

Another interesting definite integral may also be obtained from the formulæ given above, viz., we have from (11)

$$e + \cos \theta = \frac{(1 - e^2) \cos u}{1 - e \cos u},$$

whence from (13)

$$\frac{d\theta}{(e + \cos \theta)^n} = \sqrt{1 - e^2} \cdot \frac{(1 - e \cos u)^{n-1}}{(1 - e^2)^n \cos^n u} du.$$

Therefore, putting

$$e = \cos \alpha,$$

we have the relation

$$\int_0^\pi \frac{d\theta}{(\cos \alpha + \cos \theta)^n} = (\operatorname{cosec} \alpha)^{2n-1} \int_0^\pi \frac{(1 - \cos \alpha \cos \theta)^{n-1}}{\cos^n \theta} d\theta. \dots (15)$$

IV.—On the Nature of the Toxic Principle of the Aroideæ—By A. PEDLER, F. C. S. (Lond. & Berl.), Professor of Chemistry, Presidency College, Calcutta, and C. J. H. WARDEN, F. C. S. (Lond. & Berl.), Professor of Chemistry, Medical College, Calcutta.

In the annual report on the Chemical Examiner's Department, Bengal, for 1886, submitted to Government on the 18th February 1887, we gave a brief *resumé* of our investigations on Bish Kachoo, a variety of Arum. We pointed out that the toxic effects of Kachoo were due to purely mechanical causes, and that we were unable to isolate any specific organic poisonous principle from the tubers. In the present communication, we propose giving a detailed account of our investigations, together with an epitome of the most important points connected with the genus Arum.

Watt\* describes the Arums as a genus of herbaceous plants, with tuberous corms often edible, belonging to the natural order of Aroideæ. The genus comprises some twenty species, inhabitants of Europe, the Mediterranean region, and Tropical Asia, and extending from India to Afghánistan.

Botanically, the leaves are sagittate or hastate, base of petiole sheathing. Peduncles most frequently solitary, short or long. Spathe-tube convolute: blade when opened out ovate or ovate-lanceolate: spadix sessile, shorter than the spathe, appendix naked, frequently stalked and cylindrical, rarely clavate. Inflorescence monœcious, perianth none. Female flowers below forming a cylindrical mass, separated from the



male by a tuft of hair-like neuter flowers, which blend above into the male condition. *Stamens* 3—4: *anthers* sessile, opposite or sub-opposite, obovoid, dehiscing by a slit towards the apex, *connective* more or less prolonged: *pollen* vermiform. *Ovary* oblong-obtuse, 1-locular; *stigma* sessile: *ovules* 6 or many, orthotropous, erect: *funiculus* short: *placenta* parietal 2—3-seriate: *micropyle* superior. *Fruit* an obovoid many-seeded berry.

The following account of the species found in India we have abstracted chiefly from Roxburgh's *Flora Indica*, Watt's *Dictionary of the Economic Products of India*, Dymock's *Vegetable Materia Medica of Western India*, and O'Shaughnessy's *Bengal Dispensatory*.

*A. campanulatum*, Syn. for *Amorphophallus campanulatus*, has a tuberous root, which, when peeled and cut into segments, is sold in Bombay under the name of Madan-mash. The segments are usually threaded upon a string, and are about as large as those of an orange, of a reddish brown colour, shrunken and wrinkled, brittle in dry weather; the surface is mammillated. When soaked in water, they swell up and become very soft and friable, developing a sickly smell. The tubers contain a large quantity of farinaceous matter mixed, according to Baden-Powell, with a poisonous juice which may be extracted by washing or heat. The fresh tubers produce intense itching of the tongue when tasted, and when used as food they are often first boiled with tamarind leaves and paddy husks to remove this irritating property. The dried tubers—Madan-mash—have a mucilaginous taste, and are faintly bitter and acrid. Under cultivation the plant loses much of its acidity. It is largely used as a vegetable, and has a reputation as a remedy for piles. It is also used externally in the form of a poultice for insect bites, and as a stimulating application. In Bengal the tubers are known under the name of *ol*.

*A. lyratum*, Syn. for *Amorphophallus lyratus*.

*A. colocasia*, Syn. for *Colocasia antiquorum*. This variety is known in most parts of India as Kachu. Roxburgh describes two cultivated and three wild varieties of this species; the cultivated being Goori Kachu and Asoo or early Kachu; and the wild, Kalla, or dark-coloured Kachu, found on the edges of ditches and other wet places, Char Kachu, found on dry ground chiefly by road sides, or on dung heaps and among rubbish, and Ban-Kachu in situation and form very like the last mentioned variety. The tubers of the cultivated varieties are used as food. Of the wild varieties the leaves and foot-stalks of the dark coloured Kachu are the parts chiefly eaten by the natives of Bengal; the other wild varieties are rarely eaten in Bengal when better vegetables are procurable.

*A. cucullatum*, Syn. for *Alocasia cucullata*.



*A. fornicatum*, Syn. for *Alocasia fornicata*, known as Bees Kuchoo about Calcutta—used medicinally.

*A. montana*, Syn. for *Alocasia montana*, is, according to Roxburgh, a native of the mountainous forests of the Northern Circars, where its root is said to be employed to poison tigers.

*A. odorum*, Syn. for *Alocasia odora*.

*A. rapiforme*, Syn. for *Alocasia rapiformis*.

*Arum indicum*, Syn. for *Alocasia indica*, known in Bengal as Man-Kuchoo. In Bengal, it is much cultivated about the huts of the natives for its esculent stems and small pendulous bulbs or tubers, these being very generally eaten by people of all ranks in their curries; as a medicine, it is stated to be useful in anasarca, and also in piles and habitual constipation. In using the plant, the tough portions should be rejected, and the stems and root-stalks boiled and the water thrown away, otherwise they are likely to irritate the throat and palate.

*A. curvatum*, Syn. for *Arisæma curvatum*, is stated to have poisonous properties. In Kúlú, the seeds are said to be given with salt for colic in sheep.

*A. cuspidatum*, Syn. for *Arisæma cuspidatum*.

*A. speciosum*, Syn. for *Arisæma speciosum*. In Hazára the root is stated to be poisonous. In Chumba it is applied pounded to snake bites. In Kúlú, where the root is given to sheep for colic, the fruit is said to have deleterious effects on the mouth when eaten by children.

*A. tortuosum*, Syn. for *Arisæma tortuosum*, found in Chumba and also eastward to Nepal. The root of the plant is used to kill the worms which infest cattle in the rains.

*A. divaricatum*, Syn. for *Typhonium divaricatum*.

*A. flagelliforme*, Syn. for *Typhonium cuspidatum*.

*A. gracile*, Syn. for *Typhonium gracile*.

*A. orixense*, Syn. for *Typhonium trilobatum*. The roots when fresh are stated by Roxburgh to be exceedingly acrid, more so than *A. dracunculus* or *maculatum*. The natives apply them in cataplasms to discuss or bring forward scirrhus tumours. They also apply them externally to the bite of venomous snakes, at the same time giving internally a piece about the size of a field bean.

*A. margaretiferum*, Syn. for *Plesmonium margaretiferum*.

*A. sessiliflorum*, Syn. for *Sauromatum sessiliflorum*. The tubers are as large as small potatoes, they are very acrid and poisonous, and are only used externally as a stimulating poultice by natives. The *loth* of Dymock's *Materia Medica*.

*A. silvaticum*, Syn. for *Synantheris silvatica*. According to Dymock



the country people use the crushed seed to cure toothache ; it benumbs the nerve ; also used as an external application to bruises on account of its benumbing effect. The taste is intensely acrid ; after a few seconds it causes a most painful burning of the tongue and lips, which lasts for a long time, causing much salivation and subsequent numbness. A section of the fruit and seed show the following structures from without inwards, 1st, several rows of thick-walled cells having yellowish brown granular contents, 2nd, a parenchyma composed of thin-walled cells having no solid contents except needle-shaped crystals, 3rd, several rows of small cells containing chlorophyll, 4th, a delicate parenchyma, the cells of which are loaded with very small starch granules, mostly round, some truncated.

*A. viviparum*, Syn. for *Remusatia vivipara*.

From the brief *resumé* we have given of the Arums found in India, it will be noticed that a belief in the toxic properties of certain species appears to be pretty generally entertained. In England, *A. maculatum* is the best known species. W. Murrell, M. D.\* gives an interesting account of this variety, from which we abstract the following :—

“This plant,” Dr. Murrell writes, “has several popular names, the best known being “lords and ladies,” “cows and calves,” “the parson in the pulpit,” “wake robin,” and “cuckoo-pint.” In former times it was also known as “alron,” “janus,” “barba aron,” “calve’s foot,” “ramp,” “starch wort,” “cuckow-pintle.” The word arum is probably a corruption of “aron” a word of Egyptian origin. Pliny calls it both *aris* and *aron*.

“The plant, although somewhat rare in Scotland, is common enough all over England, and abounds in moist hedgerows and shady woods, usually flowering in May. The root, washed and dried, forms the *salep* of the older cookery books, and under the name of “Portland sago” was formerly used for adulterating arrowroot.

“It appears to have been highly esteemed by the older writers on medicine : it was used both externally and internally, and was considered invaluable in stimulating digestion and improving the circulation. Culpepper says, “a drachm of the powder of the dried root taken with twice as much sugar in the form of a licking electuary, or the green root, doth wonderfully help those that are pury and short-winded, as also those that have a cough : it breaketh, digesteth, and riddeth away phlegm from the stomach, chest, and lungs ; the milk wherein the root hath been boiled is effectual also for the same purpose . . . . Taken with sheep’s milk, it healeth the inward ulcers of the bowels : the distilled water thereof is effectual to all the purposes

\* British Med. Journ., May 7th, 1881.



aforesaid. A spoonful taken at a time healeth the itch : and an ounce or more taken at a time for some days together doth help the rupture." It was the active ingredient in the vaunted "Portland Powder," a so-called specific for gout. It is still occasionally sold in Paris as a cosmetic under the name of *Poudre de Cypre*. The London Pharmacopæia of 1788 orders a conserve in the proportion of half a pound of the fresh root to a pound and a half of double refined sugar, beat together in a mortar. The dose is a drachm for adults, and it is a good form for the exhibition of the medicine."

Regarding the employment of *Arum* in modern medical practice, there is a note by Wm. Martindale in the British Medical Journal of June 4th, 1881, which is worth recording. Martindale states, "it having been shown (Pharm. Jour. 1880, p. 849) that the active drug in the nostrum tonga was, in all probability, part of the stem of a species of *Raphidophora*, belonging to the natural order, *Araceæ*, the arum-juice was tried by a medical friend, in a case of obstinate neuralgia which was relieved by tonga; but the latter to the patient was an expensive medicine. The succus in one drachm doses gave similar relief, I was informed; further than this I have not known it tried."

Cases in which toxic symptoms ensued after the ingestion of arum leaves and tubers are found scattered in many works on Medical Jurisprudence, and also in certain medical journals.

In Beck's Medical Jurisprudence, *A. typhillum* and *A. trilobatum* are mentioned as being natives of the United States. Beck remarks that they are all acrid and have produced dangerous effects. Orfila\* gave the fresh roots of *A. maculatum* to dogs, and found that they died at the end of 24 to 36 hours without any other symptoms than dejection: after death the digestive canal was found somewhat inflamed. Marzel† also investigated the physiological action of the fresh root on dogs, and found that it acted as a powerful irritant poison. Bulliard‡ relates the following case of three children who had eaten the leaves of *A. maculatum*. They were seized with horrible convulsions, and with two of them all assistance was unavailing, as they could not be made to swallow anything. One child died at the expiration of twelve days, and the second four days later. The third child was saved with difficulty: its tongue was greatly swelled, and hence deglutition was painful and difficult. Christison§ states, "I have known acute burning pain of the mouth "and throat, pain of the stomach and vomiting, colic, and some diarr-

\* Orfila's Toxicology, vol. ii, p. 83.

† Marzel, B. Med. Gaz. 1881, p. 720.

‡ Histoire des Plantes Vénéneuses de la France.

§ Christison on Poisons, p. 602.



“ hœa occasioned by eating two leaves. The genus possesses the same  
 “ properties in other climates, the several species being classed among  
 “ the most potent acrid poisons in their respective regions. The  
 “ *A. sequinum* of the West Indies is so active, that two drachms of the  
 “ juice have been known to prove fatal in a few hours. It is not a  
 “ little remarkable that the acridity of the arum is lost not merely  
 “ by drying, but likewise by distillation. I have observed that when  
 “ the roots are distilled with a little water, neither the distilled water  
 “ nor the residue possesses acridity. Reinsch says, he has eaten powder  
 “ of arum root, which though not acrid to taste, produced severe burn-  
 “ ing of the throat not long after it was swallowed.” Guy and Ferrier\*  
 state that “ the root of *A. maculatum* is somewhat heart-shaped, and  
 “ like all other parts of the plant is highly acrid and irritating. The  
 “ juice applied to the tongue causes acute darting pain as if it were  
 “ pierced with sharp needles. The poisonous properties of the plant are  
 “ wholly dissipated by heat.” Woodman and Tidy† sum up the  
 symptoms of poisoning by *A. maculatum* as follows, “ Great local irrita-  
 tion, swelling of the tongue, convulsions, dilated pupils, insensibility  
 and coma”. Woodman and Tidy also refer to several cases of poisoning  
 by *A. maculatum*, of which we abstract the following. Dr. Russell  
 Stube‡ records a case in which a male æt. 43 took one leaf as a remedy  
 for tape-worm. The symptoms were immediate pain and pricking  
 sensation in the mouth downwards: the tongue became swollen: saliva-  
 tion and vomiting. The patient recovered. Dr. Frayer§ reports a case  
 of a male child æt. 6 who was found in a kind of fit, with spasmodic  
 action of all the muscles of the body, bloody froth at the mouth, pupils  
 dilated, heart’s action very feeble, rigid closure of the jaw. A certain  
 drowsiness succeeded. Recovery ensued. A second case is also reported  
 by Dr. Frayer|| of a male child æt. 8, in which the symptoms were  
 convulsions and widely dilated pupils. Recovery ensued. Dr. Frayer¶  
 quotes a case of a child æt. 3 who masticated the roots; the symptoms  
 were immediate burning pain in the mouth and lips, torpor in three  
 hours, followed by complete prostration in six hours with delirium and  
 asphyxia, and death in nine hours. Another fatal case is recorded in  
 the *Medical Times and Gazette* for June 6th, 1857, in which death ensued  
 from eating the leaves. Dr. Alliot\*\* gives the following account of a

\* Forensic Medicine

† A Handy Book of Forensic Medicine and Toxicology.

‡ “Lancet” April 13th, 1872.

§ British Med. Journal, Jan. 22nd, 1861.

|| Ibid: June 22nd 1861.

¶ Ibid: June 22nd 1861. Quoted from *Gazette Medica di Porto*.

\*\* British Med. Journal, April 23rd, 1881.



fatal case ; he states that on "Saturday, April 6th, I was called at 6.35 P. M. to attend a girl 4 years old. I attended at 7.15 A. M. and found her dead : the skin mottled all over, *rigor mortis* setting in and the body nearly cold. The history was that she came in from play at 3.30 P. M. on Friday, complaining of being tired. Her mother laid her down and she slept at once, at 5.30 she awoke and took some milk and tea : immediately she vomited some thin milky substance and went to bed, when she slept somewhat restlessly until 10.30 P. M. when she awoke with vomiting and severe purging : this continued with pain until 5 A. M. when she had a slight convulsion, and died at 5.30 A. M. A *post-mortem* examination was made 30 hours after death. *Rigor mortis* had nearly passed off. All the organs were healthy and normal, except that the bases of both lungs were congested. The heart was empty in both ventricles and firmly contracted. The stomach and small intestines were thickly coated with a creamy lining of mucus, with bile : no blood. The stomach further contained half an inch of the fatal leaf : there was also found about as much in one of the stools, and probably more was passed. This with the firmly contracted heart constituted the chief confirmatory evidence of the irritant nature of the poison which caused death."—Chevers,\* quoting from a note by Dr. H. Cleghorn, states, "There are several species of arum requiring examination, of a suspicious, if not of a poisonous nature. On one occasion five Mysore villagers were poisoned by partaking of the acrid rhizomes of an arum, imperfect specimens of which I sent to Dr. Wright for identification, but he could not distinguish the species. If the roots had been boiled, the fatal results would not have occurred, as is well-known, the deleterious property is easily driven off by heat." Dr. Chevers refers to two other cases, one in which a man obtained from a drug dealer a remedy for gonorrhœa, which appeared to have been a root of one of the *Aroideæ* ; fatal results ensued.

In 1886 the Civil Surgeon of Dibrugarh forwarded to the Chemical Examiner, Bengal, some portions of raw Bish Kachu tubers and leaves with the following statement. "A cooly woman administered some of the fried Kachu to another sick cooly on the same garden, but the man experiencing a burning sensation in his mouth instantly spat it out. A pig ate what was so thrown away and died in an hour. A second pig was experimented on with some of the same stuff, and fatal results also supervened." During the course of the same year a second case of poisoning by Kachu was referred to the Chemical Examiner's Department ; in this case slices of Kachu tubers were introduced into a jar containing "goor." The symptoms induced were sufficiently urgent to

\* A Manual of Medical Jurisprudence for India.



necessitate admission of the person into the Medical College Hospital ; the stomach-pump was used as the symptoms were those of irritant poisoning. Recovery ensued.

The European *A. maculatum* has been analyzed by Bucholy and Enz, and the American variety by D. S. Jones. According to the editors of the National Dispensatory, Jones proved the presence of starch, sugar, gum, albumen, resin, fat, and extractives, besides the volatile acrid principle, which is soluble in ether. Enz in 1858 obtained also saponin, "while Bird believes that a volatile alkaloid may be present."

The tubers employed by us in our experiments were kindly supplied by the Civil Surgeon of Dibrugarh, and were of the variety known locally as Bish Kachu and similar to those used in the case which he had referred to the Chemical Examiner. We made over a tuber to Dr. King, F. R. S., Superintendent of the Royal Botanic Gardens, Calcutta, for identification. Dr. King informs us that it is most probably a species of *Alocasia* or *Colocasia*. But the leaves of the species of these genera are so much alike that it is impossible to identify them without flowers.

In our experiments the tubers were first peeled ; during this operation, considerable irritation was experienced about the hands, but there was a complete absence of any irritative action on the olfactory organs or conjunctivæ. This fact appeared to us to point towards the non-volatile nature of the active principle. In a preliminary experiment we tried the effect of an injection of a portion of a tuber into a cat's stomach ; 8 grammes of a peeled and fresh tuber were rubbed down with about 15 c. c. of water and the mixture strained through muslin. The turbid fluid thus obtained was injected into a small healthy cat's stomach at 1.8 P. M. ; at 1.22 P. M. the cat was a little restless, but this soon passed off, and, as far as we were able to ascertain, no ill-effects subsequently ensued as a result of the injection. There was no question about the activity of the sample used in this experiment, because a minute fragment applied to the tip of the tongue caused in a very short time acute lancinating pain, which continued for a considerable period.

In order to obtain an alcoholic extract, the peeled and sliced tubers were strung on wire and exposed to the air to dry. The dried slices were then easily reduced to powder. The powder was packed in a percolator, and exhausted with hot 60 O. P. alcohol. The alcohol having been driven off by the heat of a water-bath, the viscid extract remaining was examined as follows. A portion was mixed with bread and given to a mouse without any effect. A large portion of the extract was treated by Stas's process for the extraction of alkaloids, and the ethereal extract given to a mouse with negative results. In these experiments we observed that, while the fresh tubers caused a marked physiological action when



applied to the mucous membrane of the lips or tongue, the dried tubers were practically inert. The alcoholic extract, as well as the extract obtained by Stas's process, were without the least action on the tongue. We also tried the effect of an extract obtained by cold alcohol, and in which the alcohol had been driven off by spontaneous evaporation, on a mouse without producing any symptoms. This extract was also without physiological action on the tongue. A glycerin and an ethereal extract, prepared by macerating the fresh tubers in the cold with those menstrua, also yielded negative results.

We now tried the effect of distilling the fresh tubers with water. The distillate had no acrid taste: it contained only traces of hydrocyanic acid. The symptoms produced by the introduction of the commoner varieties of arum tubers into the stomach cannot be explained by the presence of hydrocyanic acid. The production of hydrocyanic acid on the distillation of organic vegetable matter with water is by no means rare: ordinary linseed meal indeed yields traces of that acid on distillation with water. It is possible, however, that certain varieties of arum may contain a large amount of prussic acid, as for example the *A. seguinum* of the West Indies, which is stated to furnish a juice, two drachms of which has proved fatal in a few hours.\* The tubers left in the retort after distillation with water were still physiologically active, indicating that the active principle was not dissipated by mere boiling with water. Natives in using arum for culinary purposes frequently add an acid vegetable, or fruit, such as tamarind. We tried the action of certain acids on the fresh tubers, and ascertained that boiling with water acidulated with hydrochloric acid for a very short period rendered the tubers quite inert, when a fragment was applied to the tongue. Dilute nitric acid also acted in a similar manner. The action of acetic acid on the other hand was very much feebler, and the acid had to be stronger in order to produce any decided diminution in activity. So far, our experiments had been in the highest degree unsatisfactory; as far as we were able to judge from the evidence at our disposal, there could be no reason to doubt that the arums as a family did contain a principle capable of inducing toxic symptoms when introduced into the system. Most of the works we had consulted ascribed the poisonous effects to a volatile principle. Our experiments indicated that, while drying the tubers without artificial heat deprived them practically of all activity, exposing them to the temperature of boiling water for at least half an hour at the most only very slightly diminished their activity. As far as we were aware, there was no toxic principle known which exhibited similar reactions with reagents. We again tried the effect of the fresh tubers

\* Woodman and Tidy's "Forensic Medicine."



and leaves (which we also proved to be highly active when applied to the tongue) on a pig, a rabbit, and a guinea-pig, but with negative results. Although we took the precaution to starve these animals before giving them the leaves and tubers, there is a considerable doubt in our minds whether the rabbit and guinea-pig ever ate any of the arum; the pig certainly did eat a small portion of a leaf, but, although it must have been very hungry, it refused a mess of chopped tubers, bran, and sugar. There is thus in these experiments some uncertainty. We were particularly anxious to try the effect of the fresh tubers on a pig, because we had the very circumstantial note from the Civil Surgeon of Dibrugarh, in which it is stated that two pigs had been killed by eating some of the same tubers as those with which we had experimented.

A rough analysis of the ash indicated the presence of a large amount of potassium and magnesium; calcium was also present, but we failed to obtain indications of sodium. The acids consisted of carbonic, phosphoric, and hydrochloric, with traces of sulphuric acid. We also obtained from the dried tubers very marked quantities of potassic nitrate, so that when they had been incinerated they behaved very like tinder, containing salt-petre. The examination of the ash thus failed to afford us any clue to the physiological action of the fresh tubers.

It now occurred to us that possibly the painful effects produced by arum when in contact with the tongue &c. might be due to mechanical causes. A microscopic examination of a section of a tuber revealed the presence of very numerous bundles of needle-shaped crystals; and we also found similar crystals in the leaves and stems. These crystals were seen under the microscope to be insoluble in cold acetic acid, but easily soluble in cold diluted nitric or hydrochloric acid. Caustic potash was without action. A tuber was boiled, and sections made when cold; on microscopic examination crystalline bundles were still visible. The presence of raphides in the cells of plants is well known; even in the arum they have been before observed. Dymock mentions needle-shaped crystals in the parenchyma of the *A. sylvaticum*; and in the nettle tribe stalked crystalolithes have been described suspended in the cells. But, as far as we are aware, the significance of these needle-shaped crystals in the arum has not hitherto been recognized. There appears to us to be no reason to doubt the fact, that the whole of the physiological symptoms caused by arums are due to these needle-shaped crystals of oxalate of lime, and that the symptoms are thus due to purely mechanical causes. Bearing in mind the action of reagents on calcic oxalate, the reason why mere boiling the tubers in water failed to deprive them of their activity is explained by the insolubility of oxalate of lime in water. Again, the action of dilute acetic acid, even at a temperature of 100° C., in slightly



lessening the activity of the tubers is due to the very slight solubility of oxalate of lime in that acid. And, lastly, the complete loss of all physiological action when the tubers were treated with dilute nitric or hydrochloric acid is evidently due to the ready solubility of calcic oxalate in those mineral acids. And these assumptions, as we have already indicated, were fully demonstrated by the microscopic examination of sections of the tubers treated with the reagents we have mentioned. One point, however, remains to be explained. We observed that, on drying, the tubers lost practically the whole of their physiological activity. Clearly there could have been no loss of oxalate of lime on desiccation, and as a matter of fact we found as many crystals on microscopic examination of dried arum as we had found in the fresh tubers. We explain this apparent anomaly in the following simple manner. In the fresh condition of the tubers, the bundles of crystals of oxalate of lime are cone-shaped, more or less, the sharp points covering a wide area, and forming the base, but, in the drying of the tubers, the needles appear to arrange themselves more or less parallel to one another, and the sharp points thus cover a smaller area. And thus, instead of each crystal acting as a separate source of irritation and penetrating the tissues, the bundles act as a whole. It is well-known that finely chopped hair when given with food will cause death by setting up uncontrollable diarrhoea. The hairs covering the legumes of the *Mucuna pruriens* (cowage) are described as straight, quadrangular prismatic, and sharply pointed at the apex, 3 mm. long, and thus easily penetrate the skin, causing intolerable itching, which is greatly increased by washing and rubbing. Cowage, as is well known, has long been used as a vermifuge, under the idea that its prickly setæ, which irritate the skin so severely and are so difficult to detach, wound and injure the worms, and either kill them or promote their expulsion.\* Apparently with a similar object *A. tortuosum* is used to kill worms which infest cattle during the rains. Lastly, we have an example of finely divided mineral matter causing local irritation, in the so-called hill diarrhoea at Dhurmsala, which is apparently produced by the use of water containing very fine scales of mica.†

The usual symptoms produced by arum when administered to the human subject are great local irritation, swelling of the tongue, convulsions, dilated pupils, insensibility, and coma.‡ With these symptoms it might be argued that a mechanical theory for the action of arum would be untenable. It might be conceded that local irritation of the mouth would be produced by arum; but objected that, directly the vegetable entered

\* National Dispensatory.

† Macnamara's 8th Report on Potable Waters in Bengal, Appendix, p. 44.

‡ Woodman and Tidy's Toxicology.



the stomach, it would be acted upon by the gastric juice containing free hydrochloric acid,—and that acid, as is well-known, is a ready solvent for calcic oxalate,—so that, before the vegetable matter containing the needle-shaped crystals could enter the intestine, it would have lost its mechanical irritative properties. In answer to this we would merely remark, that, when mechanical irritation of the stomach is carried beyond certain limits, so as to produce pain, the secretion of the gastric juice, instead of becoming more abundant, diminishes or ceases entirely, and a ropy mucus is poured out instead.\* And it also appears likely to us that the great irritation produced in the mouth would react upon the stomach; for, according to experiments by M. Blondlot, the quantity of the secretion seems to be influenced also by impressions made on the mouth.† We thus fail to see any reason why the arum tissues loaded with needle-shaped crystals should not enter the intestines. Once in the intestines, the mechanical effects of the crystals would be to induce convulsions, dilated pupils, and coma; all of which symptoms are often caused by the mechanical irritation of intestinal worms.

This theory of the mechanical action of the arums, which we advanced in 1886, has since, apparently, been independently adopted by Herr Stāhl, who, at a recent meeting of the Jena Naturalists' Society, read a paper on the significance of those excreta of plants which are known as raphides, and are so often met with in the cells in large quantity. From experiments this investigator inferred that they were a protection to plants against being eaten by animals. Many animals avoid plants with raphides, or eat them reluctantly; and some animals, *e. g.*, snail species, in eating plants that have raphides, select those parts that are without the crystals. Many plants held for poisonous, *e. g.*, *Arum maculatum*, owe their burning taste simply to the very numerous raphides, which, forced out of their cells, enter the tongue and palate. The juice obtained by filtration has quite a mild taste.‡

\* Kirke's Physiology.

† *Ibid.*

‡ "Nature," Dec. 29th, 1887.

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