Researches on the nature and action of Indian and African arrow-poison / by Hermann Beigel.

From the *Journal of Anatomy and Physiology*, Vol. II.

RESEARCHES

ON

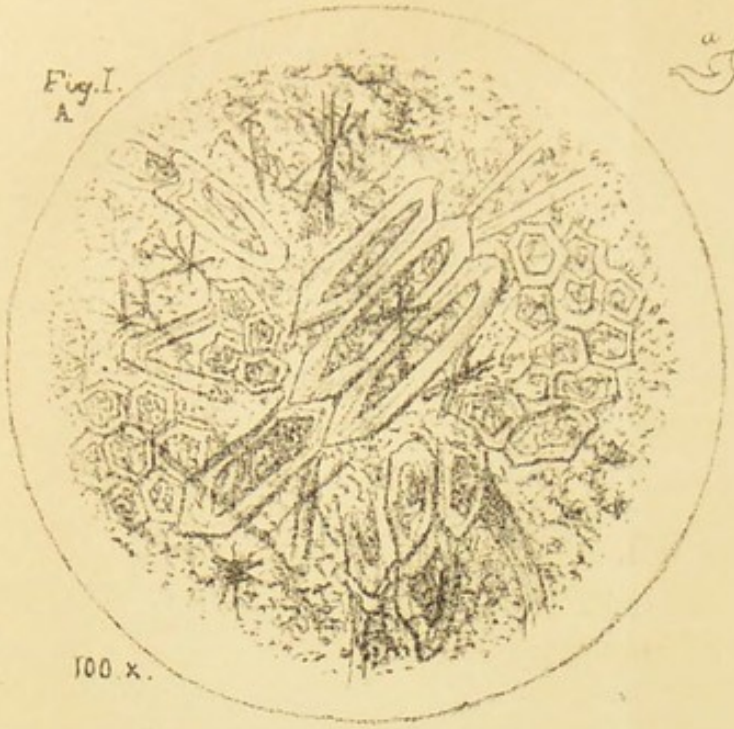
THE NATURE AND ACTION OF INDIAN AND AFRICAN ARROW-POISON.

BY

HERMANN BEIGEL, M.D., M.R.C.P. Lond.
PHYSICIAN TO THE METROPOLITAN FREE HOSPITAL.

CAMBRIDGE:
PRINTED AT THE UNIVERSITY PRESS.
1868.

Fig. I.
A



100 x.

Fig. I. Nat size.

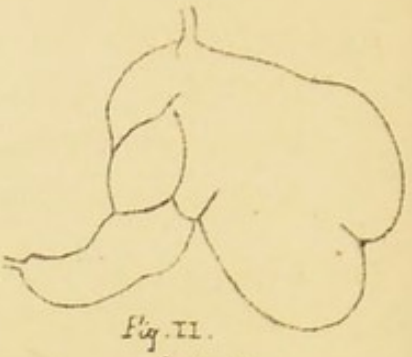


Fig. II.
Nat. size.

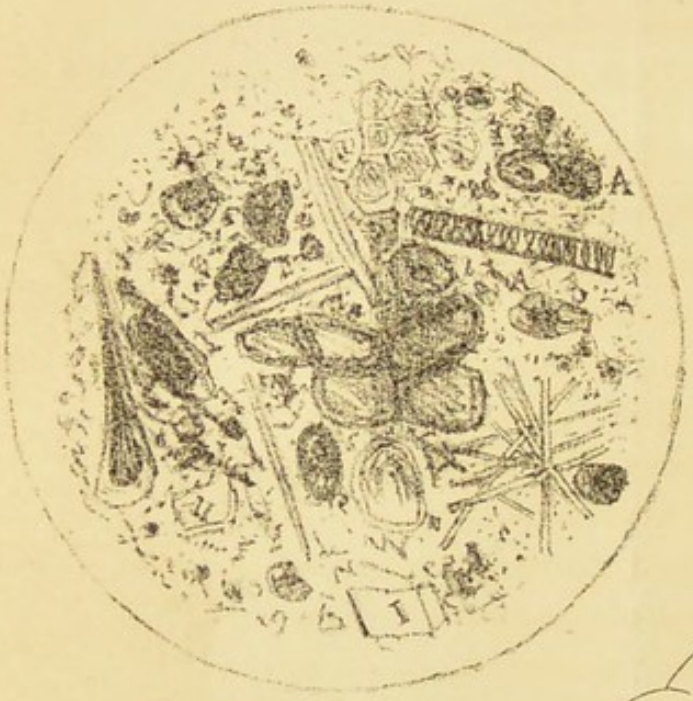


Fig II.
A
× 100.

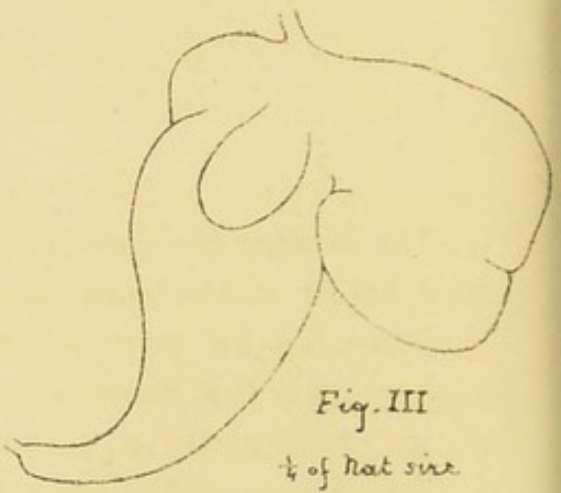


Fig. III
¼ of Nat size.

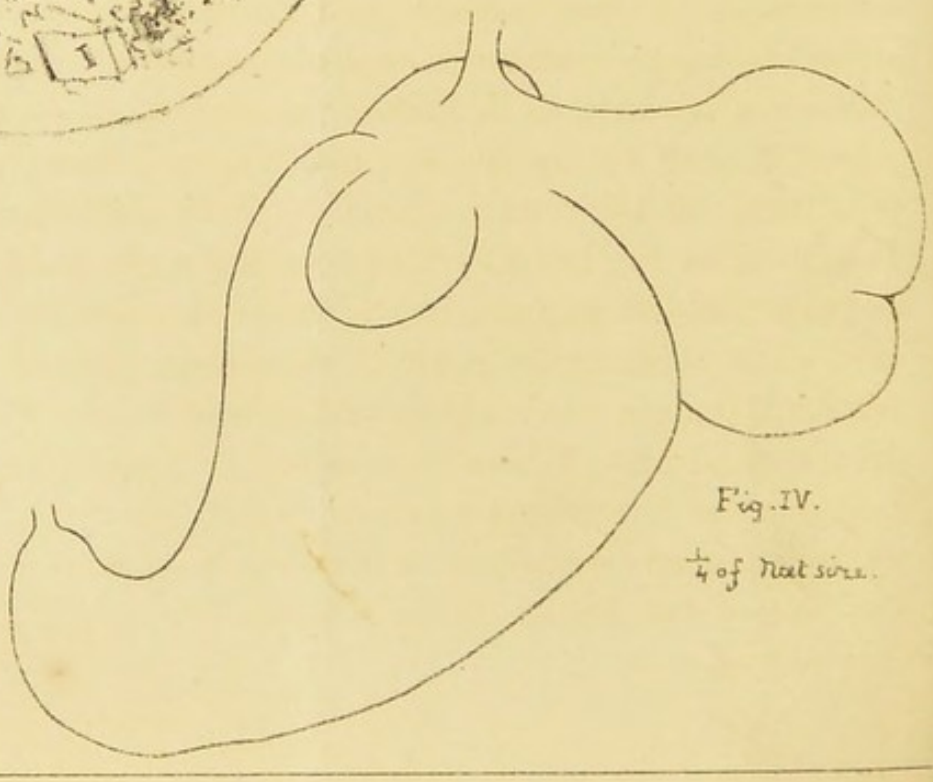


Fig. IV.
¼ of Nat size.

RESEARCHES ON THE NATURE AND ACTION OF INDIAN AND AFRICAN ARROW-POISON.

By HERMANN BEIGEL, M.D. M.R.C.P. Lond., *Physician to the Metropolitan Free Hospital.* Pl. VII. figs. I*a* and II*a*.

THE experiments, the results of which I am about to describe, have been made partly with Indian, partly with African arrow-poison. The composition and action of the one poison is so totally different from that of the other, that it is necessary to treat on them separately.

I. *The Indian Arrow-poison (Urari, Woorara, Wourali, Voorari, Curare) and its Alkaloid (Urarin, Curarin).*

1. *Urari.*

Sir *Walter Raleigh* (in 1595) seems to have been the first who heard of the substance, with which the Aborigines poison their arrows for war and the chase, but neither he nor the authors after him knew anything of the nature and preparation of the poison, which *Condamini, Pau, Bancroft,* and even *Claude-Bernard, Pelouze, Alvaro-Reynoso* and others thought to contain the fangs of snakes, poisonous ants, and other curious substances. Father *Gumilla* and *Hortzinck* gave eccentric descriptions at the commencement of the nineteenth century; and *Waterton,* as well as *Hillhouse,* a colonist of Demerara (who joined himself to the Indians, imbibing all their manners and practising all their habits, and in 1824 published a work in Demerara on the Indian tribes), considers the poisonous ant as the essential substance. But as the book conveyed some rather severe strictures on the mode of treatment, the red nations had received, the governor suppressed it, and only a few copies got into circulation. This writer says: "They (the Accaways) manufacture the Woraly-poison, which they use in shooting feathered game, by means of the woody-fibre of the centre of the leaf of the palm. This is blown through a long tube of

ten feet, which is also a kind of small palm, hollowed for the purpose and lined with a hollow smooth reed; this is called a *Sody*. The Woraly, as generally prepared, has little effect upon the larger animals, but the Macusi-Woraly is sufficiently strong to destroy large animals and even men. After witnessing various methods of preparation, I am inclined to think that the vegetable extract is merely the medium through which the poison is conveyed—the common Woraly owing its poisonous qualities to the infusion of the large ants, called Muneery, and the stronger kind from the fangs of venomous reptiles, particularly the Coony-Coochy, which is the most venomous of all known snakes. The Muneery gives the Indians by its bite a fever of twelve hours, with the most excruciating pain, and a decoction of 200 or 300 of these may well be supposed capable of depriving small animals of life."

This description will suffice to show that the author's attainments of natural philosophy were not very great, he being of opinion that the fangs of snakes are the venomous apparatus.

Humboldt was the first scientific writer who gave an authentic account[1] of the preparation and effects of Urari, of which, according to his own remarks, he first (1804) imported a considerable quantity to Europe[2].

Full light has been thrown on the plant from which the poison is extracted and on the preparation and denomination of the latter by Sir *Robert Schomburgh*[3], who searched for the plant and himself extracted the poison therefrom. "The mystery respecting the arrow-poison of the Indians," says he[4], "although not entirely cleared up, is in a great measure removed. Neither snakes'-teeth nor stinging ants form the active principle, but the juice of a plant," which he has described as *Strychnos toxifera*[5]. This plant is only known to grow in three or four situations in Guinea, and is in its habits a ligneous twiner or bush-rope (which are called in the French colonies *Liane*, and by the Spaniards *Bejuco*). The Indians of the Macusi tribe are the

[1] *Annal. de Chim. et Phys.* 1828.
[2] *Ansichten der Natur.* Stuttgart, 1859, p. 175.
[3] *Annals of Natural History*, Vol. VII. (1841).
[4] Sir Walter Raleigh's *Discovery of the Empire of Guinea*, edited by Sir R. Schomburgh. London, 1848, p. 71.
[5] *Journal of Botany*, Vol. III. p. 240.

best manufacturers of the poison, which is entirely composed of the juice of plants. Previous travellers during the present century in Guinea never saw it prepared, nor did they see the plant growing of which it is made.

The Macusis call the plant *Urari-yè*, the poison itself *Urari*, which the *Carabisi*, who constantly interchange the *r* and *l*, have corrupted into *Urali* and *Ulari*, of which *Wourali* and *Woorara* has been made, the latter name first having been used by *Bancroft*.

Sir *R. Schomburgh* has given an account of the mode of preparing the poison in the *Annals of Natural History*[1], and has prepared it himself by concentrating merely the infusion from the bark of the plant (*Strychnos toxifera*) which has been collected in his presence. It killed a fowl in twenty-seven minutes, although not sufficiently concentrated. Its effect, continues the author, is more or less sudden upon different animals, and the Indians say that monkeys and jaguars are more easily killed with it than any other animal.

The author had been repeatedly assured by the Indians that there is no remedy against the Urari, if it be good. Salt and sugar are both considered antidotes against weak poison, but avail nothing when the Urari is strong.

Amongst the different designations given to the poison, *Urari* and *Curare* seem to be the only well established names. *Urari* is not only commonly used by the Macusi, but also by the *Tarumas*, *Wapisianas*, *Aricumas*, *Wayawais*, *Atorais* and several other tribes of the interior whom Sir R. Schomburgh visited; he considers the compound terms *Uraricapra* and *Uraricuera*, two rivers, as an important argument in favour of *Urari*[2]. But *Keymis*, in his second voyage to Guinea[3], describes a fall of the river *Curwara*, from which *Curare*, generally used on the continent, seems to be derived.

The first experiments as to the action of the arrow-poison have been made by Sir *Benjamin Brodie*[4], who received the Urari from *Bancroft*. Though his experiments have been

[1] Vol. II. p. 407.
[2] *Annals of Natural History*, Vol. VII.
[3] Keymis in Hakluyt's *Voyages*, etc. London, 1600, Vol. III. p. 678.
[4] *Philosophical Transactions*, 1811, p. 207, and 1812, p. 994.

made only somewhat roughly, yet the results are not without interest. "In one case an animal (a young cat), apparently dead from the Woorara, was made to recover, notwithstanding the functions of the brain appeared to be wholly suspended for a very long period of time; in the other (a rabbit), though recovery did not take place, the circulation was maintained for several hours after the brain had ceased to perform office."

It is evidently due to the large doses—two grains to a guinea-pig— that Sir Benjamin came to wrong conclusions concerning the action of the poison. "It is evident," says he[1], "that this poison acts in some way or another on the brain, and that the cessation of the functions of this organ is the immediate cause of death."

When the poison was applied in large quantity, it sometimes began to act in six or seven minutes. Never more than half an hour elapsed from the time of the poison being inserted to that of the animal being affected, except in one instance, where the ligature was applied on the limb.

At about the same time (1813) *Charles Waterton* returned from his travels in South America and brought a quantity of genuine Urari to England, part of which is still in possession of Dr *Sibson,* who in 1839 made a great number of experiments on the poisonous effects of Urari, the results of which have, unfortunately, not been published. But by Dr Sibson's usual kindness I was permitted to make use of his note-book, and must say that he had, at the period mentioned above, arrived at conclusions which many years afterwards have been observed and published by *Bernard.*

[1] The copy of Waterton's *Wanderings in South America*, etc. London, 1852, which was presented to Dr Sibson by the author, contains on the fly-leaf the following dedication: "I offer this little book of wanderings to my dear friend Francis Sibson, Esq., with many thanks for his acts of friendship to myself and to all my family and for his excellent advice. On this day, March 10th, 1864, having the pleasure of his company at Walton Hall, I have presented to him a portion of the real, original Wourali-poison, made and used by the Indians of Maconshia. He may depend upon its being quite genuine, as I took it myself from the gourd in which they had prepared it. They were pointing their arrows at the time, and were poisoning them with it, preparatory for going in quest of game. This was in the year of our Lord 1812, far away in the wilds of Guinea. From that time to this present day it has maintained its deadly virulence, and it is just now in as fine order as it was at the time I procured it. This poison requires to be kept quite dry, nothing more. At all times it is ready for immediate use. Charles Waterton."

I gladly embrace the opportunity of expressing my thanks to Dr *Sibson* for having furnished me with a quantity of his Urari in order to compare it with the poison in the market, to which comparison I shall have to refer hereafter.

Another portion of Urari, imported by Waterton into this country, and still adherent to the original arrows, is in possession of the Rev. *J. G. Wood*, of Belvedere, the author of Routledge's *Natural History of Man*. This gentleman was kind enough not only to present me with some of the Urari but with several other poisons of savage tribes, amongst them a specimen very seldom to be met with, used by the Bushmen and prepared from some peculiar organs of the poison-grub[1]. It is a gratification to me to express my thanks to the reverend gentleman for his kindness in assisting me to extend my researches on the nature of the poisons of savage tribes.

After *Waterton's* return to England, he experimented with Urari-poison at the medical school of Nottingham before a great number of persons, principally professional gentlemen of the town and neighbouring districts. The experiments were superintended by Dr *Sibson*, who had constructed an ingenious apparatus for artificial respiration of the poisoned animals.

One ass was brought to life exclusively by the indefatigable exertions of Dr Sibson, who had continued artificial respiration for seven hours, and ultimately gained the victory over the deadliness of the poison.

The first experiments, however, to show the *physiological* effect of the Urari were published by *Bernard* and *Pelouze*[2] in 1844. These experimentalists established the fact that Urari paralyses the motor nerves, and from this fact the authors concluded the existence of an irritability peculiar to the muscles. The researches have been still more extended by *Virchow*[3],

[1] See Wood's *Natural History of Man*, Part VI. and VII. p. 286, and Bains' *Explorations in South-West Africa*, p. 253.

[2] *Compt. rend.* T. XXXI, and Bernard's *Leçons sur les effets des subst. toxiques et medicament.* Paris, 1857, p. 238.

[3] *Archiv*, Vol. I. p. 249.

Kölliker[1], *Pelikan*[2], *Brown-Séquard*[3], *Eckhard*[4], *Funke*[5], *Kühne*[6], *Pflüger*[7], and others[8].

But all these experiments were made on animals; *Tiercelin* and *Benedict*[9] seem to have been the first who applied Curare as a therapeutical agent for epilepsy, but, for want of Curare, were obliged to give up their task, which was, however, continued by two physicians at Paris, namely, by Drs *Voisin* and *Lionville*, who communicated the results of their researches first to the Société de Médécine and afterwards to the Academy of Paris[10].

The symptoms arising from the effects of Urari, according to these authors, range in two different degrees of intensity, the one to be observed after doses of from 5—9 centigrams, and consisting of defect of sight, heaviness of the eyelids, and sensation of oppression on the frontal region, the other occurring after doses of from 10—13·5 centigrams, and consisting of Diplopia, dilatation of pupils, heaviness in the head, somnolence and faintings. The symptoms of the first order may exist conjointly or follow each other. During about thirty minutes after injection their course is progressive, then they decrease, and the action of the poison lasts for about one hour and a half, after which it ceases without leaving any sequelæ whatever.

The largest dose applied by these authors was 13·5 centigrams. After 10 centigrams the symptoms just described appear more rapidly and in a more intense degree; their duration extends likewise over a longer period. They generally make their appearance after sixteen minutes when 10 centigrams have been taken, and after 12—13 minutes on doses of 11—12 centigrams; duration, from 2—12 hours, and after

[1] Virchow's *Archiv*, Vol. x. p. 3.
[2] Ibid. Vol. xi. p. 401.
[3] *Experimental Researches*, 1853, p. 38.
[4] *Beiträge zur Anatomie und Physiologie.* Hft. i. p. 47.
[5] *Beiträge zur Kenntniss des Urari. Bericht der Königl. Sächs. Gesellsch. der Wissensch.* 1859, p. 1.
[6] *Ueber Pfeilgift. Monatsber. der Berliner Akadem. der Wissensch.* 1860.
[7] *Untersuchungen über den Electrotonus*, p. 29.
[8] Haber, Ueber die Wirkung des Curare auf das Cerebrospinal systems. *Archiv für Anat. und Physiol.* 1859, p. 58.
[9] *Wiener Presse* 1866. No. 32 et 33.
[10] *Gaz. des hopit.* 1866. 109 et 111.

their disappearance no sequelæ. But, after large doses, besides the above-mentioned symptoms, sugar may always be detected in the patient's urine, and during the action of the poison no loss of consciousness whatever can be observed; the inclination for micturition is great, and the ophthalmoscope reveals but normal conditions. The pulse becomes, even after smaller doses, stronger, more frequent, and of a dicrotic character, when examined by means of the sphygmograph; temperature somewhat raised, respiration increased in frequency; power of co-ordinate movements entirely or partially lost according to the dose, but electro-muscular contractility intact.

These interesting facts, and particularly the results published by Benedict[1], according to which some cases of epilepsy had been cured "by hypodermic application of Urari, others relieved," I determined to give the method a fair trial at the Metropolitan Free Hospital.

I must confess that my confidence in a remedy over the manufacture of which in the bushes of the Indians we have no control whatever, was not very great, nor was the mode in which Benedict had published his cases of such a nature as to raise confidence; yet he states his results positively, and therefore the duty became incumbent on me, having to treat in the course of a year large numbers of epileptics, to try a new remedy in a disease against which our pharmacopœia generally proves powerless.

The want of confidence I felt from the mode of Dr Benedict's publication was caused by the fact, that the author considered cases of epilepsy "cured" in which for some weeks or months no paroxysms had occurred, and because in other cases he indulged in such expressions as "the result was beneficial."

Every physician who sees large numbers of epileptics knows well that the disappearance of the paroxysms for several months indicates but very little, and justifies him by no means to consider the case "cured," while the phrase "the result was beneficial," means simply nothing.

Before relating the results of my experiments, I shall make a few remarks on the *microscopical appearances* of Urari, refer-

[1] *Wiener medicinische Presse.* 1866. No. 32 et 33.

ring the reader in respect to its chemical composition to the analysis made by Boussignault in 1828[1].

In concentrated solutions of Urari in water or alcohol a sediment settles, which at first sight under the microscope appears an amorphous mass. But if the layer be sufficiently thin for examination, and a drop of sulphuric acid allowed to flow under the covering-glass, the object becomes more transparent and may readily be recognised as consisting of nothing but remnants of plants, different parts of which are easily to be perceived, as seen in fig. II. A.

Whether the broken-down cells are parts of one plant or of more is irrelevant for our purpose, suffice it to say that no traces of animal matter, neither of ants nor of snakes, are to be found, which would undoubtedly be the case if such were used in the preparation of the poison.

The genuine Urari, for which I am indebted to Dr Sibson and Rev. J. G. Wood, is different from that in the market; the remnants of plants being much more numerous in the former than in the latter. The same may be said of the number of the needle-shaped crystals, probably Urarin. Yet whatever the differences in the microscopic appearances of various specimens of Urari may be, all contain a considerable number of the cells A. in fig. II[A]. so that they seem to be essential. The drawing is taken from a specimen of Waterton's Urari, the larger crystals I. II. having been found in some Urari which I have received a few days ago from Messrs. Brückner and Lampe at Leipzig, who, according to their letter, are supplied by an agent at Rio Negro.

The physiological results of my experiments may best be seen by some of the cases which I have treated by means of hypodermic injection of the Urari-poison.

CASE I.—George Gd., sailor, 25 years of age, unmarried, whose history is in a forensic point of view of great interest. He is the son of healthy parents, has two sisters and six brothers, one of whom, 29 æt., has been subject to fits from childhood, at last became imbecile, and is now an inmate of Colney Hatch.

Nine or ten months ago, when patient was at Malta on

[1] *Annal. de Chimie et de Physic.* Vol. XXXIX. (1828), p. 24—37.

board of a man-of-war, he passed some pieces of tape-worm, for which medicine was given and the whole worm passed, whether the head also, patient is not aware of; a few months afterwards a fully developed epileptic fit set on, which did not recur, but very frequently "petit mal" makes its appearance, sometimes three or four times a week. It consists in the patient's rising, when at any work or conversing with friends, asking two or three nonsensical questions, the last of which is generally, "What is the time?" During these questions, patient walks a few times through the room, and then to the chimney, where he passes his urine. Then he returns to his former place and continues either his work or conversation, without any knowledge of what has happened, the whole scene lasting only a very few minutes. Patient has therefore been discharged from service, and on the 23rd of January, 1867, came under my treatment. He is an extremely strongly built man, intellectual, and with the exception of these attacks, he feels very well, all his functions being in perfect order. After having tried Bromide of Potassium and several other remedies, I injected Urari, gr. $\frac{1}{4}$, pulse before injection 74 in a minute,

10	minutes	after	injection	73
20	...	...	...	70
30	...	...	...	79
40	...	...	...	74
50	...	...	...	74
60	...	...	...	74

No other symptoms of the action of the injection. On the 29th of April an injection of Urari 1 gr. was made, and again, besides vacillations of the pulse and an apathetic expression of the countenance, no symptoms were observed. On the 2nd of May $1\frac{1}{2}$ gr. of Urari was injected. Pulse immediately before injection 74.

After	10	minutes	70
...	20	...	77
...	30	...	72
...	40	...	76
...	60	...	72
...	80	...	69
...	100	...	73

About ten minutes after injection the countenance assumed an extremely stupid expression; the eyelids fell down, covering half of the bulbus, vision very much impaired; limbs could be moved by the patient, when in a sitting position, but he could not get up from the chair without supporting himself on his arms, and even then only after several attempts had failed; the gait was staggering as if patient were intoxicated, therefore he got hold of anything near him in order to support himself. With his eyes open he could stand heel to heel, but not with eyes shut. Respiration perfectly unimpaired; action of heart normal; sensibility of skin so intact, that patient was able to distinguish the two points of a pair of compasses within the physiological limits. An inclination to micturition which Voisin and Lionville observed in their patients was not observable. These symptoms lasted for about two hours.

On the 4th of May, repetition of injection of $1\frac{1}{2}$ gr. Urari; pulse 75.

After	10	minutes	77
...	20	...	76
...	30	...	77
...	40	...	74
...	50	...	77
...	60	...	80

The phenomena were the same as on the 2nd of May, but weaker, although the dose and preparation were the same.

On the 8th of May injection of $1\frac{3}{4}$ gr. of Urari; pulse 79.

After	10	minutes	84
...	20	...	82
...	30	...	82
...	40	...	82
...	50	...	82
...	60	...	79
...	80	...	79
...	100	...	76

The characteristic expression of countenance this time perceptible a few minutes after injection; the same in respect

to the incapability of executing co-ordinate movements. Pupils much dilated, and rather inert on irritation by light. Vision much impaired; consciousness and sensibility perfectly intact; slight muscular tremor; respiration normal; action of heart rather weak, otherwise regular. Duration of these phenomena about two hours.

On the 11th of May injection of $1\frac{1}{2}$ gr. of Urari; pulse 76.

After	10	minutes	82
...	20	...	81
...	40	...	81
...	50	...	82
...	60	...	78
...	70	...	78

Phenomena similar to the former, but less strong.

15th of May, injection of Urari, $1\frac{3}{4}$ gr.; pulse 92.

After	10	minutes	84
...	20	...	84
...	30	...	85
...	40	...	86
...	50	...	87
...	60	...	86

Phenomena as above.

18th of May, injection of Urari, 2gr. Phenomena as before, but still more intense.

Several portions of the skin, where injections had been made, were swollen and painful, and therefore it became necessary to leave the next injection until the 28th of May, when two grains were again injected; the symptoms were very intense, and the condition of the optic nerve, examined by the ophthalmoscope before and after injection was also very peculiar.

Before injection it was seen to have a normal circular shape, but when sight was impaired, besides the vessels of the choroid being more than normally filled with blood, the optic nerve assumed this elliptic shape ●, which again became circular as soon as the power of vision was restored.

This alteration of the optic nerve has been observed in the

same patient several times, and it was of peculiar interest to notice the same alteration during an attack of "petit mal" which occurred when he one day was in my consulting room.

On the 1st of June there was a repetition of injection of 2 grains of Urari, with the same result as before.

We shall have to refer to this patient again when speaking of the action of the Alkaloid of Urari.

Case II. Lewis Is., a butcher, 23 years old, for many years suffering from epileptic fits, which seem to be hereditary in his family. The attacks are severe, the history of this case does not bear otherwise on the question under discussion. It may therefore suffice to remark, that the patient is of a slim stature and rather weak, colour of countenance pale, mucous membranes the same, Acne all over his face, and the body covered with Psoriasis guttata, which according to patient's statement, is not of a syphilitic nature.

On the 17th of April, 1867, an injection was made of Urari, $\frac{1}{2}$ gr.; pulse before injection 84.

After	5	minutes	87
...	10	...	91
...	15	...	97
...	20	...	91
...	30	...	90
...	40	...	87
...	50	...	90
...	60	..	80

No symptoms whatever of the action of the poison.

May 1. Injection of one grain of Urari, which produced no effect.

Case III. Henry P., 17 years of age, a robust lad, about a year ago fell from a horse, and since that time suffers from epilepsy. He came under my treatment on March 6, 1867, and on the 1st of May an injection was made of 1 grain of Urari, after which neither subjective nor objective symptoms could be observed. On the 4th, 8th, 11th, 15th and 18th, the same dose was repeated with the same effect. Therefore on the 22nd $1\frac{1}{2}$ gr. were injected; pulse before injection 95.

After	10	minutes	99
...	20	...	105
...	30	...	103
...	40	...	101
...	50	...	106
...	60	...	101
...	90	...	102
...	100	...	99

Fifteen minutes after injection sight became dim, and soon Diplopia set in, the one image being above the other; face turgescent, speech heavy, stupid expression of countenance, upper eyelids dropping down, therefore eyes half-closed; gait uncertain; arms, according to patient's description, felt like heavy weights, and in consequence impossibility to put his hands to his head. Sensibility and intellectual faculties perfectly intact.

February 5, 1868. At half-past twelve one grain and a quarter of Urari were given internally. Patient had eaten nothing since nine o'clock in the morning, when he made his breakfast, consisting of three cups of tea and a few pieces of toast, and declared himself to be rather hungry; ten minutes after taking the Urari his sight was extremely impaired, and Diplopia existed in a marked degree. Patient saw the features of persons present double, and at the same time was well aware of the delusion; he experienced intense pain in the stomach, but it lasted only a few minutes. Examination by means of the ophthalmoscope revealed only normal conditions. The action of the muscles was in no way impaired, probably from the small dose taken; patient could therefore walk firmly, and in spite of impaired vision the upper eyelids did not drop down; the symptoms disappeared after about three quarters of an hour.

On March 18th. One grain of Brückner and Lampe's Urari was injected without producing any effect.

March 21st. gr. $1\frac{1}{2}$. No effect.

March 25th, gr. 2. The same result.

March 28th, gr. $2\frac{1}{2}$ were injected. The symptoms which followed consisted in redness of the face, slight dimness of eyes, and slight uncertainty of gait; which symptoms prove the Urari

used since the 21st of March being weaker than that of Paris, but nevertheless even of Brückner and Lampe's Urari $\frac{1}{8000}$ of a grain was sufficient to kill a large frog.

On the 7th of April patient of Case I. took $3\frac{1}{2}$ grains internally without exhibiting any symptoms. The thermometer during one hour and a half in patient's axilla remained standard at 38·7 (Cels.), pulse 15 in a quarter and respiration 4. Two hours before injection patient partook of a luncheon, consisting of bread, cheese and some ale.

Case IV. Julius Is., 16 years of age, 18 months ago was attacked by epileptic fits without any accountable cause. Since that time the paroxysms recurred with terrible frequency. Patient is a well-made lad, but the expression of his countenance indicates great suffering. On the 12th of January, 1867, he came under my care, and on the 1st of May an injection was made of Urari, 1 gr., which was followed by no symptoms.

May 4. Injection of $1\frac{1}{4}$ gr.; pulse 91.

After	10	minutes	102
...	20	...	96
...	30	...	98
...	40	...	99
...	50	...	95
...	60	...	94
...	80	...	95
...	100	...	91
...	110	...	86

Ten minutes after injection the upper eyelids dropped down, but patient was capable of raising them voluntarily if told to do so. Both palms of his hands were covered with sweat; gait somewhat uncertain, backs of both eyes paler than normal. Besides these symptoms patient complained of dryness in the mouth. Duration of the symptoms about three quarters of an hour.

May 8. Injection of one grain and a half of Urari. The action of the poison this time became already evident a few minutes after injection, and was so intense that patient was

incapable of sitting in a chair, and therefore was obliged to lie down on the floor. Sensibility and mental faculties perfectly intact, but there existed rather severe *tinnitus aurium.* Pupils much dilated, without loss of reaction on light. Action of heart feeble, but normal, respiration perfectly normal; pulse before injection 96.

After	10	minutes	93
...	20	...	92
...	30	...	91
...	40	...	90
...	50	...	89
...	60	...	85

One hour after injection, all symptoms, with the exception of the *Tinnitus,* were still undiminished, and after two hours nearly all symptoms had disappeared, and patient was capable of going home steadily.

May 11. Repetition of the same dose of Urari, with the same result.

Case V. This patient was the first to whom I applied hypodermic injections of Urari, and this accounts for the long time I tried very small doses of the poison without seeing any results, till the experiments of Voisin and Lionville came to my knowledge, which induced me to apply larger doses.

Patient was 18 years of age and strongly built; he was attacked eight years ago, and on the 11th of October, 1865, came under my care.

On the 21st of August, 1866, I injected one-eighth of a grain of Urari, which of course produced no effect whatever; the doses were raised gradually with great precaution and amounted on the 3rd of October to one grain, with negative results. On the 6th of October one grain and a half was injected, which for the first time in my experience revealed the effects of the poison, consisting in this case in loss of control over co-ordinate movements and in impaired sight; after about two hours patient went home, on arriving he fell asleep and slept for many hours.

October 22. Injection of $\frac{1}{2}$ gr. No result.

December 29. $\frac{1}{8}$ gr. No result.

January 16, 1867. $\frac{5}{8}$ gr. Slight dulness of sight, but no other symptoms.

February 6. $\frac{7}{8}$ gr. Dulness of sight of the left eye, no other symptoms.

February 13. $\frac{13}{24}$ gr. Slight dulness of right eye, no other symptoms.

March 16. $\frac{3}{4}$ gr. Beside variations in the frequency of pulse, no other phenomena.

March 20. $\frac{7}{8}$ gr. Pulse before injection 72.

After	5	minutes	72
...	10	...	76
...	15	...	75
...	20	...	73
...	25	...	74
...	30	...	79
...	40	...	76
...	50	...	72
...	60	...	72

Five minutes after injection slight muscular tremor, after fifteen minutes sight of right eye impeded; both symptoms lasting only for a few minutes; no other phenomena.

In order to be enabled hereafter to consider the action both of Urari and its alkaloid at one time, I shall now give the results of

2. *Urarin (Curarin).*

As soon as experiments had been made in Europe with the arrow-poison of the Indians, several chemists, *Boussignault*, *Rolin*, and *Trapp*, tried to extract the alkaloid, in order to place the experiments on a more trustworthy basis from reasons already explained; for it is only the alkaloid on the doses of which dependence can be placed, the Urari being a composition, differing not only in different tribes, but even if prepared by the same individual differing according to the care the latter takes in brewing the poison.

The problem of producing Urarin in a pure, crystallized state has satisfactorily been solved by Dr Preyer, of Bonn. The mode

of preparation, as well as the results of some experiments, have been communicated by him to the Medical Society of the Lower Rhine[1], on the 21st of July, 1865. 0·0003 gram. were sufficient to paralyze a frog, and 0·001 gram. produced the same effect on a guinea-pig, weighing 2100 grams., the effect taking place rapidly and lasting about half-an-hour. Dr Preyer experimented with a considerable number of frogs, rabbits, guinea-pigs, dogs, rats, birds, and other animals, and in all the irritability of the muscles remained intact, contracting on direct irritation of the nerves.

Concerning the dose in which Urarin is to be administered, Dr Preyer, according to his paper as well as to a letter written to me, is of opinion that the Alkaloid acts about twenty times as intensely as the Urari from which it has been produced. In a well-grown rabbit $1\frac{1}{2}$ milligr. proves fatal, guinea-pigs died after injection of 1 milligr., and frogs could not survive $\frac{3}{10}$ milligr. Bernard's experiments[2], which Dr Preyer has witnessed, have shown that the mode of injection is of vital importance for the animal. Doses of the alkaloid, which imply no danger when injected hypodermically, proved immediately fatal when injected into the portal vein; and injections into the muscles kill much sooner, if the dose is sufficiently large, than if injected into the connective tissue immediately beneath the skin. Great care must be taken to break no vessel; in fact, it is necessary that after injection no drop of blood should escape. The absorption of the poison under such circumstances takes place but slowly, but the danger at the same time is reduced to a minimum. Bernard placed a piece of sponge, filled with a fatal dose of the poison, under the skin of a rabbit, and though, after twenty-four hours, no Urari could be discovered in the sponge, yet the rabbit exhibited no poisonous symptoms from the slowness with which absorption had taken place.

Of the effect of Urarin in men, Dr Preyer knew only that seven milligrs., equal to one-eighth of a grain, produced no marked symptoms.

[1] *Berliner Klinische Wochenschrift*. 1865. No. 40, and *Comptes Rendus*, 1865, June 27.

[2] *Comptes Rendus*, 1865, June 27.

In October, 1867, I had sent from Mr Kluetech, of Bonn, who prepares the alkaloid according to Dr Preyer's directions, two tubes, each containing 30 milligr. of Urarin. I dissolved the contents of both tubes in five drams of distilled water, so that five minims of the solution contained 1 milligr. of Urarin. On the 26th of October I injected the patient of Case I., 5 milligr. of the solution, without perceiving the slightest effect after two hours. I, therefore, on the 2nd of November exceeded the maximal dose of Dr Preyer by 1 milligr. without producing the slightest effect.

November 9th. Injection of 10 milligrs.; pulse before injection 17 in a quarter of a minute.

After	5	minutes	17
...	15	...	13
...	30	...	17
...	45	...	17
...	60	...	18

Except slight dilatation of pupils, no effect whatever; urine contains no sugar, background of eyes unaltered, muscular action normal.

November 16th. Injection of 12 milligrs. A few seconds after injection patient perceived a slight heaviness in his head, which only lasted a few seconds. Pulse before injection 19 in a quarter of a minute.

After	15	minutes	13
...	30	...	17
...	45	...	18
...	60	...	18

No other symptoms.

November 20th. Patient tells me to-day that, when he reached his house after last injection, he became sleepy, and slept for several hours.

Injection of 13 milligrs. Immediately after which the pulse was throbbing 19 times in a quarter of a minute.

After	15	minutes	18
...	30	...	18
...	45	...	18
...	60	...	18

No Urari-symptoms whatever.

Having nearly arrived at the double quantity of what Dr Preyer had injected, without seeing any result, I thought that patient's system perhaps enjoyed a certain immunity in consequence of the number of times the injections were applied to him, I therefore injected on Nov. 30th Urari $2\frac{1}{4}$ grs. The symptoms set in a few minutes after injection, and were very intense. Pulse before injection 19 in a quarter of a minute, immediately after injection 19.

After	15	minutes	19
...	30	...	18
...	45	...	17
...	60	...	18
...	75	...	19

About ten minutes after injection the upper eyelids dropped, and the eyes were closed; it was only with great exertion that patient could open them, and keep them open for a few seconds. Speech very heavy, but patient answered questions quite sensibly. The phenomena concerning the optic nerve were again observed, but this time the longest diameter of the elliptic figure was in an opposite direction, viz. thus ●.

When requested to count my fingers, held about 5 feet before the patient's eyes, he declared that he saw nothing, not knowing that his eyes were closed. When his attention was drawn to this fact he opened his eyes and saw all objects doubly, being fully aware of the delusion. Motility was impaired only in respect to the eyelids, organs of speech, and the lower extremities, while the upper extremities were so far from being affected that patient with his own hands held his upper eyelids, while I was examining his eyes with the ophthalmoscope. Respiration was performed freely and energetically, while the action of the heart was weaker than normal, the accent of the second sound being somewhat louder and stronger than is normally the case. Temperature of the skin not raised, no sugar in the urine, no abnormal secretion of the lachrymal or other glands or kidneys. Diplopia lasted for about one hour and a half, and, after the lapse of two hours and a half, patient was enabled firmly to walk home. Sensi-

bility and consciousness were not impaired a moment. No sickness or headache were perceived during the whole time.

Case VI. William M. R., a strong lad of 12 years, suffering for several months from St Vitus' Dance, the right side particularly, both right extremities constantly moving, even when patient is asleep. On December 13th, 1867, 5 milligrs. of Urarin were injected. Pulse before injection 16 in a quarter of a minute.

After	15	minutes	23
...	30	...	22
...	45	...	20
...	60	...	20

A few minutes after injection the boy became pale and faint, pupil dilated, in the course of about a quarter of an hour twice vomiting, after which patient resumed his normal colour, and about an hour after injection no symptom was perceptible except frequency of pulse. The movements of the limbs were not altered during the time. It must be remarked that the little operation of injection seemed to me the principal, if not the only, cause of excitement in the boy.

Urarin being rather an expensive drug I did not feel inclined to continue experimenting with the same.

Thus my experience as to the efficacy of the alkaloid of Urarin is based on negative results.

General Remarks.

The effect of the action of the Urari-poison differs according to the dose which has been injected, this not only being the case in respect to the symptoms observed in men, but also to the phenomena which we are able to demonstrate by physical means in frogs after death. It seems to me that many points, on which some authors are at variance, have their cause in the negligence of not stating the amount of Urari they have been injecting. Claude Bernard's and Kölliker's statement, that the Urari deprives the motor nerves of their capability to cause contraction of those muscles into which they are inserted, is not in compliance with the many experiments I have made.

According to these authors, the sciatic, or any other nerve, may be insulated, pinched and exposed to a strong electric current, without causing one single fibre to contract. This is true when large doses have been administered, but after small doses, 500th or less of a grain to a large frog, diminishes the action of the motor nerves, but by no means destroys it. The sciatic nerves of several frogs, the largest weighing two ounces and a half, and being poisoned by an 800th of a grain of Urari, answered each irritation of an electric current by contractions of the extremity. The same result was obtained by exposure of the lumbar nerves to the current, and the convulsions, in this instance, of the lower part of the back were still more violent when one Electrode was applied to the lumbar nerves of one side and the other Electrode to those of the other side. The convulsions, however, do not last long, and a few minutes must elapse before the experiment can be successfully repeated.

The irritability on direct application of the current to the skin or muscles is undiminished during life and remains intact for many hours after death. This phenomenon gave rise to the opinion of some authors, that the Urari-poison merely affects the trunks of motor nerves, but does not penetrate to the ultimate insertions of these nerves, which therefore are not exposed to the poisonous influence, so that the contraction of the muscular tissue on electricity would merely be the result of the irritation of the intact ends of the nerves contained in the muscles[1]. But Kölliker has shown, by indisputable results of experiments, that the action of the Urari-poison first begins just in these ends of the nerves in the muscles, and he infers from his experiments that the poison, after having destroyed the action of the intramuscular ends, passes on by degrees to the trunks of the nerves, without demonstrably affecting the nervous centres or interfering with the fibres of the sensitive nerves. On these facts Kölliker and Bernard maintained their views of a special irritability peculiar to the muscle; and Funke's[2] objection, that the poison may affect the whole nerve

[1] Eckhard, *Beiträge*, p. 47.
[2] *Lehrbuch der Physiologie*, 1863. Vol. I p. 961.

with the exception of the very last ends within the Sarcolema, must be supported by graver evidence than a mere presumption, in order to grapple with facts and conclusions based on such. From the results of a large number of experiments, I therefore am in favour of an irritability peculiar to the fibres of the muscles.

The action of the poison is in the first place, as shown by Sir *Benjamin Brodie*, propagated, not by the nerves, but by the blood-vessels. *Claude Bernard* and *Pelouze*[1] were of opinion that no action takes place if Urari be taken internally; but *Pelikan* has shown the fallacy of these gentlemen's conclusion, the doses having been too small and the stomachs of the rabbits used for the experiments too much filled. My own experiments in man have shown the influence of the state of the stomach on the action of the poison. In the one patient (Case III.) who, when taking the Urari, was "rather hungry," the phenomena appeared very rapidly, the doses not being higher than $1\frac{1}{4}$ gr. while in another patient to whom I administered two grains on the 14th March, no symptoms whatever were perceptible; this patient having had a good breakfast in the morning and a hearty luncheon about one hour before taking the drug.

Claude Bernard, a few years ago, altered his opinion concerning the capability of Urari for being absorbed by mucous membranes. He concedes that the non-absorption through the mucous membrane of the alimentary tract is not absolute. Dogs when in the act of digestion, according to the author, may take considerable quantities of the poison with impunity, which would prove fatal to them when hungry. Absorption takes place likewise through the mucous membranes of the respiratory organs, but not of the bladder, conjunctiva, and the external surface of the skin of the frog.

The symptoms arising from Urari appear in a certain rotation and are so very characteristic that the diagnosis of poisoning by that drug could, I think, be made without difficulty. The first of these phenomena, provided the quantity either injected or taken internally has been sufficiently large to produce an

[1] *Leçons*, p. 282, and *Comptes Rendus*, Vol. xxxi. p. 533.

effect, is the *relaxation of the muscular system*, first noticeable in the altered expression of countenance, this becoming apathetic, stupid, to which dropping of the upper eyelid soon accedes, partially or totally covering the bulb. The individuals under the poisonous influence sometimes not being aware of this occurrence, are under the wrong impression of being unable to see, whilst their eyes are only closed. If told of the error they open their eyes, but are not able to do this as they would under normal circumstances, part of the eye-ball always remaining covered by the lid. When small quantities have been administered, the muscular system does not partake any farther in the affection, but in case of larger doses the control over voluntary movement may be lost entirely, the involuntary continuing, weaker perhaps, but regularly. My experiments have shown that certain parts or groups of the system of voluntary muscles are more affected than others, the upper extremities, for instance, still being capable of performing firmly their movements, while the lower are staggering and uncertain. Death only occurs by Urari if such a dose has been taken as to paralyse the heart or the muscles of respiration, otherwise the heart continues to perform its duty in a regular manner, and even in case of inactivity of the respiratory muscles the animal will be restored to life and health if artificial respiration is performed.

"I have observed," says Dr *Sibson*[1], in his very excellent paper *On the changes in the situation of the internal organs*, etc., "the motions of the heart in the ass in more than one instance. I injected into the jugular vein from two to three grains of the Wourali-poison that was supplied to me by Mr Waterton; I kept up artificial respiration, removed the ribs and exposed the heart. In one ass the heart continued to beat for four hours with full energy; at the end of that time the animal showed signs of returning sensation; I cut out the heart while beating with full vigour. The struggles of the animal did not cause any back-flow of blood into the tied jugular vein

[1] *Transactions of the Provincial Medical and Surgical Association*, Vol. XII. 1854, p. 512. See also Dr Sibson's Paper on the causes which excite and influence respiration. *Ibid.* XVII. p. 309.

through which the poison was injected; the vein swelled behind the ligature. To ascertain the gliding movements of the heart, I fixed pins first into one part, then into another, of the moving walls." Dr Sibson's note-book is full of similar and still more interesting instances; yet the most remarkable are those he superintended when Mr Waterton was experimenting at Nottingham. To one of these cases I have alluded in the beginning of this paper, but, bearing so importantly on the question under consideration, I think it necessary to give two *in extenso*, they being published at full length in the Nottingham newspaper of 1839.

A female ass, 8 years old, of rather poor condition, but previous to operating exhibiting a regular action of the heart—pulse 62—was poisoned at 9 hours 6 minutes in the morning, by an arrow-head being put into an incision made in the neck; at 9h. 12m. pulse 60, and continued uninterruptedly the same for five or six minutes longer, when it began to increase. At 9h. 20m. pulse irregular and risen to 72, the respirations at 14 in a minute, pupils becoming dilated. At 9h. 32m. pulse still 72, the animal manifesting symptoms of uneasiness. At 9h. 36m. pulse 84, and the creature repeatedly lifted its fore legs, which trembled, and the next minute fell down, being exactly 31 minutes from the time of introducing the poison: there was a slight struggling, but the muscular power soon ceased, the pulsation was imperceptible, except a faint fluttering at the heart, and animation appeared to be extinct. The animal was then raised upon a table, an opening was immediately made in the trachea, and at 9h. 41m. artificial respiration commenced by means of Dr *Sibson's* apparatus, consisting of a double pair of bellows, keeping up a constant current of air.

At 9h. 44m. the pulsation became once more distinct, as high as 72, and continued varying for seven hours from 56 to sometimes 100, but most frequently at between 70 and 80. At 7h. 38m. natural respiration was free, and artificial discontinued.

Another experiment was made next morning at eight o'clock on a male ass, about five years of age; it appeared

very vigorous, but with ventral hernia on the right side. It stood perfectly quiet, and the action of the heart was at 36. Mr Attenburrow, surgeon, cut into the trachea at 8 h. 4 m., then an incision was made on the fore part of the right shoulder, into which, at 8 h. 6 m. Mr Waterton inserted an arrow-head with the Woorali on it; the quantity being not quite one-fourth of that used upon the ass yesterday. At 8 h. 16 m. pulsation was 66, and about four minutes afterwards the pupil of the eye became gradually dilated, though the animal stood perfectly patient, manifesting no symptoms of uneasiness. At 8 h. 30 m. pulse 62; at 8 h. 38 m. spasmodic twitchings were evident on the region of the abdomen; the animal still eating, and apparently not much distressed. The next minute the legs trembled, and at 8 h. 40 m. the creature fell on its belly, but tried to rise again. At 8 h. 43 m. the tube was introduced into the trachea; at 8 h. 44 m. action of the heart regular, but respiration convulsive and difficult, with repeated gasping. It struggled occasionally, and at 8 h. 49 m. the pulse was 54, with spasm and difficult respiration, but the pupils of the eyes not so much dilated. At 8 h. 54 m. the arrow-head was withdrawn and no poison remained on it, the pulse continued the same and the respirations were 44, the vision pretty perfect. At 9 h. 7 m. respiration ceased, the vision entirely gone, the action of the heart energetic, extremities warm, throbbing of the carotid artery strong, artificial respiration commenced at an average of 18 a minute, and at 10 h. 25 m. the nostrils gave indications of restored respiration, artificial respiration kept up at 16 per minute, no pulsation perceptible, except in the action of the heart. At 10 h. 27 m. natural respiration recommenced, at 10 h. 36 m. symptoms of returning vision, at 10 h. 40 m. respiration much hurried and irregular, at 10 h. 41 m. artificial respiration discontinued, at 10 h. 44 m. natural respiration 38."

In my own cases both respiration and action of the heart went on regularly even under most marked symptoms. It is true the pulse underwent some alterations, but they could hardly be considered to be governed by certain laws, the number of pulsations immediately after injection being sometimes increased, sometimes decreased, but in almost all cases even-

tually returning to the standard before injection. It must likewise be borne in mind, that the injection of about two grains of Urari cannot be effected without causing some pain which fully accounts for the variations of the pulse.

Some experimentalists have shown the vasa-motor nerves to be paralyzed by Urari, and in consequence the peripheric vessels becoming dilated and giving rise to lower temperature[1]. My experiments have led me to deny the decrease of temperature which either vacillates in a very small degree—according to my opinion, the result of external influences—or remains standard. In a case in which two grains of Urari were effectually injected I measured the temperature, the result is shown in the following table:

Immediately after injection

Minutes.	Pulse.	Respiration.	Temperature.
	47	17	36·8 Cels.
5	65	...	36·8 ...
10	66	...	36·8 ...
15	65	17	36·8 ...
20	65	...	36·8 ...
25	65	...	36·8 ...
30	64	17	36·8 ...
35	66	...	36·8 ...
40	64	...	36·8 ...
45	65	17	36·8 ...
50	68	...	36·8 ...
55	68	...	36·7 ...
60	66	18	36·7 ...
65	...	...	...
70	...	...	...
75	67	17	36·7 ...
80	...	...	...
90	67	17	36·7 ...

The temperature was taken from the mouth, where the bulb of the thermometer remained, of course, during the whole time

[1] Tscheschichin's *Mittheilungen aus dem physiolog. Laboratorium zu Würzburg.*

of measurement. I need not mention that the injection was made, and the reading of the thermometer begun, after the mercury had ceased to rise, and remained standard for about five minutes, which in a sensitive instrument is not the case before the lapse of about 15—20 minutes.

These observations are in accordance with those of *Claude Bernard* who does not admit of raising the temperature under the influence of Urari.

Another constant symptom of the effect of Urari is impaired vision. *Voisin* and *Lionville* consider this phenomenon to be the first, but, as I think, wrongly, for, in all cases under my observation, the muscular system was first affected, although the relaxation of the features was the only perceptible symptom. Pressure in the frontal region, heaviness in the head, and similar phenomena mentioned by others, I have not been able to observe, and a few very recent cases, in which the injection was followed by fainting feelings, induced me rather to connect that phenomenon with the mental impression exercised on the patient by the injection. The impairment of vision generally consists of dimness in the eyes and diplopia, the background of the eye generally being paler than is normally the case; but in other instances we find the vessels much injected and, therefore, a larger number of small vessels visible than is the case in a normal eye. The explanation of these phenomena may be found in the paralytic state of the vasa-motor nerves. The phenomenon observed in one individual, viz. the alteration of the shape of the optic nerve, is a remarkable fact, and since no real alteration of the shape of the nerve is possible from its position in the surrounding tissues, no other explanation remains but to consider it as a consequence of an alteration of the refractory conditions of the eye existing during the action of the Urari. This opinion has been advanced by Mr *Bader*, ophthalmic surgeon to Guy's Hospital, and by Dr Liebreich at Paris, to whom I have mentioned the case.

The acoustic nerve has been affected in a similar manner to the affection of the optic nerve in one patient; but this affection having been observed once only amongst a large number of cases, it cannot well be considered, I think, a

symptom characteristic to the action of Urari, at least not when small doses are administered.

Amongst the symptoms described by *Voisin* and *Loinville* we find an abnormal secretory action of the glandular system, rigors, excessive heat and general perspiration. Neither of these phenomena have occurred in my cases, except, in one instance, sweat of the palms of both hands. It is not altogether without interest to remark, that this particular symptom is not unfrequently met with in certain diseases connected with derangements of the nervous system, as Epilepsy, Hysteria, Paralysis, etc.

However severe the symptoms may be, consciousness and sensibility remain intact, provided the dose had not been large enough to paralyze the respiratory muscles, otherwise respiration ceases, consciousness is lost, and the animals become attacked by convulsions.

If the control over the co-ordinate movements is but partially lost, the energy of the individual is capable of decreasing that loss to a great extent, so that a patient who declares himself unable to raise his arms, ultimately is capable of doing it, if he be encouraged to do so, and do not give it up after the first attempt has been made.

A most remarkable fact is the recurrence of all the symptoms on the patient's coming into the open air. With a few exceptions all injections have been made by myself at my consulting room, the patients remaining with me until all phenomena had disappeared, vision, muscular action had returned, in short, until the patient was perfectly able to walk home; I only dismissed him, after having been convinced of his being in such a state. On the next visit some patients informed me, that all symptoms they had experienced after injection returned as soon as they came into the open air, and that the symptoms lasted nearly for the same time as before.

In conclusion, it remains only to say a few words concerning Urarin. If Dr Preyer's statement as to the strength of the alkaloid, being about twenty times that of Urari, be correct, the highest dose injected by me, viz. 13 milligr. (about $\frac{1}{4}$ gr.), would be equal to about five grains of Urari, a dose which, un-

doubtedly, would prove fatal. The possible difference of the Urari used by me and that from which the alkaloid has been extracted does not explain the different strength, for experiments made in different parts of Europe have shown that nearly the same doses have been applied with the same results, so that, in fact, the difference in the strength of Urari generally used for experiments seems to vary but little[1].

The largest number of injections of Urari have been made in the patient of Case I. In him the first symptoms of Urari were observable after at least more than one grain (gr. $1\frac{1}{4}$—$1\frac{1}{2}$) had been injected, whilst 13 milligr. of Urarin produced no effect whatever. The conclusion is therefore warranted that Urarin is not six times stronger than Urari, or—to speak still more reservedly—than the Urari used in my experiments. But it must be borne in mind, that 13 milligr. by no means indicated the beginning of the effect, and that I discontinued the application of the alkaloid merely from the costliness of the preparation.

II. *The African arrow-poison.*

Though numerous experiments have been made with Indian arrow-poison from the time when Urari was first brought over to Europe, I cannot find any record of experiments with the poison used by the Africans for turning a harmless arrow into a terrible, deadly weapon.

I therefore gladly embraced the opportunity of making a few trials, the results of which are contained in the following communication.

The poison was taken by me from arrows, sent by R. B. M. Walker from the Gaboon, west coast of Africa, to the Anthropological Society of London.

The *arrows* came from the Isyâsâ and Isyîro tribes, measure about sixteen inches, and have the thickness of a raven's quill. They are very sharply pointed, and the points are

[1] Brückner and Lampe's Urari requires, however,—as found by experiments made, when this paper was already in the press—a dose of three grains, hypodermically injected in an adult, in order to produce the slightest possible symptoms consisting of a mere dimness of the sight.

for two inches covered with a thick layer of the poison, which is of a brownish colour, firm, without smell, of a bitter taste and, like the Urari, easily soluble in warm water or alcohol, on the solution settling, leaving a sediment. The microscope reveals the latter to consist of brokendown vegetable tissues, as seen in Figure II A.

The cells are very numerous, and consist of the different parts of a plant. If a drop of sulphuric acid be added, needle-shaped crystals are formed, probably the alkaloid of the poison.

To be sure that the cells were not scraped off with the poison from the arrow, which seems to consist of a reed-kind, I put sections of the latter under the microscope, but could not discover any resemblance between them and the vegetable remnants of the poison.

As one glance on the woodcut will suffice to show the difference between the tissues of the plants from which the Indian and African arrow-poison are extracted, so will the first experiment show that the action of both are totally different; and in a certain sense, as will be seen hereafter, acting in opposite directions.

A small piece of the poison being placed under the skin of a middle-sized frog, the animal died in about ten minutes in convulsions.

Another frog, poisoned by Urari, survived a few minutes; but on opening both frogs, the heart was actively beating in the latter, but standing still in the former, and on application of the electric current to both frogs, about half an hour after death, not the slightest reaction was perceptible in the one poisoned by the African poison, whilst the other maintained its irritability on electricity for many hours.

This experiment, though roughly made, warranted the conclusion, *that the African arrow-poison affects, in the first place, the nervous centres, and destroys at the same time the irritability peculiar to the muscles.* This conclusion has been fully borne out by the following experiments:

Two grains of the poison were dissolved in one drachm of distilled water, and the experiments made on five healthy, large frogs, four of which had injected a tenth of a grain each, while

the fifth was made to swallow a somewhat larger quantity. For comparison's sake, a sixth frog was poisoned by an equally large dose, as in the first four frogs, of Urari.

The first fact observable was the more rapid action of the Urari-poison; for the urarirised frog after a very few minutes began to lie flat on the table, the hinder legs extended, while the other frogs at this time were still jumping about without exhibiting any sign of affection. But after about ten or fifteen minutes their movements began to be slower; yet complete paralysis could only be observed after about three quarters of an hour.

It is well known that urarirised frogs are most appropriate objects for observing the circulation of the blood, provided such doses are given as to paralyze, but not to kill the animals. But in the frogs treated with African poison, the circulation could already be seen going on very slowly when the first sign of beginning paralysis consisted only in slow movements.

The state of sensibility was likewise very different. The urarirised frogs, as already mentioned, retain for a very long time the capability of being convulsed by the electric current when applied immediately to the skin or muscles, and to a certain extent even when applied to the nerves. This property exists only a short time after the death of animals poisoned by the African arrow-poison, and after about half an hour neither direct nor indirect application of the strongest current, applied to the skin, muscles or nerves, will cause any contraction of the frog's muscles.

In another series of experiments five large frogs were injected with the following doses of the African poison:

No. I. Two milligrs.

No. II. One milligr.

No. III. One-tenth of a milligr.

No. IV. One-twentieth of a milligr.

No. V. One-fortieth of a milligr. = 0·0640 grains.

Frog No. I. After five minutes paralysis ensued, and although twitching on the skin by means of a forceps still produced reaction of the muscles, yet when the thorax was opened the heart was not beating any more, having ceased to throb after

a systolic movement, the ventricles being pale and empty, the auricles teeming with blood.

Frog No. II. The same phenomena, but beginning somewhat later. When the hinder legs were still energetically moving, on irritants being applied to the skin, the blood-corpuscles under the microscope could be seen moving very slowly in the vessels of the web, indicating that paralysis of the heart and vessels had begun; in the finest capillaries circulation had ceased altogether, and when the thorax was opened, after another minute, the heart was found in the very same condition as described in No. I.

Frog No. IV. died twenty minutes after injection, and

Frog No. III. about three minutes later.

Frog No. V. died after one hour and a few minutes, under the same symptoms as the others.

In all animals the application of the electric current to the nerves remained without any effect, while sensibility in some frogs could be seen on application of the current to the skin or muscles for a few minutes after death, in others for about an hour, the frogs treated with the smallest doses always retaining sensibility for the longest period, which did not, however, extend over an hour.

These experiments have, of course, to be repeated with more care; but from the results already obtained, we may infer that the danger of the African arrow-poison exceeds by far that of Urari, provided a sufficient quantity be introduced into the system of men or animals.

Ceteris paribus, there is a chance of recovering from poisoning by Urari, if respiration is not impaired, or if artificially continued, while all hopes at once vanish if the African poison has taken effect on the centres of the nervous system; and unfortunately the quantity required for this effect seems likewise to be very small.