillary emulsion was injected just before 8 P.M. This was followed (Fig. 19) by a slight rise to  $99.7^{\circ}$  at 8 P.M., and then by a steady fall to  $99^{\circ}$  at 11.50 P.M., and by a further fall, following a normal line until 2.45 A.M., when the lowest point,  $97.3^{\circ}$ , was reached. Then began a rise, at first slow until 7 A.M., and then more rapid until 11 A.M., when  $99.7^{\circ}$  was reached. On Feb. 7th–8th 1917, in the same case (Fig. 20), the temperature,  $98.2^{\circ}$  at 12 noon, rose at 2.30 P.M. to  $99^{\circ}$ , reaching  $99.9^{\circ}$  at 6 P.M. Then followed a fall to the lowest point reached,  $96.4^{\circ}$ , at 12.15 A.M., followed by a slight rise to  $97.3^{\circ}$  at 1 A.M., a fall to  $96.8^{\circ}$  at 4 A.M., and an irregular rise to  $99.7^{\circ}$  at 11 A.M. It will be noted that here there is no continued "plateau," and that although the curve is irregular it is by no means characteristically "tuberculous" in any other respect. In a second group of curves any well-defined plateau is still absent, for although the temperature on Feb. 24th–25th (Fig. 21) runs above  $99^{\circ}$  for nearly ten hours between 12 noon and 12 midnight, it twice falls below that level—at 5 o'clock in the afternoon and between 9.30 P.M. and 10.45 P.M. At no time does it rise beyond  $99.7^{\circ}$ , and during the greater part of the period it is below  $99.3^{\circ}$ . Between 12.30 A.M. and 1.15 A.M. there is a fall of  $0.7^{\circ}$ , the temperature then going down steadily until 7 A.M., when it reaches  $97.9^{\circ}$ , and then rises equally steadily to  $99.6^{\circ}$  at noon. With the object of confirming or correcting these observations another temperature record was taken on April 2nd–3rd, 1917. Here, again (Fig. 22), no plateau is seen; the rectal temperature does not continue above  $99^{\circ}$  for more than six hours;  $98.8^{\circ}$  at 12 noon,  $99^{\circ}$  at 2 P.M., it reaches the highest point,  $99.6^{\circ}$ , at 6.30 P.M. By 8 P.M. it had fallen to  $99^{\circ}$ , at 10 P.M. to  $98.3^{\circ}$ , and then, with slight intermissions, to  $96.8^{\circ}$  at 5.45 A.M. and  $96.6^{\circ}$  at 8 A.M., after which there is a steady rise to  $98.6^{\circ}$  at noon. In the afternoon, between 3 and 4 o'clock, the injection of 1 mg. of old tuberculin was followed by no tuberculin reaction (Fig. 23). There was a slight—practically normal—rise of temperature to  $99.5^{\circ}$ , followed by a steady, though irregular, fall to  $97.6^{\circ}$  at 11.20 P.M. and a further fall to  $96.9^{\circ}$  at A.M., after which the temperature began to rise, and at noon had reached  $98.7^{\circ}$ . During the whole period none of the characters of a true tuberculin temperature were noted. The records obtained from this case, K. S., a non-tuberculous patient, served as admirable controls for comparison with those of his brother, M. S., a markedly tuberculous patient. Both had been and were observed under exactly similar conditions. All the records were taken at similar intervals, and external factors, diet, temperature (summer and winter) were identical.

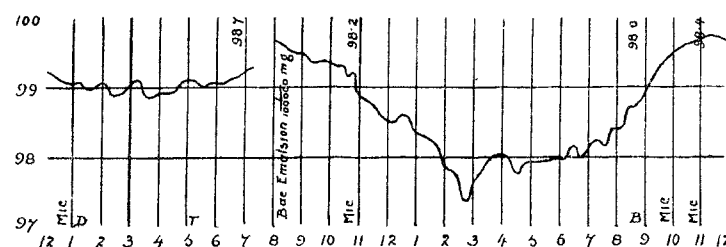


FIG. 19.—K. S., aged 20. Record made Jan. 23rd–24th, 1917. A contact case, brother of M. S. (Figs. 3–7). Tested with 1/100,000 mg. bacillary emulsion. Diagnosis doubtful.

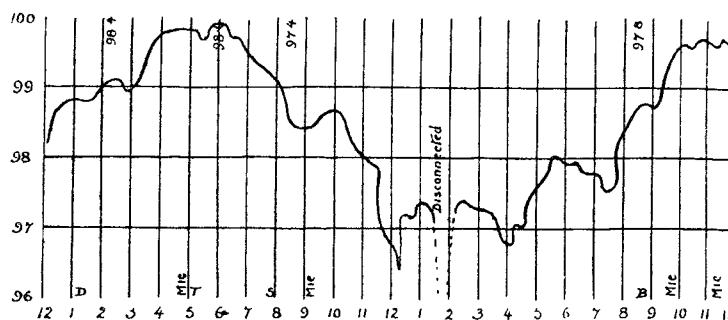


FIG. 20.—Record from same case (K. S.), Feb. 7th–8th, 1917. Plateau only four and a half hours, and curve very steady and regular. Diagnosis still "doubtful, but, if tuberculous, prognosis favourable."

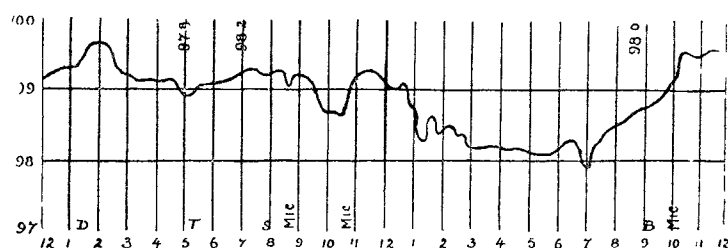


FIG. 21.—Record from same case (K. S.), Feb. 24th–25th, 1917. Morning temperature rather high. Diurnal range  $1.7^{\circ}$ . Plateau (?) but temperature is steady and not much affected by external influences. Diagnosis still "doubtful, but, if tuberculous, prognosis good."

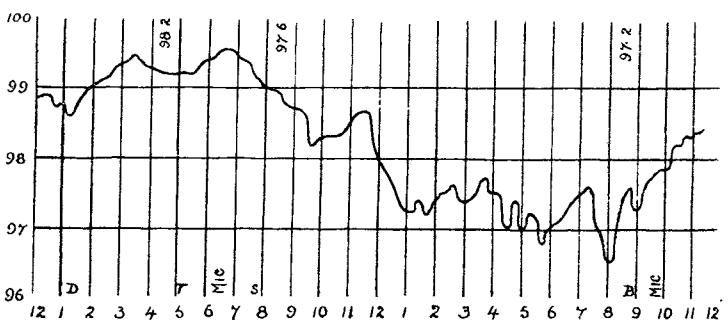


FIG. 22.—Record from same case (K. S.) five weeks later, April 2nd–3rd, 1917. Plateau contracted to seven hours. No marked peaks or depressions. Irregularities in the curve occur only when patient is restless or awake. No night sweat with early morning fall. Diurnal range  $3^{\circ}$ .

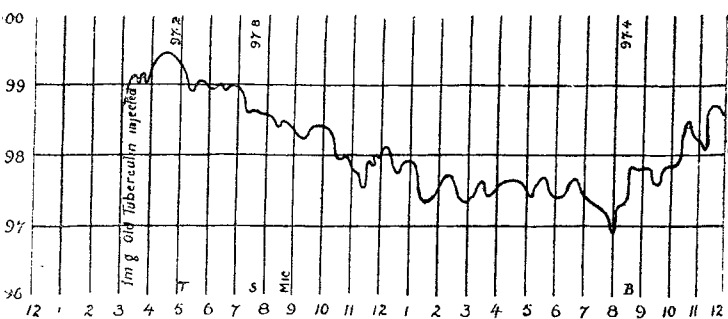


FIG. 23.—Test record from same case (K. S.), April 2nd–4th, 1917, after injection of a test dose of bacillary emulsion 1/100,000 mg. No plateau, curve somewhat more irregular than usual, but the curve now follows quite normal lines. Diurnal range  $2.6^{\circ}$ . Diagnosis: No tuberculosis.

*The Advent of Thermometry.*

Fever or pyrexia has long been associated with various forms of pulmonary consumption and tuberculosis, but with the advent of thermometry it assumed a special importance. Aitken,<sup>11</sup> following Wunderlich,<sup>12</sup> drew attention to the fact that in tuberculosis, especially in its acute form, the persistence of a uniformly high temperature, quite apart from other signs, is sufficient indication that there has been no arrest in the progress of the disease. Aitken, however, realised the difficulty of making a definite diagnosis or prognosis on a single observation. In a series of unsigned articles dealing with Wunderlich's thermometrical work<sup>13</sup> the importance of a rise of temperature in tuberculous conditions—e.g., "while tubercle is being deposited in any of the organs of the body the temperature of the patient is preternaturally raised"—is strongly insisted upon, this rise being "a measure of the rapidity with which tubercle is being deposited in any of the organs of the body." Again, in 1860 Ringer and Rickards<sup>14</sup> demonstrated that the temperature of the body is always preternaturally elevated, while tubercle is being deposited in any of its organs. They hold, moreover, that if there be a chronic elevation of the temperature, and this be not due to rheumatism, ague, suppuration, or chronic induration of the lung, it must be looked upon as being due to a tuberculous deposit in the body. With the advent of the tubercle bacillus temperature records became of still greater importance, especially as bearing on the progress of the disease.

In 1893 J. Kingston Fowler<sup>15</sup> made a valuable contribution to our knowledge of this subject, drawing attention to the indications as to the progress and activity of the tuberculous process offered by the degree and type of pyrexia. He pointed out that the "tuberculosis" daily temperature curve is usually characterised by pyrexia commencing in the afternoon, gradually increasing to a maximum at 8 or 10 P.M., and then falling continuously until the early morning, when the thermometer may register one, two, or even three degrees below normal. He admits that this type of pyrexia is not confined to tuberculous disease, although it certainly occurs in connexion with it with special frequency, *its presence often first indicating the real nature of a doubtful case*. He is of opinion that no satisfactory explanation of this pyrexia has ever been given, although "when occurring in a case of pulmonary tuberculosis with a rapid disintegration of the lung, it is generally ascribed to septic absorption," though a similar rise in cases of tuberculous pleurisy and tuberculous peritonitis may be met with. He looks upon this fever as the "expression" of an attempt on the part of the organism to deal with and destroy the product of the *Bacillus tuberculosis*, or of "a direct effect on the heat-regulating centres of the absorption of the toxic material ..... a sudden increase in the area of lung affected, or an accession of activity of the morbid process without definite signs of extension, is almost invariably marked by the occurrence or increase of pyrexia."<sup>16</sup>

A moderate rise with a distinct morning fall "indicates a progress of infiltration, with foci of softening, or, again, when the regularity of the evening rise and the morning fall is disturbed in any way; as when there is a sudden increase in the evening fever associated with a less marked morning remission, or when, on successive days, the lowest point touched gradually recedes from the base-line and regularity is replaced by marked variability, we are rarely wrong in concluding that an extension of the morbid process has occurred, and conversely it is scarcely necessary to state that between such periods of pyrexia there may be long intervals marked by absence of fever during which there is either partial or complete arrest of the morbid process."<sup>17</sup>

*"Normal" and "Inverse" Types of Pyrexia.*

He notes, too, that in fibroid tuberculosis, a chronic condition in which tuberculous foci, even when present, are isolated, the disease is sometimes "characterised by hypopyrexia which may persist almost throughout the case even during periods of extension of the disease within the lungs,"<sup>18</sup> the temperature in certain of these cases never rising above 98.4° F. In an equally exhaustive paper, Dr. S. Vere Pearson<sup>19</sup> records a number of observations of great interest and value. He divides the temperature met with in his cases of tuberculosis into four groups, for each of which he constructs a curve; one for a type of temperature which he speaks of as "normal," a second as "half-normal," a third as "half-inverse," and a fourth as "inverse." He maintains that if a sufficiently large number of cases of pulmonary tuberculosis be studied, examples will be found coinciding with, or approximating to, one or other of the following types: (i.) the lowest temperature is met with at 12 noon instead of first thing in the morning; (ii.) the highest temperature is reached at 9.45 P.M. instead of 6.45 P.M.; and (iii.) an entirely erratic type of temperature, sometimes inverse, sometimes highest at noon and sometimes lowest at noon. The third of these groups he looks upon as indicating a bad prognosis, the late high temperature (ii.) as being of less grave significance and (i.) of least grave significance.

Dr. Pearson was evidently confronted with the same difficulty that early presented itself to us during the course of our work—the difficulty of determining the early morning temperature of his patient, a difficulty which led us to search for the *normal diurnal variation*. We then found that temperature is, to a certain extent, even in the normal individual, a matter of custom and habit, but that, speaking generally, the lowest temperature is usually recorded when the bodily and functional activities of the individual are at their lowest ebb, and if, for any reason whatever, these have been subject to excessive stimulation or have been compelled to pass through an abnormal cycle there may be, during the period of exhaustion, a lower or the lowest temperature at a period other than that at which it is usually met with under normal conditions. It has been generally accepted that the early morning temperature of a patient with quiescent or healed tuberculosis is lower than that of a healthy person, and that the rectal temperature after recovery from a relapse may be several points lower than the temperature met with, as a rule, after recovery from the primary trouble. Sometimes it is the morning temperature alone that is lower; sometimes *all the rest-temperatures are lower*—indeed, Vere Pearson lays stress on the small excursion that occurs after a return to health, but we are inclined to the opinion that no such restriction of the excursion may take place and that the mistake involved has arisen because after rest and treatment the "minimum" temperature *is usually recorded after the morning rise has commenced*. No definite and reliable temperature curve can be built up on observations taken at fixed times, even when taken every four hours, and certainly not when taken only four times a day.

*Healthy Diurnal Variation and Range.*

When we first took up our investigations on the temperature of the animal body we long remained in considerable doubt as to what should be looked upon as a normal temperature and what its normal diurnal variations and range. Most of the earlier observers, finding themselves confronted with the same difficulty, made efforts, in many instances very successful efforts, to obtain information on these points, and some have recognised the relative movements of the several

<sup>18</sup> Loc. cit., p. 268.<sup>11</sup> Science and Practice of Medicine, second edition, 1863; third edition, 1864, vol. i., pp. 32-63.<sup>12</sup> Das Verhalten der Eigenwärme in Krankheiten, Leipzig, 1868, Trans. New Syd. Soc., 1871.<sup>13</sup> Medical Times and Gazette, 1866, vol. i., pp. 177, 201, 228, 311, 394, 418, 666.<sup>14</sup> Ibid., 1866, vol. i., p. 250.<sup>15</sup> The Varieties of Pulmonary Tuberculosis, Practitioner, 1893, vol. li., p. 256, et. seq.<sup>16</sup> Loc. cit., p. 260.<sup>17</sup> Loc. cit., p. 262.<sup>19</sup> The Temperature as a Guide to the Treatment and Prognosis of Phthisis, THE LANCET, 1909, ii., 852. At the time the part of our first paper dealing with clinical cases was written (THE LANCET, 1916, i., 496, et seq.) we had, owing to war conditions, no access to much of the literature of the subject. We have since read Dr. Pearson's article in which he gives his observations on the fever of phthisis and describes most fully an erratic type of temperature which corresponds very closely to the fluctuating temperatures of our records.

temperature points, noting that under certain conditions the highest point might be attained an hour or two earlier or an hour or two later than usual in the evening and, similarly, the lowest point an hour or two earlier or later in the morning. In spite of this we find that the times at which temperatures are taken are usually "fixed." Consequently the highest and lowest points are frequently missed, and deviations from the normal indicative of altered conditions, remain unobserved.

In his paper Vere Pearson sets up a somewhat arbitrary standard which, however, in the absence of continuous records, probably affords a good "working rule"; he says that fever is present when the morning temperature reading is above  $98^{\circ}$ , the evening record above  $99.4^{\circ}$ , and that a call for care and rest is then indicated. "The heightening evening temperature," he says, "may be the indication of the slight remains of activity, but a raised morning temperature means more than this."

To the series of normal temperature curves already published<sup>20</sup> we now add others; two (Figs. 16 and 17), obtained from a patient who, after an attack of influenza, was kept under observation as a suspected case of pulmonary tuberculosis; and five others from a "contact" who never developed tuberculosis (Figs. 18-22). In the former case the highest temperature attained is between 7 and 9 P.M.,  $98.8^{\circ}$  on the one day, and between 7 and 10 P.M.,  $99^{\circ}$  and  $99.1^{\circ}$  at 7.45 A.M. on the first day, and  $97.1^{\circ}$  at 4.30 A.M. the next day. The injection of a dose of bacillary emulsion causes a rise of only  $0.2^{\circ}$  at the highest point, though there appears to be a slightly higher temperature for a period of eight hours. There is no sudden rise at any point, the gradient of the fall is very gentle, no "plateau" is developed, and the irregularities characteristic of a tuberculin curve are absent.

#### *Time of Highest and Lowest Daily Reading.*

In the healthy individual any temperature of  $98^{\circ}$  or below has been accepted as a normal morning reading. We should place the figure for a rectal temperature nearer  $97^{\circ}$ , but it is evident, from a study of the various records of healthy individuals of different ages, that even in the same person the minimum reading varies on different days at the same hours in the morning even under similar conditions, except as regards the period at which the individual is enjoying his most profound sleep, the time at which all the bodily functions and activities are most in abeyance. It must, of course, be borne in mind that as a rule whilst the quasi-continuous records are being taken the patient is confined to bed, and that he is only kept in bed because there is need for rest during the course of treatment. The measure of rest, however, complete or incomplete, can be accurately determined by a study of the curves obtained.

It is obvious, from what has been stated above, that the difficulty of determining the exact time at which the temperature should be taken is completely eliminated by the adoption of the continuous or quasi-continuous method. Vere Pearson draws attention to the fact that the lowest temperature for the 24 hours, not only in the healthy individual, but in most cases of tuberculosis in which the disease is not active, occurs between the hours of 1 and 4 A.M. Our experience enables us to agree with this, except that this lowest point may be reached as much as three or four hours later. Again, although we are in general agreement with his statement that the highest daily reading is usually between 3 P.M. and 8 P.M., our experience is that the highest daily reading is sometimes earlier than the above and sometimes later.

#### *Deductions from Morning and Evening Rectal Measurements.*

We have made careful study of the information as to the temperature changes recorded by later observers, amongst others, F. Burton-Fanning and S. G. Champion,<sup>21</sup>

K. Turban,<sup>22</sup> F. R. Walters,<sup>23</sup> Arthur Latham,<sup>24</sup> and A. C. Inman,<sup>25</sup> as occurring in different types of pulmonary tuberculosis. There appears to be a consensus of opinion that where rectal temperatures are taken—and all, with the exception of Burton-Fanning, agree in insisting that the rectal temperature, and that only, is reliable—(i.) any slight daily repeated rise above the evening normal must be accepted as indicating the presence of active tuberculous disease; (ii.) a morning rise, even comparatively slight, whether accompanied by an evening rise or not, may be a still graver sign. Most observers draw attention to the fact that this morning rise is frequently the indication of an inverse temperature such as may be associated with cases of acute miliary tuberculosis or very advanced cases of rapidly caseating catarrhal pneumonia—the terminal phase of so many types of pulmonary tuberculosis.

Vere Pearson maintains that here there may be but slight difference between morning and evening temperatures and, further, that were single morning and evening temperature only taken at the usual times they would almost certainly be accepted as normal. There appears, however, to be general agreement that patients in whom the temperatures show little variation, even at a low level, during the 24 hours, often possess little reactive power and "have to be dealt with very cautiously." (iii.) The continuous temperature in which though morning and evening temperature are both somewhat higher than normal, that of the evening not being raised so much as is that of the morning, indicates a commencing inversion. A marked evening rise, especially when accompanied by irregularities—remittent and intermittent; (iv.) is characteristic of acute caseating tuberculosis; (v.) a normal or subnormal temperature is met with in cases of chronic fibroid tuberculosis and, especially in somewhat more active disease, following a raised evening temperature.

It has been pointed out, repeatedly, that in acute miliary tuberculosis there is an increase of pyrexia usually occurring after midday and marked by great irregularities "the maximum being observed between 8 and 10 P.M., followed by a remission accompanied by profuse sweats in the early morning." Again, the "inverse type" in which the evening temperature is lower than the morning temperature is said to be characteristic of this form of tuberculosis. All are at one, further, in holding that wherever the type of temperature curve has become changed in any way—i.e., has departed from the normal, ever so slightly—the patient must be advised to "make haste slowly." We agree<sup>26</sup> with Vere Pearson, that by a careful study of rectal temperature the onset of relapses and complications are recognised more readily and certainly than by any other method:—

"It is of particular importance in respect of the early recognition of a relapse to remember that not infrequently the physical signs of the extension of the disease in the chest are only to be found after the symptoms of the set-back have subsided. Hence, anything which helps towards an early recognition of tendency to relapse is of the utmost importance in treatment, because with skill the inclination towards renewed activity or extension of the disease can be checked, and thereby often, I feel sure, a definite set-back warded off."<sup>27</sup>

#### *Temperature Observation as an Aid to Early Diagnosis.*

We go further, however, for, from our own experience, these temperature observations are of even greater importance in the early diagnosis of tuberculous disease, and we hold that the commencement of the process assumes to the infected organism the same relation that a relapse bears to the patient with the developed disease. In the one case we are on the outlook because we have already obtained evidence of the presence of the disease, in the other we may frequently obtain the evidence do we but search for it.

<sup>22</sup> Beiträge zur Kenntniss der Lungen-Tuberkulose, Wiesbaden, 1899, and Die praktische Bedeutung der Opsonischen Index bei Tuberkulose, Münch. med. Wochenschr., 1908, Bd. lv., p. 1993.

<sup>23</sup> Tuberculin and the Sanatorium, Brit. Jnl. Tuberculosis, 1912, vol. vi., p. 107; Practitioner, 1913, vol. xc., p. 69.

<sup>24</sup> The Uses of Tuberculin in Pulmonary Tuberculosis, Proc. Royal Soc. Med., 1912, vol. v., Pt. 3, Therap. Sect., p. 55.

<sup>25</sup> The Specific Diagnosis of Pulmonary Tuberculosis, THE LANCET, 1910, ii., 1747.

<sup>26</sup> Loc. cit., Figs. 16, 17, 18, and 19, p. 450.

<sup>27</sup> Pearson: THE LANCET, 1909, ii., 853.

<sup>20</sup> THE LANCET, 1916, vol. i., Figs. 5 and 6, p. 285, and Figs. 16, 17, 18, and 19, p. 450.

<sup>21</sup> The Comparative Value of the Mouth, the Rectum, the Urine, the Axilla, and the Groin for the Observation of the Temperature, THE LANCET, 1903, i., 856.



It will be readily understood, then, from what we have stated, that it is not always an easy matter to determine by single routine morning and evening temperature readings whether a febrile condition is present or not. Further, it is now recognised that in night workers who rest during the day a "normal inverse" temperature obtains as soon as a habit is formed. We are of opinion, moreover, that the inverse temperature met with in acute miliary tuberculosis of the lung and similarly present in the advanced and rapidly progressing catarrhal pneumonic type of pulmonary tuberculosis is due, in part at any rate, to the disturbance of the cycle of the functional activities that accompanies the rapid extension of the tuberculous process. In both types of tuberculosis the presence of the inverse temperature affords evidence that the disease is assuming an acute progressive form and that there is little prospect of any permanent arrest of the disease.

Marcus Paterson has long held that the patient with large cavities—cavities bounded by walls of fibrous tissue—in the lung must be looked upon as an individual resistant to the disease. In such a patient the disease has progressed slowly; there may have been several or many exacerbations, but these have given rise to *comparatively slight* constitutional or physical manifestations but to *marked* proliferation of the connective-tissue cells. So consistent have been our observations on the cases treated at the Bourn and Papworth colonies that, taking the cases collectively, fibroid, miliary, and pneumonic caseous cases, the slowly developing and resistant or fibroid cases, and the more rapidly progressive cases, we think it may now be accepted that the pyrexia varies almost directly with the rapidity and extent of the breaking down of the tissues through the activities of the tubercle bacillus, the breaking down of the bacilli, and the absorption of the products of these lytic processes by the surrounding tissues and inversely as the "resistance" of the tissues of the patient. It is obvious that if this be correct fibroid tuberculosis, under ordinary conditions, will be characterised by comparatively little rise of temperature, though as the result of a dose of tuberculin injected artificially it may be possible to set up a well-marked reaction. The same holds good of those lesions in which the caseous masses, surrounded by a fibrous capsule, are cut off or isolated from the surrounding tissues. Only when there is some disturbance of the fibrous tissue, some acute inflammatory process, some lysis of the bacilli present, some violent exercise inducing absorption of the caseous tuberculous material and the products of bacteriolytic action and auto-inoculation of the patient is any marked rise likely to occur. Moreover, as soon as the tuberculous focus is emptied of its degenerated content pyrexia becomes less marked—there is less auto-inoculation reaction. In the somewhat rapidly progressing caseous tuberculosis where the tuberculous process extends beyond a quiescent or fibrous lesion and where, in addition to the interstitial tuberculous process, there is a rapidly extending catarrhal pneumonic tuberculosis, the process of auto-inoculation goes on much more rapidly and completely, giving rise to severe constitutional changes, amongst which continued pyrexia during the working hours of the day is a marked feature, varying according to the extent of the lesion (the amount of "tuberculin" available), the readiness with which the tuberculin may escape from the caseating lesion, and the activity and extent of the factors—work, movement, &c.—concerned in the diffusion of the "tuberculin." That tuberculin alone is capable of exciting a rise of temperature in a tuberculous patient appears to be beyond question. The heat-regulating centres then become unstable, over-worked, or irritable, whilst when the products of septic or other bacteria act as adjuvant factors—and this occurs specially in the later stages of the disease—the temperature variations undoubtedly become exaggerated, and, very frequently, considerably altered in general character. For the present, however, we confine our observations to what may be termed a "pure tuberculin reaction."

Quasi-continuous temperature records of the cases now under consideration have been made over a period

of eight years, but most of them have been made on patients treated at Papworth. Some of the patients studied have succumbed to tuberculosis, others are still at work, but in all the conditions have been carefully noted. Some of the contacts of these cases serve as controls and are still under observation, and the earlier deductions made from a study of the various temperature charts are thus capable of verification by subsequent experience.

*The "Plateau" Curve is Pathognomonic of Tubercle.*

The most important of our observations is that as in tuberculosis in cattle, so in pulmonary tuberculosis of the human subject when the disease is progressive, a continuous temperature chart shows a characteristic curve—the "plateau" already described<sup>28</sup>—a curve which can always be reproduced in the tuberculous subject by over-exercise or by the injection of a suitable dose of tuberculin. Further, on reference to the notes of the cases here recorded it will be found that in all the doubtful cases in which the patient ultimately did badly this "plateau" temperature curve developed even during the early stages of the disease. This plateau, as we have seen, is characterised by a more or less rapid rise of temperature, 99° or more, a temperature which remains above 99° for a period of from 8 to 12 hours, the plateau commencing usually, though not invariably, about 2 P.M., and extending until 10, 11, 12 o'clock at night or later, when there is usually a sudden fall, often with, but sometimes without, a "night sweat."

The indication so afforded is so reliable that it may be accepted as almost pathognomonic even when other aids to diagnoses are wanting and a series of curves taken from a suspect embody information which will almost certainly eliminate doubt as to the diagnosis, whilst in a diagnosed case the "plateau" curve indicates the need of further treatment, in that it supplies definite evidence of the activity of the morbid process.

In all the cases in which the plateau is well developed the up and down lines are well accentuated, very slight physical movement or mental disturbance causing sudden rises, rest and ingested cold fluids determining equally rapid falls, whilst a restless night with disturbed sleep invariably gives rise to an irregular curve. In tuberculous patients, as in the healthy individual, the temperature is lowest at a time when sleep is most profound, and when the various functions appear to be least active. Another important feature is that as the disease progresses the plateau becomes more and more extended, and as this occurs there is a tendency for the summit to move more and more to the right, that is, to be prolonged into the morning hours; consequently in very advanced stages of the disease this may become so marked a feature that we have practically an "inverse" temperature.

In all the advanced cases and in some of those progressing but not yet advanced, "peaks" appear at intervals along the plateau, and for short periods the temperature may run to 102°, 103°, or even 104°—1°, 2°, or 3° above the general level of the plateau.

The evidence of auto-tuberculinisation is invariably most marked at the times at which the various functions of the body are most active, the night sweats ushering in the rapid fall of temperature at the end of the plateau, in certain cases, to subnormal. We look upon a sudden fall as associated not only with the night sweat but with the exhaustion of the patient induced by the tuberculin reaction, a process quite distinct from the disappearance of the pyrexia on the formation of a well-defined cavity, the result of softening and the evacuation of the caseous material—the tuberculinising centre. As the disease advances the variation between evening and morning temperature up to 103° and down to 96° or lower appears to be nothing but an exaggeration of the tuberculin reactions from auto-inoculation, as we find that in cases in which the tuberculin plateau is well developed the fall of temperature is sudden during the night and the point reached is extremely low; consequently the diurnal variations

<sup>28</sup> Loc. cit., pp. 495, et seq.

as measured by the ordinary clinical thermometer. must be great. It is only towards the end that the increase of the pyrexia becomes continuous, the highest point sometimes being separated from the lowest by a single degree only.

#### Conclusion.

We maintain that the quasi-continuous temperature record of a reaction is a valuable diagnostic indication as to (1) the tuberculous nature of the disease; (2) the activity of the process; and (3) the prognosis. As to the type of the disease, however, "acute miliary," "caseous pneumonic," "chronic fibroid," &c., though, as seen above, the temperature may give some indication, the physician will find that physical signs afford considerably more specific information.

The temperature indications as to the resistance, or lack of resistance of the tissues of the patient are of extreme interest, especially in regard to prognosis. Instability of the temperature affords evidence of (a) a high toxic absorption; (b) ready reaction of the tissues to the toxic stimulation; and (c) marked interference with the rest function of the patient. A restless night is reflected in the temperature curve, and it appears that the inverse temperature is, to a large extent, the result of a continued auto-inoculation, during which a minimum stimulus produces a maximum reaction both as to amount and duration.

In the night sweats we have evidence of some interference with the autonomic nerve centres, leading to dilatation of the surface blood-vessels, great radiation of heat from the cutaneous surface, and a rapid lowering of the general temperature.

At the outset of our observations we thought it well to compare the rectal temperatures with a series of temperatures taken in the mouth with the ordinary mercury clinical thermometer, but, as will be seen from the figures marked on the charts, these temperatures bear little relation to the rectal temperatures. In the advanced stages of the disease some information could certainly be obtained from these readings, but we are now satisfied that they give little indication of the extent or progress of the disease or, in its earlier-stages, of its presence.

To the Medical Research Council we are indebted for a grant to enable us to continue this investigation, and we wish here to tender our hearty thanks for the assistance so afforded.

## HELIOOTHERAPY IN THE HIGH ALPS.

By A. ROLLIER, M.D.,

MEDICAL DIRECTOR OF THE HELIOTHERAPEUTIC INSTITUTIONS AT LEYSIN, SWITZERLAND.

THE therapeutic action of the sun has for a long time been attributed to the invisible rays of the spectrum, especially to the ultra-violet, of which the bactericidal action has been demonstrated by a number of eminent bacteriologists (Arloing, Luclos, Tyndall, and others). Experiment has also shown that it is to the ultra-violet rays again that the production of cutaneous pigment must be attributed; this is considered a defensive reaction, preventing chemically active rays from penetrating deeply into the tissues. The ultra-violet rays are absorbed by the melanin of the epidermis, by the lipochrome of the adipose tissue, and by that of the blood plasma. Absorption by lipochrome can be proved by the spectroscope. The amount of energy derived from the rays absorbed, and the use made of it by the body, form interesting subjects for speculation, but lack of experimental evidence makes it impossible for any definite conclusions to be formed. Reference should, however, be made to the experiments of Dreyer, which showed that certain fluorescent substances, such as eosin and erythrosin, have the power of transforming rays of short wave-length into those of longer wave-length. In a paper published in 1908<sup>1</sup> Dr. Rosselet and I drew attention to the indications for attributing

the same power to cutaneous pigment. Inability to find a solvent capable of dissolving melanin made definite proof of this hypothesis impossible.

The experiments of Weissner, demonstrating the powerful bactericidal action of the infra-red rays, show that it is not only the ultra-violet which are of therapeutic importance. On account of their greater wave-length and amplitude, these infra-red rays give out a considerable amount of heat when they impinge on the surface of the body, and in comparison with the superficial action of the ultra-violet rays they have quite remarkable powers of penetration. Malgat claims to have demonstrated their passage through hand, arm, and even thorax, but his experimental methods, especially with regard to the thorax, were not very satisfactory. On account of their heat the infra-red rays are also active in vaso-dilatation, which favours phagocytosis, and tends to relieve the congestion of the internal organs. Although it cannot be denied that excellent therapeutic results have been obtained with artificial light, especially with ultra-violet rays produced by the mercury vapour lamp, I am strongly of opinion that up to the present science has not yet invented an adequate substitute for sunlight; on this point I have the support of Finsen himself, who admitted that the ideal treatment for lupus was heliotherapy at a high altitude. In view of the fact that in nature we so frequently meet with organic substances or living cells which are affected only by rays of wave-lengths varying between definite and comparatively narrow limits, it seems not improbable that similar conditions apply to the human body, and that certain rays act on one type of cell and quite different ones on another. Were this the case, the advantages found in practice from the use of the total solar radiations would receive an easy explanation.

#### Climate.

Heliotherapy may be carried out in any place where the sun shines; but different points on the earth's surface show great variation in the quality of the sunlight which reaches them, and also in other factors affecting the cure.

To reach sea-level the sun's rays have to pass through the whole thickness of the atmosphere; over all our big cities the latter is rich in mists, dust, and micro-organisms of every kind, which absorb both heat and light-rays in a proportion sometimes as high as 95 per cent. This absorption not only deprives the patient of a large number of useful rays, but by heating the air may give the sun-bath a relaxing instead of a stimulating effect. At high altitudes, on the contrary, the air is transparent, free from solid particles, and easily traversed by the sun's rays, which pass through without absorption, and warm and invigorate the body of the patient while leaving the air cool and fresh. For this reason a much greater intensity of direct sunlight can be borne at high altitudes, and heliotherapy may be practised in every month of the year.

#### The Skin.

I feel it necessary at this point to make a plea for that much ill-used organ, the skin. We Europeans are apt to regard with a complacent superiority the way in which less enlightened races maltreat their bodies (e.g., the feet of Chinese women), but we ourselves would do well to imitate more closely certain less cultivated races with regard to the treatment of the skin. The paramount importance of this organ cannot fail to be realised when we consider the complexity of its functions.

It is, in the first place, an admirable protection against pathogenic organisms; it is the seat of cutaneous sensation, and an excretory organ second only in importance to the kidney; it is very closely concerned in the delicate mechanism regulating the temperature of the body; and finally, as a very vascular layer it plays an important part in the nutrition of the underlying tissues. By covering the body with clothes every one of these functions is interfered with to a greater or lesser extent. I have frequently noticed that the resistance of a patient against disease is closely proportional to his degree of pigmentation, and pigmentation does not take place under clothes. It is a well-known fact that cutaneous sensation is much more delicate in the uncovered regions of the body, and it is equally obvious that clothes, by preventing free evaporation, interfere with the excretory functions of the skin. The contrast between the tolerance to wide ranges of temperature shown by the face and hands and the extreme sensitiveness of the rest of the body gives some idea of the extent to which disuse atrophy of the heat-regulating mechanism has taken place. The increased vascularity of the skin produced by the sun's rays causes considerable thickening of the organ itself, and also appears to result in an increase of the adipose tissue

<sup>1</sup> Sur le rôle du pigment épidermique et de la chlorophylle. (Bulletin de la Société vaudoise des Sc. Nat., vol. xlv., 1908.)