

unknown cycle running amongst these droughts, or in connection with Australian droughts, the dates of which have been unknown until now. These dates are points in history, and the fact that they fall into a cycle of weather, itself supported by all the available drought dates of the last thousand years of history, is in strong confirmation of the accuracy of these B.C. dates.

These intervals in which our droughts are found repeated are surprising, but I am not unaware of the differences of opinion in regard to chronology, but take the dates as given, and it is remarkable how exactly they fit in. But there is another point of importance hidden in these dates, and probably you have not noticed it. Pharaoh's drought was predicted, and a Jew was made chief man under the king, and he was doubtless versed in much of the wisdom of the priests, and carried that wisdom to the Jewish priests, who did not forget it, as the figures make manifest, and if warning of such evils could be depended upon, it is not likely they would forget it. The figures show that Elijah's prediction was a repetition of Pharaoh's drought 42×19 years after it; also Elisha's prediction was nineteen years after Elijah's, and it is noteworthy that the drought in David's time, although it does not appear to have been predicted, was 19×36 after Pharaoh's. This seems to me to be very strong evidence in favour of the view that the Egyptians knew of the nineteen years' cycle, and that the Jews brought the knowledge away with them.

Those learned in Assyrian antiquities tell us that the book containing "the Observations of Bel," the oldest astronomical book of that part of the world, was ordered to be kept by the king 3800 years B.C.; that book shows that they kept a record of astronomical and all other events, that they had discovered the nineteen years' cycle of eclipses, and we are told that it was a doctrine with them, that one event caused another, and all astronomical and meteorological observations were thus bound up together. Under such conditions I do not think it would be possible for them to avoid finding in the droughts a similar period to that in the eclipses, *i.e.* nineteen years; but even if they did, it would have been impossible for those who kept the Nilometer in Egypt to avoid finding it in the heights of the Nile floods, which were of such vital importance and so carefully recorded.

Since I have been working at this subject there have been a number of red rain storms noted in New South Wales, and the latest, on April 10, suggested to me this line of investigation. Red dust is obviously a proof of drought somewhere, otherwise the dust could not rise; and since these proofs of drought are entirely apart from the others, and recorded not as droughts but as marvels, which in days gone by created no little alarm, it will be worth while to see how far they support or contradict the nineteen years' cycle. The result of this resolution came as a surprise to me, because it was so unexpected; I had no idea there were so many records of red rains, or that they went so far back in history.

There are altogether sixty-nine recorded instances of the fall of red rain; of these I have recorded six for New South Wales. The first was fourteen years after the foundation of the city of Rome, that is in B.C. 738, and there are nine others B.C., all of which fit into the nineteen years' cycle; between 538 B.C. to 582 A.D. I can find no record of red rain, but from 582 to 1896 there are fifty-nine recorded falls of red rain, and all of them fit into the nineteen years' cycle. We have here, then, ten B.C. droughts which go with the eight mentioned before to make eighteen B.C. droughts in support of the cycle, the remainder, fifty-nine, are included in the previous list.

I have endeavoured to put before you some of the reasons which have convinced me that there is a cycle in weather; but the necessity for brevity in order to keep within the limits of one address, has rendered it necessary to express in a few sentences the results of many separate investigations, and the evidence does not seem so strong when thus condensed as it does when a number of facts one by one are brought to light from diverse sources, all of which individually support the proposition. I can assure you that the evidence was far more convincing when taken in detail; but want of time to get these details into one address, make this course impossible. Enough appears to have been said to prove that the cycle does exist, and to show the very great importance of this re-discovery of a law of climate which, there are many reasons to think, was well known to the Jews, the Egyptians, and other ancient peoples; they at least knew how to forecast droughts success-

fully, and in Egypt, like sensible people, made provisions for them.

An examination of the weather of one hundred years of New South Wales has shown that certain features recur every nineteen years; we have seen that the droughts of history—the great and conspicuous droughts I mean—all drop into this same cycle: both those that happened before the birth of Christ, and those that have occurred in our era; for instance, Elijah's drought happened in B.C. 908, that is, 2736 before our great drought in 1828, and the interval is 19×144 . Great hurricanes, the great frosts of history, all the red rains, and all the droughts that history records, with a very few exceptions, likewise are included in this cycle, and the level of great lakes in Palestine, South America, and New South Wales are subject to the same mysterious influence that controls our weather.

As my investigation proceeded, the weight of evidence gradually converged upon the moon as the exciting cause. I have never had any sympathy with the theory of lunar influence upon weather, and received, rather against my will, the evidence that presented itself; still the logic of facts left no alternative but to accept the moon as prime motor. There has not been time to complete this investigation, and when finished it must form another paper. Meantime I may say that, so far, the comparison of the moon's positions in relation to the sun and earth and droughts shows that when the eclipses congregate about the equinoxes, that is, in March and September, they do so in the years which give us great droughts. Further, that when the eclipses accumulate in February and March, that is, at the vernal equinox and the month before it, and September, the autumnal equinox, and the month before it, August, we have the more intense and relatively shorter droughts of the second series, with heat, gales and hurricanes; on the other hand, when they accumulate about March and April, that is, the month of equinox, and the one following, and about September, the month of equinox, and October following it, we have droughts of the first series that are less severe, but much longer than the droughts of the second series. I have spoken chiefly of droughts; though, so far as our own history is concerned, it would have served the purpose just as well if I had taken up the periodicity of wet years, but outside Australia it would have been very difficult to get the necessary data, for history has much more to say about the horrors of drought than the abundance of wet seasons.

SNAKE VENOM AND ANTI-VENOMOUS SERUM.¹

I HAVE already recorded in a series of memoirs published since 1892 in the *Annales de l'Institut Pasteur* and in the *Comptes rendus de l'Académie des Sciences*, the results of my researches on the venom of snakes, on the immunisation of animals against this venom, and upon the production of an anti-venomous serum. Prof. Fraser has confirmed the facts that I have published, and has successfully repeated almost all my experiments. I bring before you, to-day, a series of new facts relative to the same question. I may say at the outset, in contradiction of the opinion recently expressed by certain physiologists, that it is fully proved that the venoms of the various species of snakes produce physiological phenomena which have certain features common to all, and that the actions of these venoms only differ as regards their local effects. It is now possible to separate, artificially, the substances which produce the local phenomena from those which produce the bulbar intoxication. This separation may be effected by means of heat. If any sample of venom be thrown into watery solution and heated at 85° C. for a period of fifteen minutes, the albumin contained in the solution is coagulated and the phlogogenic substances are destroyed, whilst the toxicity of the substance is entirely unaffected. MM. Phisalix and Bertrand have already demonstrated this fact in the case of the venom of the viper found in France. After heating at 85° C. and filtration, all venoms, both viperine and colubrine, produce the same effects; they only differ as to the degree of their toxic activities. Similarly all are destroyed by the hypochlorites of the alkalis and by chloride of gold, the use of which substances I have suggested—particularly the hypochlorite of lime in a solution of

¹ Abridged from a paper read before the Section of Pathology and Bacteriology of the British Medical Association, by Prof. A. Calmette, Director of the Pasteur Institute, Lille.

1 in 60—for the local treatment of snake bites, to prevent the absorption of the venom.

Quite recently M. Phisalix, assistant in the Paris Museum, has announced that he has succeeded in separating the vaccinating substance of venom by filtering it through a Chamberland filter. The animals into which this experimenter inoculated the filtered venom did not die, and he found that they were vaccinated against the inoculation of a lethal dose of non-filtered venom. I have repeated these experiments with the greatest care, but the results that I have obtained are very different from those obtained by M. Phisalix. When a solution of normal venom is filtered through a Chamberland bougie a great part of the venom is kept back by the porcelain, just as is the case when microbic toxines are similarly filtered. It is certainly found necessary to use two and a half times more of the filtered venom than of the non-filtered venom in order to kill animals of the same weight; but if before filtration care is taken to separate the albumin of the venom by heat, it is found that the porcelain no longer keeps back any of the toxic substance. The animals are killed by the same dose of solution both before and after filtration. It follows very evidently, therefore, if the venom which has not been freed from albumin is less toxic after filtration than before, that this must be due to the fact that the albumin adheres to the porous wall of the filter, so forming a perfect dialysing membrane through which the venom can pass only with very great difficulty. I have been able to prove this by restoring a certain proportion of albumin by means of the addition of normal serum to venom that had previously been deprived of its albumin by heat. On filtering this venom containing the added albumin, I found that the liquid which passed through the filter was again considerably less toxic. Animals which have received filtered venom, and which have not succumbed after the lapse of three days, resist a minimal lethal dose of venom—*i.e.* they do not die; they are already vaccinated, just as are those that have been injected with a less than lethal dose of normal venom. There is, I believe, no reason to suppose that, as has been maintained by Phisalix and Bertrand, there is brought about by heat or by filtration of venom any separation of two substances, the one toxic and the other vaccinating, which are supposed to be found together in normal venom. This hypothesis does not appear to me to be justified by experiment, and it is absolutely certain that if one inoculates an animal with a quantity of heated venom, or of filtered venom of which the toxicity has been modified in sufficient quantity to kill the animal, it will react exactly as if it had been injected with a dose of normal venom a little below that required to produce death. In both cases, and in the same time, the animal acquires through this inoculation a state of resistance which enables it, at the end of several days, to receive with impunity an amount of venom capable of killing animals of the same weight. The serum of animals vaccinated against one species of very active venom, such as the venom of the cobra for example, is perfectly antitoxic as regards the venom of all other species of snakes, and also, as I have been able to prove, against the venom of scorpions.

The best method of procedure for the purpose of vaccinating large animals destined to produce anti-venomous serum consists in injecting them from the outset with gradually increasing quantities of the venom of the cobra mixed with diminishing quantities of a 1 in 60 solution of hypochlorite of lime. The condition and the variations in the weights of the animals are carefully followed in order that the injections may be made less frequently if the animals do not thrive well. Quantities of stronger and stronger venom are in turn injected, first considerably diluted and then more concentrated, and in order that the animals (horses) may give a serum equally active for the various phlogogenic substances which determine the various local actions it is necessary, when they have already acquired a sufficiently perfect immunity, to inject the venoms derived from as large a number of different species of snakes as possible. The duration of the treatment is of considerable length, at least fifteen months, before the serum is sufficiently active to be used for the purposes of treatment. The serum that we actually prepare at the Institut Pasteur, Lille, is active to the degree of 1/200,000th, that is to say, it suffices to inject, as a prophylactic dose, into a rabbit a quantity of serum equal to the 200,000th part of its weight in order to protect it against a dose of venom killing an animal of equal weight in three or four hours. If this serum be injected after the venom, it is sufficiently active in a

dose of $\frac{1}{2}$ c.c. given thirty-three minutes after the inoculation of a dose of venom lethal in three or four hours to prevent the death of the animal. Large quantities of this serum have been sent during the last few months to India, to Cochin China, to Australia, and to other countries where venomous serpents are most frequently met with, and we have already been able to collect certain interesting observations on people bitten. It is, however, very difficult in the greater number of instances to obtain information as to the species of venomous snake that has inflicted the wound. It has seldom been found possible to kill or capture on the field the snake inflicting the bite, so that all the statements as to the species of the snake which have not been so determined must be considered as open to some suspicion. I have already published one case, a most conclusive one, that of an Annamite bitten very severely in the hand by a cobra at the Bacteriological Laboratory of Saigon, who was cured by a single injection of 10 c.c. of serum. I have quite recently received the report of another very interesting case, for which I am indebted to Mr. Hankin, director of the laboratory of Agra in India. The patient in this instance was bitten by one of the most dangerous reptiles found in India, the Bugarus.

It has, indeed, been fully demonstrated, both by experiments on animals and by the actual treatment of snake bites in the human subject, that we have in anti-venomous serum a "specific" remedy which is very efficacious against venomous bites. It is, therefore, surely necessary to hasten to distribute it in all those countries where dangerous snakes are found. The only real difficulty consists in procuring sufficient quantities of venom for the immunisation of large animals, such as horses, to furnish adequate quantities of serum. The Pasteur Institute at Lille actually possesses enough venom, and horses completely immunised numerous enough for the most pressing wants. Serum prepared in an absolutely pure condition can be preserved for more than a year without losing any of its curative properties. In all countries where snakes claim their numerous victims, and especially in India, where the annual number of deaths resulting from venomous bites rises to about 22,000, it would surely be expedient that the various Governments should take steps to establish depôts, at least, in the principal agricultural, forest, and mining districts, where medical aid may be afforded as early as possible to every person bitten who comes to seek treatment. Each of these posts should be supplied with (1) a stock of serum, renewed each year; (2) hypodermic injection syringes; (3) a perfectly freshly prepared solution of hypochlorite of lime, and other medicaments and instruments necessary for the dressing of wounds. The expense of effecting such an organisation would be very slight. I ask you, gentlemen, to pass unanimately a resolution that may have the effect of inducing, or affording justification to, the Indian Government to realise this humanitarian scheme.

Dr. Calmette delivered a lecture, with experimental illustrations, in the Laboratories of the Conjoint Board of the Royal College of Physicians and Surgeons, on "The Treatment of Animals poisoned with Snake Venom by the injection of Anti-Venomous Serum." In the course of his lecture he said:

I have to-day the opportunity of giving you the results of experiments that have been performed under Dr. Woodhead's licence, but under my direct personal supervision, so that they may be depended upon as affording direct proof of the value of my method. Those animals that have been successfully treated you may examine for yourselves; others that have been poisoned with the snake venom, but have not received the serum, have succumbed; these latter serve as control experiments with which to compare the results obtained when the serum has been given.

These experiments are easily carried out, and are absolutely painless. In rabbits, as in the human subject, the first symptom indicating the action of snake poison is slight somnolence, which, becoming more and more marked, is gradually succeeded by a condition of unconsciousness associated with, first, muscular contraction and then with loss of motor power, which, commencing in the hind limbs, passes forwards until the respiratory centres are affected, the cardiac centre being the last attacked. When the animal dies, the heart is found in a condition of diastole. The venom may be injected in two ways—intravenously, when a comparatively small dose acts with great rapidity; and subcutaneously, when the dose also acts powerfully but more slowly. A lethal dose of cobra poison injected

subcutaneously is about 1 milligramme of dried substance, which proves lethal in about twelve hours. Twice this quantity injected into the veins kills a rabbit of about 1500 grammes in sixteen minutes. Five times as much introduced subcutaneously proves fatal in about three and a half hours. I may, however, give you the results of experiments devised to bring out the exact action of the anti-venomous serum, which experiments have been followed by those who are working in these laboratories.

To exhibit the efficiency of protective injections, at nine o'clock this morning four rabbits, weighing between 1450 and 1770 grammes, were injected intravenously in the lateral aural vein, each with 3 c.c. of the anti-venomous serum. This afternoon these rabbits have been injected intravenously with 2 milligrammes of dissolved dried venom sufficient to kill the animal in sixteen or seventeen minutes. None of these animals show any symptom of sleepiness, and it is evident that the venom will have little, if any, effect upon them. At the time that these animals were injected with the two lethal doses, two control rabbits, weighing 1340 and 1275 grammes respectively, were similarly injected intravenously with 2 milligrammes of the venom; these both succumbed to the symptoms above-mentioned, one in about sixteen minutes and the other in seventeen minutes. We have here, then, ample evidence of the great protective power that the serum exerts when injected into the body before the venom is introduced. In a second series of experiments, carried out to demonstrate the curative properties of this serum, six rabbits were similarly treated with 5 milligrammes of venom injected under the skin. Half an hour afterwards two of these animals received 3 c.c. of the serum intravenously; neither of them showed any symptoms of poisoning, and remained perfectly well. Two others of these poisoned animals, one hour after the venom had been introduced, were similarly injected intravenously with 3 c.c. of the serum; they also remained well. Two of the other rabbits should have been left for one and a half hours, but the dose of poison was so large that one of the animals succumbed at the end of an hour and twenty minutes; the other animal was immediately injected with the same dose of serum as above, with the result that it is now well, although the dose of venom was so large and had been allowed to act for so long a time—long enough, indeed, to kill the other animal injected at the same time. This is a very striking proof of the efficacy of the serum.

Although the anti-venomous serum does not act directly upon the toxin, but only through the cells, it begins to exert its influence immediately it is introduced into the body. This fact is well brought out by the following experiments:—Three c.c. of the serum were injected into the lateral vein of the left ear of a rabbit weighing 1280 grammes; fifteen minutes later this animal received into the lateral vein of the right ear 2 milligrammes of the venom, sufficient to kill it in less than twenty minutes had it not received the serum. The animal has remained perfectly well, and still shows no evidence of poisoning by snake venom. A more striking experiment still is one of which I give a description. A rabbit having received intravenously 2 milligrammes of venom, two minutes later is injected with 5 c.c. of the anti-venomous serum in the vein of the opposite ear. The animal has remained perfectly well.¹ Such an experiment shows that the venom does not destroy the cellular elements at once, and that even when the poison has already found its way to the circulation these cells may be rendered insensible to the action of the poison by means of the action of the serum.

[Dr. Calmette then gave extracts from the paper which he brought before the British Medical Association at Carlisle, and concluded by asking Dr. Woodhead to read the following.]

Gentlemen, the experiments that have been described to you concerning the efficacy of the "anti-venomous serum," the results of which you have before you, prove that the said serum really constitutes a specific remedy against venomous snake-bites. The use of this serum must necessarily become generalised at no distant date in all countries where venomous snakes are found, in order that both men and domestic animals may be protected. Is it not advisable, therefore, for the British or Colonial Governments, which are deeply interested in this matter, to take rigorous measures to prevent the sale in England and in its colonies of serums for which no absolute guarantee of

¹ All these animals were still alive and in excellent health eight days later.

efficacy and purity is given? I have the honour to propose that you will adopt the following propositions, and bring them in some way before the Government at as early a date as possible:—

(1) That there be instituted in London and in each British colony where there are found venomous snakes a sanitary committee, to be entrusted with the duty of testing the efficacy of anti-venomous serums offered for sale or sent out to be delivered gratuitously by druggists and others.

(2) That no bottle shall be sold or distributed unless bearing the mark of such control.

(3) That this control be effected according to the sole, simple, and rapid method which alone presents every guarantee of accuracy.

(4) The method proposed is the following:—A standard solution of venom will be placed at the disposal of the appointed experts. The toxic unit of this solution will be based on the quantity of venom necessary to kill a rabbit of 2 kilogrammes in twenty minutes by intravenous inoculation in the marginal vein of the ear, the above quantity corresponding on an average to 2 milligrammes of cobra venom (weighed dry) and to 4 milligrammes of rattlesnake venom. An anti-venomous serum, to be sufficiently active for therapeutic use, must be a preservative in a minimum dose of 2 c.c. on intravenous injection into a rabbit of 2 kilogrammes against an intravenous injection of the toxic unit of venom. The preventive inoculation must be made fifteen minutes only before the inoculation of the venom. The testing of the serum is thus effected in less than one half-hour.

(5) That stations provided with serum and all the necessary apparatus for its application be established in the principal centres of agriculture and in the mining and forest districts of the colonies infested with venomous snakes, such as Australia, Burmah, and India, so that every person bitten may be able to come at once and receive treatment.

REPORT OF THE DEPARTMENT OF SCIENCE AND ART.

THE forty-third Report of the Department of Science and

Art, dealing with the work of the Department during the past year, has just been issued in the form of a Blue-book. The report may be taken as a statement of the condition of elementary science teaching in this country; therefore, some of the facts and opinions contained in it are worth recording.

In the science division it is pointed out that in the decennial period, from 1886 to 1895, the number of schools has increased from 1682 to 2673, of classes from 5862 to 9545, and of students from 94,838 to 193,404. Of the 193,404 pupils under instruction in 1895, 188,380 come within the category of those on account of whose instruction payments on the results of examinations are made by the Department. Of the schools examined, 2139 were in England and Wales, 366 in Scotland, and 168 in Ireland. There were 113,398 individual students examined, and 52,079 were successful in passing in one or more subjects. The payments to Science Schools, exclusive of those made to Training Colleges on the results of the examinations for the year 1895, amounted to £142,543, an increase of more than £2000 on the preceding year.

Of the 2673 Departmental Science Schools in 1895, 115 were Organised Science Schools, that is to say, schools in which organised courses of instruction are followed. A new scheme of work for such schools came into force last year, and so far it appears to have worked satisfactorily. Practical physics was made obligatory in these schools by the new scheme, and the result is that while only a few years ago a physical laboratory was a rarity, one will shortly be found in every school in which science forms a proper place in the curriculum.

Mr. C. A. Buckmaster, one of the senior inspectors, places his finger upon a weak point in the education of teachers when he says, "the great failing of the elementary teacher as a science instructor is not want of knowledge, but want of ability to experiment." The reason is that few Training Colleges provide facilities for courses of experimental work, though such scientific practice should be an essential condition for the teaching of science subjects in the Elementary School Code.