*With the Author's best regards
THE & remembrance of all his
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PHYSIOLOGICAL ACTIONS

OF

DAJAKSCH,

AN ARROW POISON USED IN BORNEO.

BY

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PHYSIOLOGICAL ACTIONS OF DAJAKSCH.¹

EXPERIMENTAL researches as to the action of poisons on the animal organism present to the physiologist by no means an uninteresting field of inquiry, inasmuch as they either provide him with the only means of ascertaining certain physiological facts, or enable him to confirm results reached at by less refined methods of investigation. A good example of the latter is the working of the poison which forms the subject of the following paper.

Characters of the Extract.—The dried extract has a dark iron-gray colour; is fragile. It is dissolved by water, but not so readily as is *woorara*; and, when finely pulverized, it is to a slight extent soluble in both alcohol and ether. It is not more soluble in hot than in cold water. Water dissolves it more readily in the presence of acids, whereas alkalies do not increase its solubility in water. It is insoluble in chloroform. The foregoing solutions give an alkaline reaction with test paper. The watery solution used for experiment had a bitter taste, was of a brown colour, and its odour resembled organic matter decaying in a moist place.²

General Symptoms produced by the Poison.—The first noticeable evidence of the working of this poison, when administered subcutaneously, is restlessness, and signs of irritation. These reflex movements are not those resulting from excessive pain, but resemble such as are produced by a mild local irritant. This is followed by a state of languor—the animal lying perfectly still, and the respiration being slow, but not laboured. Its posture, however, does not allow of the supposition of want of motor power, but only of indisposition to move. This condition is interrupted by several fits of convulsions,

¹ While working in his laboratory in Berlin, Professor Du Bois-Reymond kindly gave me this poison, *dajaksch*, which he had received from a doctor who had been in Borneo. It was in the form of an extract, wound round a small piece of stick, and dried thereon. It was wrapped up then in paper, and sealed in a piece of bamboo about three inches long, which bore the inscription, "Dajaksch: Pfeil-gift von Borneo."

² From this simile it is not to be thought that the extract used was already too old and had begun to decompose. All those who smelt the watery solution considered its odour to be quite characteristic; and though the comparison is not perfectly accurate, it is as nearly so as possible. The odour, moreover, does not increase as the solution is kept longer, and is not very strong, though marked.

which increase in intensity from time to time. By degrees, paralysis, at *first* of sensation, and *then* of motion, sets in. The onset of the paralysis is in some instances not very marked, and in no case did the general paralysis seem to be an effect of the action of the poison. This paralytic stage shortly precedes death, and sets in from half an hour to an hour after the cessation of the heart's contractions. Lastly, the respiration is noticed to become heaving and irregular; sometimes the respiratory movements are spasmodic, gasping, and occurring at long intervals. In the case of warm-blooded animals, vomiting and the passage of feces and urine are noticeable symptoms, which present themselves soon after the exhibition of the poison, and continue to a greater or less extent till general paralysis takes place.

Specific Action of Dajaksch on the Pupil and on the Heart.—On the application of a couple of drops of a diluted watery solution of Dajaksch mixed with glycerine, between the eyelids, in the case of the lower animals the iris was found to contract. But this effect was not nearly so marked as that noticeable on the use of the *Calabar bean*; and therefore it is only incidentally noticed here. In those cases in which death resulted from the use of the poison, the contraction of the pupil was first observable at the commencement of the convulsive stage, and lasted till general paralysis set in, when the pupil began again to dilate. Though this poison produced contraction of the pupil in the lower animals, it is not to be concluded that it has the same effect on the pupil of man; for it has been repeatedly found that poisons which, to a marked extent, contract the pupil in the lower animals, do not act on the human subject.

The Complete Cessation of Cardiac Action is, however, the characteristic effect of dajaksch on the animal organism. In the course of a short time (varying according to the amount and strength of the solution used), after the subcutaneous administration of the poison, the heart's pulsations are found to become feeble. Shortly thereafter the heart contracts irregularly and *peristaltically*. The irregular pulsations consist in the auricles contracting twice as often as the ventricles,—once with the ventricles, and once during the intermediate pause.¹ By degrees the ventricles cease to contract, and exhibit only a slight heaving movement of their walls, by the blood passing through them; and at last they become *simultaneously* motionless. Some time thereafter (about half an hour when the dose is small), the auricles are observed to pulsate more and more slowly and feebly, and at last they also become motionless. General motion and sensation are as yet unimpaired; so that, if the experiment be made on a frog, and it be at this stage released from its fastenings, it jumps about briskly with an immovable heart. No portion of

¹ These irregular and peristaltic contractions of the ventricles are best observed in the frog. In these animals the ventricle can be distinctly seen to contract peristaltically (like the intestines) from the apex to the base.

the cardiac organ is re-excitabile, either by mechanical or electrical means after it has once become paralyzed. The heart ceases to contract in systole. The ventricles are observed to be bloodless and pale, whereas both the auricles contain blood—the left auricle and the veins leading to it being distended with dark-coloured blood.

Post-mortem Appearances.—These are by no means characteristic. Besides the condition of the heart which has just been mentioned, the other organs of the thorax and abdomen are sometimes partially hyperæmic, but present to the naked eye no other appreciable alteration. The muscles of the extremities contracted *readily* in the case of frogs when excited directly or through their nerves by a current of electricity; whereas the experiments made on warm-blooded animals gave this curious result, that a strong electrical stream produced *slight* contractions of the voluntary muscles when they were excited directly, but *failed* to produce contractions when passed through their nerves. In both classes of animals the muscles retracted on being incised. Electricity, moreover, had no power in renewing the contractions of the heart or of the intestines after death.

This diversity on the part of the voluntary muscles of frogs may perhaps be accounted for by the well-known extraordinary contractile vivacity of the muscles of these animals, as compared with those of others.

The question now suggests itself, How does this poison—dajakseh—produce the paralysis of the heart? Exclusive of a direct paralysis of the muscular fibres (which is not likely to be the case, seeing the other muscles of the body remain so long unaffected), this phenomenon may be produced through any one of the three nervous sources which supply the cardiac nerves, viz., through the vagus, through the sympathetic system of nerves, or through the spinal cord. Experimental research has long ago demonstrated that the cardiac branches of the vagus have the function of arresting the heart's contractions, while those from the sympathetic are the truly motor nerves, and those from the spinal cord the probable sensory cardiac nerves. The proof necessary, therefore, to determine this point requires to be both negative and positive.

Commencing, then, with the former, three sets of experiments were made to exclude the action of this poison through the *vagus*. *Firstly*, The voluntary muscles of a frog having been completely paralyzed by means of woorara, which did not however in the slightest degree affect the contractions of the heart; a dose of dajakseh was next administered to it subcutaneously, and the result was as follows:—The latter poison exhibited its action on the heart in the same time and in the same way as it had done in frogs not previously poisoned with woorara. *Secondly*, The medulla oblongata of other frogs was broken up with a needle, so as to destroy the origin of the vagus, and this in itself produced a momentary cessation of the cardiac pulsations; but after these were

renewed, a dose of dajaksch was given, with the result that it acted on the heart exactly as it had done in the case of normal healthy frogs. *Lastly*, The vagus was divided in its course, and on the application of the poison the effect on the heart was exactly the same as in both the previous instances, proving that dajaksch does *not paralyze the heart through the vagus*. What further confirms this conclusion is the fact that irritation of the vagus produces only temporary paralysis of the heart; whereas, after the use of dajaksch, the heart cannot by any means, mechanical or electrical, be re-excited to contraction.

Besides the circumstance that, as the results of experimental observation, the cardiac branches supplied by the spinal cord seem to be for the most part sensory nerves, this source is further excluded by the following consideration,—That the paralysis of sensation and motion do not set in, in the case of poisoning with dajaksch, till long after the heart has been completely paralyzed. Moreover, post-mortem research does not lead us to suspect paralysis through the spinal cord. Therefore, nothing now remains to us except to conclude that the paralysis of the heart results from the action of this poison on the sympathetic cardiac ganglia.

Positive proof of the foregoing assumption, and an explanation of the manner in which the paralysis attacks the several chambers of the heart, is afforded us by the following fact:—If the heart be removed from the body immediately after it is apparently paralyzed, but while the animal possesses general sensation and motion unimpaired, and Stannius' experiment be made on it, we have this result,—that on exciting the ganglion of the sinus venosus with a *strong* stream of electricity, the auricles are observed to contract twice slightly, but the ventricle not in the slightest degree; whereas, if the auricles be separated from the ventricle, neither contract on being electrically irritated.

Conclusions.—We may conclude, then,—

1st, That this arrow-poison, dajaksch, produces death by paralyzing the heart; which is proved further by the fact, that, after ligature of the heart, death results in the same way and in about the same time as after poisoning with dajaksch.

2d, That the cessation of the cardiac contractions is brought about through a paralysis of the cardiac ganglia of the sympathetic, exactly as the same is seen on performing Stannius' experiment. In other words, that with this poison we have a much finer means of performing Stannius' experiment than the knife and forceps afford us.

3d, Hence, that the ventricle first ceases to contract, because the ganglia situated between it and the auricles, and which for the most part supply the ventricular sympathetic nerves, are first paralyzed. Then that the auricles become motionless after the ganglia supplying them (the ganglion of the sinus venosus in frogs) are paralyzed.

4th, That the other general phenomena produced by this poison, as paralysis of general sensation and motion, etc., may be considered as the natural results of the paralysis of the heart.

Experiments made with DAJAKSCH, illustrating the previous Remarks.

A. Illustrating the Constitutional Effects of the Poison.

I. IN THE CASE OF COLD-BLOODED ANIMALS.

EXPERIMENT 1.—Administered to a frog (which had been kept at least twenty-four hours in the laboratory), subeutaneously on the back, a dose of a watery solution of dajaksch. This dose was equal to about twice the common dose of a similar watery solution of woorara.

Immediately after the exhibition of the poison, the animal moved restlessly about. In twenty minutes thereafter, it lay quiet. In seventy-two minutes the frog was apparently partially paralyzed, and dragged its hind-legs when strongly irritated. During this time it moved restlessly at intervals, and the paralytic condition was preceded by convulsions. In eighty-five minutes after the exhibition of the poison, the animal submitted itself to be laid in any position, and did not evince the slightest signs of the presence of motion or of sensation. The pupils were noticed to be contracted to half their normal size. Ten minutes after this no respiratory movements could be distinguished; the eyelids were open, and the animal appeared to be dead.

Autopsy—immediate.—The heart was found to be perfectly still, and not at all excitable on the use of any mechanical irritation. The left auricle was noticed to be greatly distended with dark-coloured blood. The organs generally, especially the stomach, lungs, liver, and kidneys, were somewhat congested. The intestinal canal did not appear hyperæmic. The muscles of the limbs contracted when irritated by an electrical stream both directly and through the main nerve of the limb.

II. IN THE CASE OF WARM-BLOODED ANIMALS.

EXPERIMENT 2.—Injected subeutaneously into the thigh of a well-grown adult rabbit rather more than a cubic centimetre of a watery solution of dajaksch. This dose contained a half-grain of the dried extract. Three minutes after the exhibition of the poison, on being freed, the animal moved about restlessly. Diarrhœa and urination took place. The vessels of the ear were observed to contain less blood than formerly. In seven minutes thereafter the animal lay quite quiet. The vessels of the ear were again refilled. On being looked at five minutes later, the animal continued to lie in the same motionless state, and the vessels of the cartilage of the ear again appeared to be contracted. Twenty minutes after the exhibition of the poison, the rabbit appeared quite dead. Death was preceded by slight convulsive movements of the extremities.

Autopsy—ten minutes after death.—The heart was motionless. On being opened the ventricles were found to contain a very little blood. The right auricle was devoid of blood; but the left auricle, as well as the veins leading into it, were noticed to be distended with dark-coloured blood. The lungs, liver, kidneys, and whole intestinal canal did not present to the naked eye any abnormal appearance whatever. When irritated directly by an electrical stream, the muscles of the extremities contracted *very* slightly; but the muscles of the thorax and abdomen were *not at all* excitable by electricity. A few minutes later the muscles of the extremities also gave *no* contractions with an induced stream of electricity. None of the voluntary muscles contracted when incised, or when the chief nerve of the limb was divided, or when excited by an electrical stream passed through the chief nerve of the limb. The ventricles were *not* excitable to contraction by an electrical current; but the auricles contracted *readily* by this means. When tested again, thirty-five minutes after

the death of the animal, the auricles were found to be less excitable by electricity. Fifteen minutes thereafter slight contractions of the auricles were produced by electricity. Three minutes later the right auricle could not be excited any more to contract, and the electrical stream caused contractions only at the most distant part of the left auricle. Twelve minutes after this, and sixty-five minutes after death, no part of the left auricle was any longer excitable by electricity.

EXPERIMENT 3.—Administered to a young cat subcutaneously in the left thigh a dose of the watery solution, equal to a quarter-grain of the dried extract. In fifteen minutes after the exhibition of the poison, fæces were passed. This was followed by vomiting, and the animal shrieked in great distress. Between the paroxysms of sickness, the cat lay crouching in a dark corner of the room quite still; but, on being strongly irritated, it moved, showing voluntary motion to be unaffected. The paroxysms of vomiting recurred at short intervals, and were preceded by loud shrieking. Fifteen minutes later, the cat appeared quite listless, and allowed itself, without offering any resistance whatever, to be laid in any position. Sensation seemed to be absent. The heart, on being examined, from time to time, through the thoracic wall, was noticed to be pulsating more and more rapidly and irregularly. Thirty-two minutes after the administration of the poison, strong convulsions of the whole body occurred. Just before these convulsive paroxysms, the heart could be no longer distinguished by feeling through the thoracic wall. Immediately after these fits passed off the animal darted into the centre of the room screaming; but finding a want of power in its hinder limbs it could not run further, and so dragged itself along for a few inches and fell on its side. A few seconds thereafter it struggled strongly to recover its former position; but, being unable to support itself any longer, it spread out its limbs and lay on its belly with its head turned to the left side. In a few seconds it gave a loud shriek and died. The pupils were noticed to be dilated; the lower jaw was dropped.

Autopsy—immediate.—The heart was motionless and not excitable by mechanical irritation. Its cavities presented the same appearance as in the previous experiment. The veins of the thorax and abdomen were found distended with dark-coloured blood. The stomach contained some frothy mucus, and was slightly congested towards its pyloric end. The other organs, though examined, presented no abnormal hyperæmic condition. The peristaltic movements of the intestines were absent. The muscles of the extremities contracted when incised, but were not affected by mechanical irritation of their nerves.

EXPERIMENT 4.—Gave an adult sparrow a dose of the solution, equalling about one-tenth grain of the dried extract. Three minutes after the administration of the poison by the mouth, the bird having been flying about the roof of the room, suddenly fell down dead.

Autopsy—immediate.—The heart was found passive, and its chambers severally in the same condition as in the previous experiments. The heart's contractions could not be in the slightest degree excited by mechanical means. The pupils were observed to be dilated.

EXPERIMENT 5.—Gave a large adult grey cat subcutaneously, in the left thigh, a dose of a watery solution containing rather more than one-tenth grain of the dried extract. About ten minutes after the exhibition of the poison the animal began whining, and was restless. This was continued at intervals. An hour after the poison had been given, occasional vomiting and diarrhœa set in. Motion and sensation were unimpaired. An hour thereafter, the heart's pulsations were felt through the thoracic wall to be very rapid and irregular. Sensation seemed to be slightly affected. Pupils were of normal size. Twenty minutes later, urine and fæces were observed to be passed very often. The fæces were fluid, yellowish white, and of a strong odour. Voluntary motion was unimpaired. The cat lay crouching and listless in a dark corner, and, when moved from its place, purred angrily and strove to get back to its corner. When again observed, about an hour later, motion and hearing were found to be unaffected; but vomiting still recurred at intervals. Half an hour there-

after it continued to lie quietly in the dark corner when undisturbed; but when approached it purred angrily, though it would not stir from its place. Vomiting, diarrhoea, and urination had now quite ceased. When the heart was examined through the thoracic wall it seemed to be pulsating irregularly, but not so rapidly as formerly. On being looked at next morning, about twelve hours after the administration of the poison, the cat was found languid, but in other respects it appeared to be in normal health. At first it would not drink any milk, but in a few hours it began to take its food as formerly, and seemed to have *quite* recovered the effects of the poison. It seemed to have lain in the same corner all night, and in the same crouching posture.

B. *Illustrating the Special Action of the Poison.*

I. IN PRODUCING CONTRACTION OF THE PUPIL IN THE LOWER ANIMALS.

EXPERIMENT 1.—Poured a drop of a weak solution into the right eye of a rabbit. The right pupil seemed to begin to contract in about two minutes after the administration of the poison. About an hour later the right pupil was observed to be half as large as the left one, and after another half-hour it became two-thirds smaller than the left one.

EXPERIMENT 2.—A few drops of a weak watery solution were applied with a brush to the right eyeball of a dog which had very active irides. When looked at about an hour after the application of the poison the right pupil was found to be contracted to half its normal size, and to be more sluggish than the left one. Besides causing local uneasiness the poison seemed to have no other effect. The pupil contracted to about one-third of its normal dimensions; but after about three hours the poison appeared no longer to act on the pupil.

II. IN PARALYZING THE HEART.

(a) *In the case of Frogs.*

EXPERIMENT 1.—Exposed the heart in a frog, and found its pulsations to be 46 per minute, regular, and of normal strength; in five minutes thereafter gave it subcutaneously, in the thigh, a large dose of a strong solution of dajaksch. Immediately after the injection of the poison the heart's pulsations were 46 per minute. In ten minutes after its exhibition the heart's pulsations were found to be 8 per minute, and feeble, but regular. The frog made strong muscular movements when irritated, but these did not in the slightest degree affect the heart's pulsations. In eight minutes later the ventricle ceased pulsating, and the auricles contracted feebly and at irregular intervals. Four minutes thereafter the auricles ceased to contract, but voluntary motion was found to be perfect. The paralysis of the heart was followed in seven minutes by intermittent convulsive movements of the extremities. During this convulsive period, respiration was slow and laboured. Before the ventricles ceased contracting, it pulsated more and more feebly, slowly, and not synchronously with the auricles. Voluntary motion continued unaffected for nearly three-quarters of an hour after the heart became motionless, but during this time several convulsive fits occurred. An hour and seven minutes after the cessation of cardiac action the animal lay dead, with its lower limbs stretched out behind. When an induced electrical current was passed into the muscles of the extremities directly and through the main nerve of the limb, it caused contractions an hour and a quarter after death.

EXPERIMENT 2.—On exposing the heart of a frog, its contractions were found to be 48 per minute, and regular. The poison was exhibited just as in the last experiment. Three minutes after the administration of the poison, reflex movements were noticed, but the heart's pulsations were found to be the same. In thirteen minutes after the commencement of the experiment the ventricle was quite still, and not re-excitably by mechanical or electrical means. Before becoming motionless, the ventricle pulsated more and more slowly and feebly, and then contracted in a peristaltic manner from its apex to its base.

The auricles pulsated 14 times per minute, but at regular intervals. Five minutes later the auricular pulsations were found to be 4 per minute, and, of these, 3 occurred during the first quarter of a minute. Two minutes thereafter the auricles pulsated 6 times per minute, but irregularly as before. Respiratory movements were feebler. Three minutes later the auricles were observed to contract 5 times per minute, *i.e.*, 4 times in the first twenty seconds, and then followed a strong contraction at fifty seconds. Sensation and motion were found unimpaired. When noticed, ten minutes later, the auricular contractions were 7 during twenty seconds, and then none for one and a half minute, when a strong contraction occurred. In five minutes thereafter slight convulsions of the lower extremities seemed to be present. The auricular pulsations were 2 per minute, and at regular intervals. For twenty-one minutes after this the auricles continued pulsating, but more and more feebly, very irregularly, and at long intervals. Then they suddenly ceased contracting. The respiratory movements were observed to be laboured, and to occur at long intervals. Sensation and voluntary motion seemed to be unimpaired. Half an hour after the paralysis of the auricles the animal was found to have lost sensation and motion, and appeared dead.

EXPERIMENT 3.—On taking a frog and exposing its heart, whose contractions were 40 per minute, regular, and of normal strength, I administered to it a good large dose of dajakseh, subcutaneously as formerly. In nine minutes thereafter the cardiac pulsations were found to be 18 per minute, and regular, but feebler than before. In eleven minutes after the administration of the poison the ventricle was observed to contract non-synchronously and peristaltically from apex to base. Six minutes later the auricles were found to contract twice as often as the ventricle,—once with the ventricle, and once in the intermediate interval. But both sets of contractions occurred at regular intervals. Three minutes after this the ventricle ceased to pulsate, and was not re-excitable. In eight minutes after the paralysis of the ventricle, the auricles exhibited very feeble heaving movements, not to be called contractions. General sensation and motion were at this time found to be unimpaired. Three minutes later, and half an hour after the exhibition of the poison, the auricles were found passive. Sensation at this time was somewhat impaired, but not motion, for the animal jumped about briskly when freed. In rather more than half an hour after the cessation of the cardiac contractions, general sensation and motion were found to be absent; the frog submitted to be laid in any position. At this time the heart was cut out of the body, and Stannius' experiment performed on it, with the following results:—On irritating the ganglion of the sinus venosus with an electrical stream, the auricles contracted each time after being twice irritated, but not oftener; whereas the ventricle remained motionless on being irritated. On separating the auricles from the ventricle, neither contracted on being irritated. These two slight contractions of the auricles were therefore the last traces of their contractility. Five minutes after the heart had been removed, the frog gasped and died. The pupils were observed to be of normal size. When an induced current of electricity was passed through the muscles of the extremities directly, and through the sciatic nerves, it elicited *normal* contractions of the muscles.

EXPERIMENT 4.—To a frog, whose heart had been exposed, and its pulsations found to be normal, was given subcutaneously a dose of the watery solution, containing about a grain of the dried extract. In five minutes after the exhibition of the poison the animal was very restless, and exhibited strong reflex movements. Ten minutes thereafter the cardiac pulsations were irregular, much slower than at first, and very feeble; and two minutes later the ventricle was observed to be motionless. The auricles ceased to pulsate half an hour after the ventricle had stopped. A strong electrical stream elicited no contractions after the cardiac chambers became still. Paralysis of motion set in a quarter of an hour after the auricles had ceased to pulsate. The muscles of the extremities, an hour after the paralysis of the heart, contracted strongly when irritated by an electrical current directly or through their nerves.

(b) *In the Case of Warm-blooded Animals.*

EXPERIMENT 5.—After artificial respiration had been established, and the heart exposed in a young rabbit, about half a grain of the dried extract of *dajaksch*, dissolved in half a cubic centimetre of water, was injected through a small opening in the skin of the left thigh. Before administering the poison, the cardiac contractions were noticed to be of normal strength, and 100 per minute. Half an hour later the above dose, seeming not to affect the heart, but having caused only a frequent passage of feces and urine, and reflex movements of the body, another dose of half a grain was administered. Immediately after the exhibition of the second dose, the peristaltic motion of the intestine was marked, and the reflex movements of the limbs were strongly developed. Ten minutes later the cardiac pulsations were observed to be slower and more feeble than at first. They next became irregular, both as to duration and synchrony, and then the ventricles exhibited vermicular contractions, passing from their apex to their base. Twenty-eight minutes after the second dose had been given, the cardiac chambers were noticed, all at one and the same moment, to cease pulsating; and after a pause the auricles resumed their contractions, whereas the ventricles remained motionless and not re-excitabile. The auricular pulsations were slow, feeble, and at first regular, but by degrees they became irregular. The auricles ceased to pulsate about half an hour after the ventricles had stopped. Up to this time sensation and motion were found unaffected, but by degrees paralysis followed.

On passing a very strong stream of electricity from a galvano-electromotor, about three quarters of an hour after the auricles had ceased to pulsate, through the muscles of the extremities, they were found to contract (but not strongly) when directly irritated; but they did not contract at all when electrically excited through their nerves. Electricity did not produce the slightest ventricular contractions, whereas the auricles contracted readily under the same influence. The auricles continued for half an hour longer to be excitable by electricity, though to a less and less extent, and then they lost this property. The intestines could not be excited to peristaltic action by the use of an electrical current. The voluntary muscles of the extremities retracted when incised.

Remark.—In the above series of experiments an autopsy was made in each case, with the same results as previously.

C. *Experiments proving negatively the Action of the Poison through the Cardiac Branches of the Sympathetic.*

EXPERIMENT 1.—Having ligatured the left femoral artery of a frog, I gave subcutaneously a large dose of the poison, without exposing the heart.

The usual general symptoms of restlessness, reflex movements of the limbs, contracted pupils, convulsions, and general paralysis were noticed.

On opening the body, the heart was found in the same condition as in previous experiments. The muscles of *both* hinder extremities were found to be *equally* excitable on the application of an electrical stream, directly and through the sciatic nerves; as also on being irritated directly and indirectly by mechanical means—showing that this poison does not act directly through the circulation as *woorara* does.

EXPERIMENT 2.—After exposing the heart of a frog, administered to it a common dose of a watery solution of *woorara*. Paralysis of the voluntary muscles having been as usual produced by this poison, but the heart's pulsations being found to be 36 per minute, regular, and of normal strength, a dose of *dajaksch* was next injected subcutaneously into the left thigh.

Fifteen minutes after this latter injection, the ventricles and auricles were observed to pulsate non-synchronously, and the ventricular contractions to be peristaltic, passing from apex to base. Four minutes thereafter the auricles were found contracting twice as often as the ventricle. Three minutes later the ventricle was not contracting any more, but exhibited a heaving movement

of its walls. In ten minutes more the ventricle ceased to pulsate. About half-an-hour after the ventricle became passive, the auricles also ceased to pulsate. The general symptoms followed the same course as in experiments on healthy frogs.

EXPERIMENT 3.—Having broken up the medulla oblongata of a frog with a needle, exposed its heart, and found the cardiac pulsations to be 32 per minute, regular, and of normal strength, a dose of dajaksch was administered subcutaneously. Six minutes after the exhibition of the poison the cardiac contractions were noticed to be irregular and feeble. The auricles contracted twice as often as the ventricle; but on gentle irritation both sets of chambers pulsated synchronously. Five minutes later the ventricle ceased to contract, and heaved only; and in a few minutes thereafter it was motionless. About half an hour after the exhibition of the poison, and a quarter of an hour after the ventricle had ceased to pulsate, the auricles became motionless. Then the frog was released, and jumped briskly about. The general symptoms followed in the usual order, and in rather more than an hour after the administration of the poison, the animal was dead.

Remark.—These last two experiments oppose the supposition of the paralysis of the heart being produced by the poison acting on the vagus.

Concluding Remarks.—Owing to the small amount of the poison which was at my disposal, the above researches are not so complete as might be desirable; and a very important element wanting in the above sketch is a prefatory notice respecting the natural history of this interesting poison; but this is not as yet attainable, the poison being comparatively, if not quite, new. The peculiar action of dajaksch on the heart may recall the well-known Java arrow poison, Upas Anthiar. But these two poisons, though perhaps allied in their natural history, differ in other respects from one another. Upas Anthiar is properly a Java poison, and, if met with in Borneo, it is only found and used there to a slight extent; whereas dajaksch is the name of a well-known native tribe in Borneo. In chemical characters these poisons show themselves also not to be one and the same. Lastly, these poisons seem to differ from one another in the physiological effects they produce on the animal organism. For, as Professor Kölliker of Würzburg stated, as the result of his investigations, in a paper read before the Medical Society of Würzburg in 1857, Upas Anthiar produces paralysis of the heart by acting directly on its muscular fibres; whereas dajaksch produces cardiac paralysis by acting on the sympathetic ganglia of the heart.

Physiologists have now, seemingly, two separate means of producing that wonderful and interesting phenomenon of a living animal with an immovable heart; but they are required also anew to unravel this problem,—Wherein consists the death of an animal, or what is the boundary between life and death?

I have much pleasure, at this time, in tendering my grateful thanks to Dr Rosenthal, Professor Du Bois-Reymond's assistant, for his aid while making the above researches.