A STUDY OF THE DIAGNOSTIC CRITERIA RELATIVE TO THE IDENTIFICATION OF SEEDS OF PLANTS IMPORTANT IN PHARMACY WITH SPECIAL REFERENCE TO MEMBERS OF THE FAMILY APOCYNACEAE.

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INTRODUCTION.

The history of world exploration, more especially that pertaining to the opening up of tropical lands, contains many references to plants potent for good or for evil to human or animal welfare. For example there are those poisonous plant extracts used by savage tribes to put on arrow tips as an aid in hunting and in war. Again there are the fish poisons of the East. Examples could be multiplied. Often, the organic principles which these plant extracts contain, have taken on, in the hands of Western pharmacology, a beneficient role and so entered into the armamentarium of curative medicine.

Many of these materials come to our shores in a crude state, as for example, curare from South America, in the form of a native-produced extract. Others appear as seeds or other plant parts collected mainly from the wild. Thus, commonly, the supplies are variable in character and each consignment has to be checked for authenticity and chemical potency. Very often, closely related species are substituted one for the other; each supplying principles alike in general character but significantly different in use in Pharmacy. In such cases adulterants, substitutes, and accidental admixtures must be guarded against when the manufacture of a particular remedy is in view.

A very pointed example of this is provided

by /

by members of the Family Apocynaceae, especially those of the genus Strophanthus. The seeds of many species of this genus are known to contain toxic glycosides some of which have been employed in medicine for well over half a century. Much research has been performed on the compounds concerned but the literature regarding them is full of anomalies. This in many cases is undoubtedly due to uncertainty or inaccuracy in the identification of the species involved in particular cases. One of the best examples of this occurred in the early researches on the glycoside sarmentogenin which was first isolated by Jacobs and Heidelburger in 1929. At the time when the work was published no particular importance was attached to it; it merely revealed another new glycoside. Unfortunately no sample of the seeds used for the original extraction was retained. In more recent years sarmentogenin has come into increased prominence as an intermediate in the synthesis of cortisone. In this latter connection it soon became apparent that some samples of allegedly the same species gave very little sarmentogenin and others none at all. The kind of position thus disclosed has been seen, though perhaps not so pointedly, in other cases. Indeed to-day seeds of many members of the Family Apocynaceae already established in the Pharmacopoeias of the world as official drugs or as sources of official extracts have not yet been examined with sufficient exactitude as to enable precise identification /

identification to be made. The seeds of many species have not even been examined critically.

The chief interest, then, of the present report centres on the seeds of the genus Strophanthus, but before embarking on a detailed description of the features of the various seeds it will be appropriate first to define the Family as a unit and suggest its natural relationships.

The Family Apocynaceae, a member of the Contortae and closely allied to the Asclepiadaceae, is large and reported by Macfarlane (1933) to contain about 135 genera and 1750 species. These are widely distributed over the world, mostly in tropical or sub-tropical areas, and are particularly abundant in tropical Africa and tropical America. The plants are usually climbing and twining shrubs but the habit shown by specimens of the same species tends to differ according to the supply of light in the place of growth. Thus the same species may be met with either as a bush in some circumstances or as a large liane under other conditions. This plasticity is well seen when plants found growing at the sunny border of the forest are compared with those developed under the deep shade within. In the former situation they are twiggy bushes, from which the collection of fruits is a very easy matter, while in the latter they become lianes which flower up above the canopy of the foliage of giant trees, which may exceed 150 feet in height.

Leaving these fluctuations aside, the fundamental /

fundamental characters of the Family may be listed:-

The habit is variable and may be shrubby or sub-arborescent — rarely condensing into suffruticose or even herbaceous, and there is frequent development of shrubby, twining stems or branches. Long simple latex tubes ramify in root and stem and continue out into the leaves. The latex, in some cases, is used as a source of rubber.

The leaves are commonly simple, arranged opposite or, more rarely, alternate or 3-, 4-nately whorled; each leaf with or without stipular lines, scales or other appendages.

The terminal or axillary inflorescence is cymose and bears regular pentamerous flowers.

The gamosepalous calyx, in the more primitive genera, is devoid of basal internal glands but in the higher genera these appear in increasing numbers and complexity.

The gamopetalous corolla varies widely in size according to species and is salver, campanulate, funnel, or urceolate in shape, with a shallow to elongate tube that is usually devoid of ridges, scales, or teeth, but in some of the higher genera may gradually produce these internally in a sub-oral or oral position. The petaline colour varies, with transitions from greenish-yellow or greenish-white to yellow or from white to pink, crimson, or purple (rarely blue) colourations.

The five epipetalous stamens, inserted at varying /

varying levels from the base to the throat of the corolla, are constructed of elongated to short almost absorbed filaments and anthers that show striking evolutionary advances. For example, these bodies may show simple, paired, often blunt anther lobes with free basal swellings (as in the simplest division of Plumeroideae) to anthers with acuminate and often connate apices (which surround the stigma) as well as attenuate polliniferous basal tails or lobes which dehisce throughout their entire length, as in the simpler genera of Tabernaemontanoideae. Others again show, as in the higher genera of Tabernaemontanoideae, acuminate anther-apices which become fused to some extent with the substigma while the basal tails become barren (often horny and deflexed) processes. The most advanced form, found in the group Echitoideae, show connate anther-apices and also a plate of connective tissue between the basal tails which often fuse intimately with the swollen and frequently five-lobed stigma to form a composite mass on top of which the bilobed stigma may persist or be more or less absorbed. This disc or receptacular nectary is of great interest and taxonomic importance and attains its most varied forms, largest size, and variable relation in the Echitoideae.

The superior ovary (rarely semi-inferior as in Plumeira) is most commonly bi-carpellary but in a few species of Pleiocarpa there is an increase to 3 - 5 while in the derivative genera Notonerium and Lepinia the carpels are usually four. These whole carpels /

carpels are usually separate in the ovarian and lower stylar portions but fuse above and often enlarge into what may be called a sub-stigma on top of which is the bifid stigma. In some species this last may become functionless or even absorbed, and in such cases its function is assumed by five viscid areas of the sub-stigma. In some genera of Carisseae (Clitandra spp., Landolphia, Carpodinus, etc.) the carpels have become syncarpous so that the ovary is one-celled with parietal placentation and the fruit is a bicarpellate berry. In others (Carissa, Acokanthera) and also in some species of Peschiera or Tabernaemontana as well as in the derivative genus Allamanda, the two carpels partially or completely fuse and the fruit is a two-celled berry, or, as in Allamanda, a one-celled echinate capsule. Again, in Rauwolfia, the fruit is drupaceous and may be of large size.

The ovules, which are generally anatropous, are numerous and appear bi- to multi-seriate along the ventral suture of each carpel but may become few to one in each carpel as in many Carisseae and Rauwolfiae.

The seeds are ovoid (often compressed) and winged or hairy. Hairs may be borne all over the surface of the seed while plumose tufts of longer hairs are seen basally or apically. The seed-coats or testa may vary in texture from membranous or fleshy to fibrous or coriaceous with or without projections on the internal surface grown into the endosperm.

The endosperm is sometimes abundant and then varies in different species from soft and fleshy to hard and /

and horny. It may be uniform or ruminate. Occasionally the endosperm may become largely or wholly absorbed.

The straight embryo has flat or rolled cotyledons with superior radicle. The fruit, in simpler cases, consists of two separate follicles but in more advanced types firm, dry, one-seeded indehiscent mericarps, or by modification towards succulence and increase in number, 2 - 5 berries; rarely they are hardened and then break into one-seeded mericarps.

The subfamily Echitoideae contains the most highly evolved forms and is the richest in genera and species. It shows the largest and most showy flowers and has highly efficient means for wide dissemination of the seeds. In contrast to the other and less highly evolved groups, it includes almost wholly lianoid climbing shrubs or sub-shrubs with stems that are often of great length and vigour; only a few species are upright shrubs or trees or are upright or trailing suffruticose plants or even herbs. The corolla varies from small to medium to large and attractive; the staminal filaments are usually very short, the anthers are acute and closely connate into a mass at a level either surrounding or above the substigma and stigma; the anther-lobes are obliquely divergent towards their bases and are polliniferous only in the upper half or third while the lower portions are barren and prolonged into down-directed, often hairy, tails between which the connective may be broadly /

broadly expanded and provided with one or more hairy patches. The substigma usually is enlarged, five-grooved, and exudes a viscous secretion which agglutinates it to the connective plates or other parts of the stamens. The bi-follicular fruits, when mature, contain many, flattened, elongated, seeds which are diffusely hairy or have a plumose terminal tuft at one or both ends.

This subfamily contains 46 - 50 genera and about 810 species: of these nearly 410 are South American and fully three-quarters of that number are native in the region extending from East Brazil to the West Indies, while about 30 are found in Mexico and pass northward into the States; upwards of 90 are West African, fully 75 extend from Central to East and South East Africa; about 120 are tropical sub-tropical Asiatic, while 28 are Australo-Pacific. However, none of the most highly evolved genera reach Australia. This latter fact is often taken to indicate that complete separation of the Asiatic from the Australo-Pacific land areas had already been effected prior to their commencing evolution and segregation from the older Asiatic types.

The genus Strophanthus, to which what is to follow pertains, was erected by Pyramus de Candolle in 1802 who at that time knew of only four species. The generic name is derived from the Greek and refers to the long tails of the corolla lobes which are twisted in the bud, a feature common to almost all the 50 or more species known to date.

The genus may be described as follows:-

plants /

plants woody, mostly climbing; sometimes erect shrubs or small trees. Climbers often erect or sub-erect in the lack of support, particularly when young; can be trained to be either vines or bushy erect plants. Some species (e.g. Strophanthus hispidus P.DC.) climb 80 feet or more to the tops of trees and have stems several inches in diameter; Strophanthus Emini Aschers and Strophanthus mirabilis Gilg are greatly branched bushes; Strophanthus Welwitchschii Schumann and other species are sometimes ground creepers. Stems sometimes corky-winged; branches mostly spotted with lenticels. Latex present or absent.

Leaves short-petioled, opposite, rarely 3- or 4-whorled (as in Strophanthus speciosus Reber), entire. In different species they differ greatly in shape, venation, texture, and other details. Entirely glabrous, or puberulous, or hispid with long bristles, or may be thickly woolly superficially like the leaves of Verbascum Thapsus. Develop mostly after flowering has begun, but exceptions to this are not rare.

Inflorescence terminal; cymes 1 - 3 branched, many or few flowered; sometimes, particularly in species with large flowers, reduced to a single flower. Bracts, like the calyces, differ greatly in shape, size, and texture in the various species; they may be very small or very large, narrowly linear of broadly-leafy; they are entirely deciduous.

Sepals five, almost free to the very base, little or greatly imbricate depending on their width, sometimes spreading or reflexed when the flowers are mature. /

mature. Glandular at base within; glands 5 - 20, scale-like or lobular, differing greatly in size.

Corolla with cylindrical tube, flaring at the upper part, often showy, white or yellow to reddish or purple, the different parts of the corolla — tube, lobes, and scales — often of different shades and colours. Corolla lobes 5, the expanded part mostly broadly ovate, rarely narrow; tip rounded in Strophanthus gratus (Wall & Hook) Franchet or rarely merely pointed, but mostly long-tailed, the tails two or three times as long as the corolla-tube and linear, or remarkably elongated and thread-like, sometimes over one foot long and dangling from the canopy. Scales 10 (except in Strophanthus Jackianus Wall), free to the base or partly united, small and inconspicuous or large (as in Strophanthus Tholloni Franchet and Strophanthus gratus), included within the tube or exserted far out.

Stamens 5, inserted in the ampliate part of the corolla-tube. Filaments very short. Anthers arrow-shaped, longitudinally dehiscent, with pollen in the upper and lower parts; tips of the anthers sometimes merely inconspicuously short-apiculate; often the connectives at the apex are elongated into lanceolate points 2 - 3 times the length of the fertile part of the anthers and forming a cone over the stigma.

Carpels 2, on a slightly concave receptacle; often half inferior, glabrous or hairy; united at the apex just below the style. Ovules numerous. Style long-filiform. Clavuncle cylindrical, 5 - 10 flabellate-crested. /

late-crested. Stigmas of two short apiculi.

Follicles 2, ventrally dehiscent; various in shape and size, sometimes over one foot long, either narrow or up to four inches in diameter. These fruits ripen long after the flowering period; they may be situated at the lower part of the plant or high up. Species vary in the number of fruits per plant; Strophanthus hispidus P.DC. and Strophanthus sarmentosus P.DC. may have 10 to 20 fruits to each individual.

Seeds very numerous, spindle-shaped, occasionally lanceolate or almost oval, roughly about half an inch in length but differing in shape and size in different species; densely hairy to glabrous, grey to deep brown. Awn up to four inches long, with a thick plume of hygroscopic hairs towards the apex. Embryo of two fleshy cotyledons with a club-shaped or cylindrical radicle.

General Distribution of the Genus Strophanthus.

According to Monachino (1950) the genus has a natural distribution only in Africa and Asia. In Africa it is found throughout the whole continent south of roughly 15° N, in forests, savannas, and steppes. It reaches its greatest diversity in the equatorial areas of Central Africa. Staner and Michotte (1934) enumerate 18 species for the Congo and other distributions are given by Hutchison and Dalziel (1931) /

(1931) and by Stapf (1909). Only one species, Strophanthus speciosus Reber (S. capensis A.DC.), reaches the Cape. Omitting Arabia and Persia the genus is found in Southern India (Hooker 1882). Strophanthus Wallichii A.DC. is reported as frequent in the Mals of Orissa (Haines 1925) and has been collected in the Andaman Islands. Strophanthus Wightianus Wall has been reported from several districts in Travancore (Rama 1914) but the genus does not appear to have been reported from Ceylon.

The Malay area has several species (Ridley 1923). French Indo-China (Pitard 1933 quoted from Monachino 1950), Hainan, and the coastal areas of Southern China (Tsiang 1934 quoted from Monachino 1950) are within the distribution of the genus.

The genus reaches the Netherlands Indies and one species, Strophanthus caudatus Kurtz is reported from Java (Koorders 1912 quoted from Monachino 1950).

Taxonomically, the genus has been fairly well covered and at the present time Monachino (private communication 1952) is engaged in monographic studies in the course of which he has obtained on loan over 2000 herbarium sheets from 25 herbaria.

Members of the Genus in Pharmaceutical Use.

Although, as referred to earlier, extracts of /

of a number of Apocynaceous plants have been used probably for hundreds of years, only a limited number have found extensive employment in medicine and inclusion in any of the Pharmacopoeias. From a pharmaceutical point of view, the greatest interest centres around the glycosides and alkaloids which many of the species are known to contain and in this connection those from members of the genus Strophanthus have gained the greatest prominence. The seeds of many species of this genus are known to contain glycosides to which the general term strophanthin is loosely applied but since the principles obtained from the various species differ in their molecular structure and in their potency, the term is almost meaningless unless the source is specified. It has become accepted chemical practice to prefix the first letter of the species to the term strophanthin. Thus from Strophanthus Kombé Oliver — k-strophanthin; from Strophanthus hispidus P. DC. — h-strophanthin; from Strophanthus Emini Aschers — e-strophanthin.

The only species recognised by the British Pharmacopoeia 1948 for the preparation of the official tincture is Strophanthus Kombé. This plant became known to Europeans about 1861 when Livingstone described its use as an arrow poison by the tribes of the Shire River near Mozambique in East Africa. According to his account, the poison was known to the natives as Kombi. Later seeds of the plant from which this poison was prepared were examined by Oliver and /

and found to be those of a new species not previously described; he named it Kombe. However, though this is the only species recognised by the British Pharmacopoeia, the seeds of Strophanthus gratus (Wall & Hook) Franchet and the wood of Acokanthera schimperi (A.DC.) Schwinf. are admitted as sources of the glycoside ouabain or g-strophanthin which, in addition to being used in medicine on its own merits, is also employed as a standard when making a biological determination of the potency of extracts of the seeds of Strophanthus Kombe. This procedure is adopted because g-strophanthin is a single substance whereas k-strophanthin has been shown to be a somewhat variable mixture of glycosides.

The United States Pharmacopoeia recognises both Strophanthus Kombe and Strophanthus gratus. The French Pharmacopoeia admits Strophanthus hispidus, Strophanthus gratus and Strophanthus Kombe. No preparations of Strophanthus are included in the current (first) volume of the new International Pharmacopoeia but a monograph appears therein on ouabain or g-strophanthin, the permitted sources of which are as stated in the British Pharmacopoeia plus the wood of Acokanthera Ouabaio Arnaud.

The inclusion, in the British Pharmacopoeia, of species other than those mentioned has been suggested. Amongst those considered are Strophanthus Emini Aschers, an examination of which, from various points of view was carried out by a number of workers in the early 1930's. This examination was prompted by a desire /

desire to utilise this Empire product, large quantities of which could be obtained from plants growing in Tanganyika Territory.

The genus Strophanthus also came into great prominence in recent years when the glycoside termed sarmentogenin was found to be a useful starting point for the synthesis of cortisone.

Summary of Present-Day Knowledge of the Seeds of Strophanthus.

The morphology and anatomy of the seeds of Strophanthus which are official are described in the current standard works on Pharmacognosy together with details of their colour reactions with sulphuric acid, and the occurrence of calcium oxalate crystals in the tissues. Little detailed botanical work has, however, been done on other interesting species of which many are now known and these may easily become highly important; indeed many species do not appear to have been examined at all.

Probably the most valuable contributions to knowledge on this subject which have been published within the last twenty five years are those of Mathiesen, Wagenaar, Youngken & Simonian, and Smelt.

In 1927 and 1928 Mathiesen carried out an investigation of Strophanthus, the objects of which were:- (a) to check details of anatomical structure and colour reactions reported by previous workers and to find some diagnostic characters for the evaluation of commercial seed; (b) to record the species of Strophanthus /

Strophanthus then occurring in commerce; (c) to review the composition of typical commercial samples. In all, Mathiesen included some fourteen species in his studies but in testing for colour reactions he confined himself to the use of 80% sulphuric acid. In this latter work he placed a moderately thick section of the seed under consideration on a microscope slide, added a drop of the acid and immediately observed the course of the reaction by transmitted daylight at a magnification of 40 diameters. By this procedure he claimed that the colour changes throughout the course of the reaction could be accurately observed and were of great specific value. He found that the reaction varied in different parts of a particular seed both as to the colour developed, and its intensity: these were often indefinite, only a yellow tinge resulting. He concluded from this that in such specimens the glycoside had decomposed. He also reported that the vascular bundles of the cotyledons were stained red in all the species examined.

In connection with the anatomy of the seed Mathiesen considered that the calcium oxalate crystals found in the seed-coats formed one of the most useful diagnostic features. To observe these he advocated removing the seed-coat, clearing it by warming in chloral hydrate solution and examining under the microscope. He reported that (a) crystals were entirely absent from Strophanthus gratus, Strophanthus Tholloni, Strophanthus Welwitschii, Strophanthus Nicholsoni, and Strophanthus Emini; (b) there was some uncertainty regarding Strophanthus Kombé where the /

the crystals were always small and varied in different samples; (c) frequent crystals were seen in Strophanthus Barteri, Strophanthus Arnoldianus, Strophanthus grandiflorus, Strophanthus amboensis, Strophanthus hispidus, and Strophanthus Schuchardtii; (d) Strophanthus Courmontii and Strophanthus sarmentosus are by far the richest in crystals and in all cases part of the crystal content took the form of large prisms belonging to the monoclinic system and were present as single crystals, twin-crystals, cluster crystals, and conglomerates; here and there throughout the tissues cells occurred containing a number of very small crystals as well as one or more large single or twinned prisms. Only in Strophanthus sarmentosus did crystals occur in the embryo. The crystals reported by Hartwich (1892) in Strophanthus Emini were not found by Mathiesen.

Finally Mathiesen reviewed the composition of samples of typical commercial consignments. In all, he examined sixty seven of these, approximately half of which bore dates of collection ranging from 1907 to 1925 while the remainder were dated 1926-27. He stated "Strophanthus always was, and still is, one of the drugs not easily obtained pure. There is not much general improvements in the purity of commercial specimens. Strophanthus hispidus can no longer be found unadulterated in commerce; samples consist entirely or in greater proportion of Strophanthus sarmentosus: Strophanthus Kombe is much mixed with Strophanthus Courmontii. Specimens of Strophanthus gratus are always pure."

Wagenaar /

Wagenaar (1932) published the result of some work on the genus Strophanthus which included a modification of the sulphuric acid test as used by Mathiesen. He diluted the concentrated acid with one-third of its volume of glycerol and reported that the characteristic colours developed more slowly, were stronger, and remained more localised in the original cells than when the glycerol was omitted. He also claimed that the colours first appeared in the endosperm and agreed with Mathiesen that the procambial strands were always stained red by this reagent.

Smelt (1933) published some work which primarily had been undertaken to determine whether the seeds of Strophanthus Emini were suitable for inclusion in the British Pharmacopoeia. His article is of particular interest because he extended the number of reagents employed for the colour reactions to fourteen though the tests were applied to only a small number of species. Of this large number of reagents Smelt concluded that only four had any value for diagnostic purposes. These were:-

(a) Sulphuric acid,

(b) Solution of phenol in concentrated hydrochloric acid,

(c) Solution of furfuraldehyde in sulphuric acid, and

(d) Solution of resorcinol in concentrated hydrochloric acid.

In these tests Smelt employed alcoholic extracts /

extracts of the seeds in addition to sections of the seeds themselves and concluded that the former gave the more definite colours.

This procedure of Smelt in employing alcoholic extracts does, of course, require much larger quantities of material than are necessary when the reagents are applied to the seed-sections, but if thought desirable it might be possible to develop a "micro" technique suitable for a very small number of seeds.

The most recent addition to the literature which makes any attempt to add to knowledge of the botanical aspect of the problem is that by Youngken and Simonian (1950). This contribution deals mainly with Strophanthus sarmentosus and provides details which it is claimed make possible the distinction of this seed from those of related species. It is by no means certain, however, that the paper provides sufficient information for this purpose because, as will be shown later, with authenticated material different samples give somewhat different results.

The present position, then, may be summarised in the following manner:-

(a) The identity of the seeds which originally yielded sarmentogenin is by no means certain because Jacobs and Heidelberger (1929) who first isolated this glycoside did not retain a sample of the original material used for the extraction and subsequent samples of allegedly genuine Strophanthus sarmentosus either did not yield sarmentogenin or yielded it in amounts much less than those stated /

stated in the original report;

(b) The confusion as to the identity of the various samples of Strophanthus seed is not new. Ever since products from members of this genus were suggested by Livingstone as having a cardiac action, various other workers have attempted to classify and establish the various types found in commerce;

(c) Commercial samples of Strophanthus seeds are rarely pure in the botanical sense and insufficient data is available to enable many of the component species to be identified. This difficulty is accentuated because while some species differ in their external characters others present a very marked similarity in shape, colour, and size. This similarity extends to the seeds of species from some related genera, of which at least one (Funtumia) has been reported as occurring in commercial samples of Strophanthus seed.

To assist in overcoming these difficulties and permitting of easier identification, it has been suggested that Strophanthus seeds should be imported in their original follicles. This would not appear to provide any further guarantee of authenticity of the seeds as no dependable data exists regarding the characters of the fruits of the various species. Not only /

only so, the fruits vary morphologically, differing on plants of the same species when grown under different ecological conditions. Furthermore, importation of fruits would not be welcomed in commerce because such a procedure would result in a very large increase in costs of freight and subsequent handling.

In the light of these lacunae in our knowledge and the desire for facts of practical value, the work to be reported here deals with those features of the seed of those members of the genus Strophanthus likely to appear in any guise in the pharmaceutical business in Great Britain.

Material and Methods.

In the procurement of material for the work envisaged it was essential that every specimen should be authentic and as much as possible known of its previous history, place of collection etc. This placed a considerable restriction on sources of supply, many otherwise satisfactory samples having to be rejected or refused on the grounds of insufficiency of data. Nevertheless a representative range of material was assembled and a list of the various items is given below.

From /

From The Regius Keeper, Royal Botanic Garden, Edinburgh.

Specimen No.	Species	Geographical Origin	Nature of Sample
S 30	Strophanthus divaricatus Wall	China	two dehiscing follicles.
S 31	Strophanthus hispidus P.DC.	Northern Nigeria	intact and dehiscing follicle
S 38	Strophanthus sarmentosus P.DC.	Africa	seeds with awns present.
S 41	Strophanthus Kombe Oliver	West Africa	intact and dehiscing follicle

From The Director, National Institute for Medical Research, Hampstead, London.

Specimen No.	Species	Geographical Origin	Nature of Sample
S 10	Strophanthus mirabilis Gilg	Kenya	seeds devoid of awns.
S 11	Strophanthus Courmontii Sacleux	Africa	seeds devoid of awns.
S 12	Strophanthus Courmontii Sacleux	Mlanje District, Nyasaland	seeds devoid of awns.
S 13	Strophanthus Petersianus Klotzsch	Shire Valley, Nyasaland	seeds devoid of awns.
S 14	Strophanthus amboensis Engl. & Pax	Angola, Luanda	seeds devoid of awns.
S 15	Strophanthus Barteri Franchet	near Ibadan, S. Nigeria	seeds devoid of awns but a few have part of awn-pedicel present.
S 16	Strophanthus Nicholsoni Holmes	Central Africa	seeds devoid of awns.

From Joseph Monachino, Esq., Botanical Garden, New York.

Specimen No.	Species	Geographical Origin	Nature of Sample
S 44	Strophanthus sarmentosus P.DC.	Walkowiak, Togo	seeds devoid of awns.

S 45 /

S 45	Strophanthus sarmentosus var. major Dewèvre	near Loko, French Equatorial Africa	seeds devoid of awns.
S 46	Strophanthus amboensis Engl. & Pax	Spitzkuppen, South West Africa	seeds devoid of awns.
S 47	Strophanthus Arnoldianus Wildem & Th. Dur	Kisantu, Belgian Congo	seeds devoid of awns.
S 48	Strophanthus Emini Aschers	Tabora, Tanganyika	seeds devoid of awns.
S 49	Strophanthus Boivini Baill.	Madagascar	seeds devoid of awns.
S 50	Strophanthus Gossweilerii Hess	Vila Arriaga, Angola	seeds devoid of awns.
S 51	Strophanthus divaricatus Wall	Hong Kong	seeds devoid of awns.
S 52	Strophanthus intermedius Pax	near Vila Mariano, Angola	seeds devoid of awns.
S 53	Strophanthus sarmentosus P.DC.	French Sudan	seeds devoid of awns.
S 54	Strophanthus Tholloni Franchet	Cameroons	seeds devoid of awns.
S 55	Strophanthus Wightianus Wall	India	seeds devoid of awns.
S 57	Strophanthus congoensis Franchet	French Cameroon	seeds devoid of awns.
S 60	Strophanthus hispidus P.DC.	Gold Coast	seeds devoid of awns.
S 61	Strophanthus gratus Franchet	French Cameroon	seeds devoid of awns.

Methods.

For the examination of the anatomical features of each specimen of seed it was necessary to prepare a large number of transverse sections. In order to avoid wastage of any of the hardly-come-by material, preliminary trials /

trials were made on commercial samples of Strophanthus Kombé and Strophanthus gratus. In the first instance an orthodox technique was adopted, viz., seed softened by exposure to a moist atmosphere were passed through various strengths of alcohol to absolute and from this to xylene. Shavings of paraffin were dissolved in the xylene until it was saturated. The xylene was then evaporated off. In order to get a solid block the seeds were then transferred from the first paraffin to fresh paraffin and left there for twenty four hours before the wax was allowed to solidify and embed the seeds.

This method proved to be of little utility because, although the spermoderm* of the seeds in question is not of a particularly hard or woody nature, the extent to which the paraffin had penetrated the tissues was found to be negligible and any attempt at cutting resulted in the cotyledonous and endospermic tissues falling to powder whenever they were brought in contact with the microtome knife. Considering that this disability might be cured by a more perfect penetration of the seed by the paraffin wax and that this would be obtained by using chloroform in place of xylene, the alteration was made, but it was found that still the paraffin had not penetrated beyond the endosperm. Even when the period of immersion /

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* Spermoderm is here used to include all the coverings outwith the embryonic plant and its associated endosperm.

immersion in the xylene/paraffin or chloroform/paraffin was extended from the original twenty four hours to four days no appreciable improvement was obtained. Some radical change in procedure therefore became necessary in order to ensure complete infiltration. However, before abandoning the method it was decided to ascertain if cutting the seed into portions prior to treatment and evacuation of all air at every possible stage throughout the process would result in any appreciable improvement. Accordingly, seeds were cut (a) transversely in half, (b) transversely in thirds, (c) about 1 mm. cut off the lateral edges in a longitudinal direction. Treatment was applied as before. A minor disability arose here, for in the cases (a) and (b) the cotyledons slipped out while the specimens were passing through the lower strengths of alcohol. To obviate this, the seeds were kept intact until they reached the stage of being passed from 50% to 70% alcohol. This, in the majority of cases, succeeded but from the sectioning point of view the gain was very small as the paraffin again failed to penetrate beyond the surface layers of the exposed cotyledonous and endospermic tissues.

It now fell to devise a new technique or amend one or other of the classical procedures in order to obtain sections.

In devising a suitable method, it was felt that the following points should be borne in mind:-

(a) /

(a) The spermoderm, though not usually hard and woody, is extremely difficult to penetrate and some means of increasing its permeability to solvents and the embedding material is essential, (b) Chloroform, though a better penetrant than xylene, appears to render the tissues too brittle so that direct contact with this reagent by itself should be avoided.

It was thought that penetration of the spermoderm would be greatly facilitated by employing a modification of the procedure commonly adopted in timber technology, which involves boiling the specimen with a mixture of equal parts of 6% hydrogen peroxide and 99% acetic acid and that the hardening properties of chloroform could be counteracted by admixing it with cedar wood oil. This oil was selected because it is well known to lack the hardening properties of certain other fixed oils such as that of clove.

The following schedule, not so far reported by other workers, was developed:-

1. Whole seeds were placed in a mixture of equal parts of 6% (20 vols.) hydrogen peroxide and 99% acetic acid, evacuated for 15 minutes, and then maintained at a temperature of 54°C, in a tightly-corked tube for a period varying from 6 to 12 hours according to the particular species undergoing treatment.
2. The seeds were removed from the acetic acid/peroxide mixture, washed with 25% alcohol, transferred /

transferred to fresh 25% alcohol, evacuated for 10 minutes and allowed to stand in this strength of alcohol for 24 hours.

3. Seeds washed with 50% alcohol, transferred to fresh alcohol of this strength, evacuated, and allowed to stand for 24 hours.
4. As (3) but using 70% alcohol.
5. As (3) but using 95% alcohol.
6. The seeds were halved transversely and transferred to a mixture of the following composition:- absolute alcohol 50%, chloroform 37.5%, cedar wood oil 12.5%, evacuated and maintained, in a tightly-corked tube, at 54°C for 24 hours.
7. The seeds were transferred to a mixture of 3 parts of chloroform and 1 part of cedar wood oil, evacuated and maintained, in a tightly-corked tube, at 54°C for 24 hours.
8. Shaving of 52°C m. pt. paraffin added, tube tightly corked and maintained at 54°C for 24 hours.
9. Tube uncorked and chloroform allowed to evaporate at 54°C.
10. The seeds were transferred to fresh 52°C m. pt. paraffin and maintained above melting point for 24 hours.
11. Seeds embedded.

This procedure, though somewhat tedious, yields /

yields a specimen which cuts well. It was noticed, however, in the sections that the epidermis was frequently disorganised in parts of the seed and it was thought that the initial acetic acid/hydrogen peroxide treatment might be responsible for this. In order to clear up this point, pieces of spermoderm were removed from seeds softened by water and prepared for sectioning by the above method but omitting the acid/peroxide treatment. On comparison the same effect was observed. As a further check, hand sections were cut from material softened by exposure to a moist atmosphere. These also showed this disorganisation of the epidermal tissue which may therefore be assumed to be a natural feature of the seed.

The staining and mounting of the sections was performed in the usual way, Bismarck Brown almost invariably being used for staining and Euparal being employed as the mountant.

For the examination of surface characters and calcium oxalate cyrstals within the seed-coats, pieces of spermoderm were removed from seeds previously softened by immersion in 25% alcohol and cleared by warming with 70% chloral hydrate solution. These preparations laid out flat on the slide are to be referred to here as surface preparations. By focussing on successive depths of the preparation, details of cells not apparent in transverse sections can be observed.

The /

The distribution of lignin in both sections and surface preparations was brought up by treating the material on the slide with 1% solution of phloroglucinol following by concentrated hydrochloric acid.

For the purpose of studying the characters of the epidermis of the cotyledons, the whole cotyledon was cleared by warming with 70% chloral hydrate solution in a corked tube, for 12 hours at 54°C and then mounting in 50% glycerol.

DESCRIPTION OF SPECIES.

Strophanthus Kombé Oliver

The seed of this species appears in the Pharmacopoeias of Britain, America, Germany, France, Italy, and Spain. In each case the official drug consists of the dried seeds freed from their awns. As already noted, it was first brought to this country by Livingstone in 1861. On subsequent examination by Oliver it was found to be a new species. It is the only species recognised by the British Pharmacopoeia 1948 for the preparation of the official "tincture". It is of passing interest to record that the discovery of the potency of the drug is also claimed by Kirk who, in the same year, to quote Perrédes (1900) is alleged to have written — "The source of the poison, viz. Strophanthus Kombé was first identified by me. I had long sought for it but the natives invariably gave me some false plant..... In this way the poison was identified and I brought home specimens to Kew, where they were described." It is odd that Perredes should quote the above and make no reference to Livingstone while all the other authorities consulted are unanimous in ascribing the discovery of the plant to the latter.

However, following its discovery, its pharmacological action was investigated. It was found to be a powerful cardiac poison and its acceptance as a therapeutic agent appears to date from 1885 /

1885 when Fraser read a paper on the drug to the British Medical Association. The firm of Burroughs, Wellcome & Co. were quick to realise the importance of this and immediately sent an agent to Africa who procured fruits from natives who had them stored in readiness for the preparation of poisoned arrows. This is believed to be the first consignment of Strophanthus obtained for therapeutic purposes and it is reported to have cost the firm £20 per lb.

It soon became evident, however, when a number of different consignments began to reach this country, that considerable variation in potency occurred between the different samples and that certain differences both in appearance and reaction to sulphuric acid were evident. Accordingly, investigations commenced and these have proceeded up to the present day without providing a complete solution of the many problems involved.

The first work of importance appears to be that of Perredès in 1900 who, in an attempt to obtain sufficient information to enable the Kombé seed to be distinguished from others, made an examination of material supplied to him by Holmes who, in 1893, had reported that some seeds gave a green colouration in the endosperm and cotyledons with sulphuric acid while others gave a red colouration. Holmes regarded the former as the official type and, with apparently no further guarantee of authenticity, Perredès commenced a comprehensive morphological and histological examination of the material. From some of his findings it appears certain that it was, in fact,

Strophanthus /

Strophanthus Kombe seed with which he worked, though many of his conclusions could apply almost equally well to many of the species which are obtainable to-day.

A number of other workers have dealt with different aspects of this problem, and it will be of value to bring together their findings in so far as these have been confirmed by the present study. This composite description extended here when possible will serve as a standard of comparison with which less well-known or new species may be compared.

The plant is a woody liane indigenous to Eastern Tropical Africa, especially near the Shire river in Mozambique, Lake Nyanza, and Lake Tanganyika.

The fruit consists of a pair of follicles 25 to 30 cms. in length and about 2.5 cms. in breadth at the widest part. They are only slightly narrower at the base but taper towards the apex. Each follicle contains a large number of seeds closely packed together and each provided with a long awn. The shape of seeds at different levels along the morphological axis is not constant. In general, those in the basal portion of the follicle tend to be shorter and broader than those in the mid-region. The apical portion of the follicle is filled with the feathered awns of seeds inserted at lower levels. This variation in shape was also noticed, to a slightly greater or lesser extent, in all species of Strophanthus of which follicles were available for examination.

The /

The fruits of Kombe seen in commerce have been collected when ripe. Occasionally they are exported after having been freed from their epicarp and mesocarp but more often the seeds are separated and the awns removed before shipment. The chief ports concerned in these sendings are Beira, Somba, Quilimane, Inhambane, and Chinde.

The seeds have been found to be linear-lanceolate to lanceolate in outline, somewhat flattened and obtusely-edged. Their length varies from 8 to 25 mms.; the width from 2.5 to 5 mms.; and the thickness from 0.5 to 2 mms. The entire length of the seed including the awn was found to be from 10 to 12 cms., the units of the apical plume being 3 to 4 cms. long and with a spread of about 3 cms. The apex of the main body is acute and terminates in a broken-off point left after the removal of the awn. A slightly raised ridge, which contains the raphe, extends downwards from this point along the midline of the ventral face for about two-thirds of the length. The hilum occurs as a minute scar situated on this ridge and near the apex of the seed. The dorsal face is usually slightly convex but sometimes either nearly flat or definitely convex. The base of this main body is rounded and possesses a slight, inconspicuous, winged extension which is formed from the spermoderm. In colour the seeds are greyish-green to greenish-fawn and possess a distinct silky sheen which is due to a covering of closely appressed hairs, all of which are directed /

directed towards the apex of the seed and which are in longitudinal rows lying close together and running parallel with the morphological axis of the seed.

The seeds are relatively soft, breaking with a short fracture, and both the endosperm and cotyledons are greyish-white in colour.

Gross Anatomy.

Dissection of seeds softened in water shows three major regions:-

(a) the seed-coat which, because it may include such structures as residual nucellus (perisperm), is hereafter referred to as the spermoderm;

(b) the endosperm consisting of a thin, more or less biconvex envelope of slightly horny consistency and narrowing towards both ends;

(c) a large embryo consisting of a terete radicle directed towards the apex of the seed and two, whitish, plano-convex cotyledons lying face to face and extending nearly to the base of the seed.

Microscopy.

Taking the work of Perrédes as a basis and bringing his terminology into conformity with that used here, the corrected and amplified version of Strophanthus Kombé may be given in some detail. This presentation will serve a number of purposes. Primarily it will establish the position seen in this seed with correctitude and also provide a standard of reference /

reference against which other species may be compared.

In a transverse section mounted in pure glycerol the spermoderm shows two distinct regions; an external one composed of a single layer of cells constituting the epidermis of the seed, and an internal one composed of several layers of compressed cells forming a narrow green band much thinner than the epidermal layer. This sub-epidermal tissue is thrown into numerous sharp folds and furrows which are paralleled by similar irregularities in the outward face of the endosperm. In a few cases, the endosperm is not involved in these folds so that each consists of only the spermoderm tissues. In such cases the external portion of the fold is epidermal in character and the sub-epidermal tissue alone supplies the internal one. After soaking the section in water, or better, after mounting it in chloral hydrate solution, the outer cells of the green band just mentioned relax the folds at intervals and then follows an undulating course.

If the epidermis is separated from the underlying tissues by soaking in water and is examined in surface view, these undulations appear as ridges and furrows, the latter appearing to be filled by the occurrence there of dense masses of upwardly-directed epidermal hairs. The ridges are very much more sparingly clothed.

Perredes (1900) reported that the anticlinal walls of the epidermal cells were characteristically thickened, the thickening assuming a spindle-shaped form /

form when seen in transverse section and being, for the most part, lignified though showing a cellulose lining on its inner face. According to Perredes, this feature is quite overlooked by Hartwich, Planchon, and Nevinny, all of whom, separately, made some examination of the drug between the years 1894 and 1900. In fact, the outwardly and inner-facing walls of the epidermal cells consist of cellulose, the former being prolonged, generally at the end of the cell which is the nearer to the apex of the seed, into a long hair. The wall of the hair is relatively thin and is composed of cellulose except for a lignified rib on the side of the shaft adjacent to the epidermis. The lignification is rather more complex in the lower part of the hair; at the base of the shaft a narrow lignified ring surrounds the hair and this is connected with the lignified thickening on the anticlinal walls by a number of ascending ribs of lignified thickening. The existence of this peculiar feature has been confirmed by very careful examination of much material but as it is seen only in very good preparations its value as a diagnostic character is doubtful.

In connection with the surface view, Perredes reported that the epidermis consisted of polygonal axially-elongated cells, nearly isodiametric cells or of axially elongated cells with tortuous anticlinal walls. Examination of authentic material leads to an almost complete agreement with the above description. The use of the word 'tortuous' is, however, unfortunate /

unfortunate because in the examination of a number of specimens no example could be found where the anticlinal wall was more than undulating. Such examples were so few that the walls may very fairly be described as without distortion.

Such surface preparations, when stained with phloroglucinol and hydrochloric acid also serve to confirm the existence of the non-lignified portion of the anticlinal wall as observed by Perrédes. It is also seen that the degree of lignification is moderately heavy and uniform and that the middle lamella, though distinct, is not more heavily lignified than the thickening on the wall. This point appears to be of some importance because, as will be mentioned later, the middle lamella is, rather surprisingly, the most heavily lignified part in some species of Strophanthus.

Perrédes (1900) found that the lignified bands which extend from the ring of thickening on the anticlinal wall of each epidermal cell were best seen on the sides of the epidermal ridges as they are frequently damaged by abrasion at the summit of the ridges, while in the furrows the overlying hairs hide them from view. This is found to be true but neither easily nor frequently seen in the material examined, the abundance of hairs making such detailed examination of the epidermal cells extremely difficult.

The hairs are unicellular, thin-walled,

and /

and some 12 to 15 microns in diameter at the base of the shaft. From this point each hair tapers regularly and gradually to its subacute apex. They measure from 500 to 800 microns in length which, whilst in agreement with Perredes' report, disagrees with that of Nevinny (1887) who reported finding hairs several millimetres in length.

A further point which may be of interest in connection with the epidermis is that Blondel (1888) and Planchon (1894) both reported that the outer tangential walls of the epidermal cells are frequently so shrunken that they approach the inner ones. Perredes reported that this was only seen in comparatively rare cases and concluded that it was due to distortion caused by the razor pushing the walls inwards when a section was being cut. This cannot apply in the present work where sections were prepared by paraffin infiltration, but agreement is, nevertheless, with Perredes as this feature was only very seldom observed in the case of Strophanthus Kombe though it was found to be a constant feature of certain other species as will be mentioned later.

The examination of transverse sections of authentic material shows that the epidermis consists of a single layer of nearly isodiametric cells which measure from 18 to 30 microns in size. The tangential walls are moderately thin and the outer is prolonged into a unicellular hair as previously referred to. The anticlinal walls of these cells are conspicuously thickened /

thickened as seen in transverse view, the thickening being spindle-shaped and averaging 6 microns at the widest part. Lying within the epidermis is a sub-epidermal region varying from 9 to 12 microns in thickness and consisting of thin-walled cells which are tangentially elongated and radially compressed except where it is subjacent to an epidermal ridge. Here the cells are polygonal in outline. This region is widest under the median ridge on the ventral face of the seed and in it is embedded the vascular strand of the raphe which contains a number of very small spiral vessels. This is in agreement with the findings of Perrédès (1900), except that he gives no measurements for the spermoderm cells and reports the epidermal ridges as being much more prominent than is found to be the case here where they amount to little more than peripheral undulations.

Perrédès (1900) made no reference to calcium oxalate crystals, but in a subsequent report (1901) he admitted that they completely escaped his notice and that a further examination of his original material revealed crystals of calcium oxalate "mostly in the form of small clusters". Widely different reports have been made by other workers regarding these crystals: Hartwich (1892) reported none to be present. The accounts, however, all agree that when crystals occur they consist of calcium oxalate, but De Visser Smits (1951) in a report which deals with seven species of Strophanthus, states that in those species where crystals occur the crystals consist of calcium carbonate and, in the case of Strophanthus Kombé /

Kombé, take the form of crystalline aggregates or single crystals.

Examination of the present material confirms the fact that crystals do occur in the sub-epidermal tissue of the spermoderm, but the number is small and they are seldom apparent in the transverse section but often seen in surface preparations of the spermoderm. In the majority of cases these crystals take the form of clusters as was reported by Perredès (1900), but an occasional prismatic crystal is also seen. Chemical examination confirms that the crystals are composed of calcium oxalate and not calcium carbonate as Smits (1951) claims.

With regard to the endosperm, Perredès (1900) reported that the outline of the tissue in transverse section and mounted in pure glycerol was exceedingly irregular owing to the presence of grooves and ridges and that after soaking the material in water they still remained very noticeable. This is found not to be the case; the outer surface of the endosperm is not seen to be more than gently undulating, and this only in some cases. Perredès also claims that the outermost layer of endosperm cells are more or less cubical as seen in transverse view, and that only the outer walls of the cells are uniformly thickened while the lateral walls thin down like wedges towards the interior. The remaining cells of the endosperm, with the exception of those forming the innermost layers, are said by Perredes to be polygonal, thin-walled and very slightly thickened, if at all, at the corners. The absence of /

of intercellular spaces is also reported, together with the information that the innermost portion of the endosperm consists of several layers of much-compressed and somewhat mucilaginous cells.

It is not thought probable that a detailed description of these endosperm cells will serve any useful diagnostic purpose, but it is worth recording that very different accounts of them have been published. Hanausek (1887) described them as "polygonal, exceedingly delicately-walled and closely fitted together"; Nevinny (1887) as "isodiametric or somewhat tangentially elongated, and possessing colourless, shining, collenchymatous walls", Blondel (1888) reported three different kinds of cells in three corresponding varieties of 'Kombé' seeds. In the first they were reported as "rounded with extremely thin walls", in the second as "rounded with tolerably thin walls", and in the third case as "rounded with moderately thick walls". Still other descriptions have been given. While some variation might be expected in such detailed work, this confusion in the literature must be recognised. A kindly and possible explanation of the differing descriptions would seem to lie in suggesting that some at least of the investigators had not taken sufficient care to check the origin of their material.

Examination of transverse sections of the present authenticated material, cut midway between the extremities of the seed, show the endosperm to consist of from 5 to 10 layers of cells. In the peripheral layer the cells are somewhat radially elongated /

elongated and average from 15 to 30 microns in size. The outermost wall of each of those cells is thickened but the others are moderately thin. No indication of the wedge-like thickening on the radial walls, as reported by Perredes, can be seen. The remainder of the endosperm, with the exception of the cells forming the innermost zone, are polygonal, moderately thin-walled, and average from 30 to 35 microns in size. No intercellular spaces are seen and no thickening at the corners of the cells. The innermost layer of the endosperm is not more than 5 microns in thickness and appears to consist of very thin-walled radially-compressed cells. All previous workers have reported the absence of laticiferous elements in the endosperm and this is confirmed. No crystals are seen. The endosperm cells contain protein grains and fixed oil.

Lying within the endosperm are the two large plano-convex cotyledons. The epidermis of the cotyledon as seen in transverse view consists of a single layer of very thin-walled, nearly isodiametric, cells measuring some 10 microns in diameter. The mesophyll cells are rounded to polygonal in outline, very thin-walled, and average about 25 microns in diameter. A well-marked strand passes medianly down the centre of each cotyledon and represents the midrib. Delicate laticiferous elements are present around this central procambial strand and details of these have been reported by previous workers. The presence of such elements, however, is such a common feature of members of the Apocynaceae that it is not thought likely that they /

they will prove of diagnostic value and no further details are given here meantime.

No previous description of the epidermal cells of the cotyledon, as seen in surface view, can be found in the literature, but examination shows that they are very thin-walled, polygonal in outline, and average about 20 microns in size. Despite careful examination no stomata were seen.

Strophanthus Courmontii Sacleux

This species is considered now as it is the one which has been reported most frequently as an adulterant of, or a substitute for, the seeds of Strophanthus Kombé.

Holmes (1901) commented on the variation in activity of different samples of "Strophanthus Kombé" seed and advocated importing the seeds in their pods as he found it practically impossible to separate the various admixtures of seed with which he had to deal. Importation of intact fruits, however, was not found to be practicable because buyers were unwilling to undertake the extra work, possibly owing to the labour of separating the seeds from the fruits, coupled with the uncertainty in the weight of seed which would be yielded. Furthermore, insufficient data existed to enable even experienced collectors to identify the species wanted from the characters of the pod. Holmes attempted to obtain this data by growing plants from various commercial seeds but derived little or no information from the work, as the plants of each species /

species differed among themselves and none of them could be induced to flower.

Holmes also records receiving through the kindness of Prof. Scott-Elliot of Glasgow and F.L.M. Moir of the East African Lakes Company, four apparently distinct plants from which the "Kombé" seed was said to be collected. One of these he identified as Strophanthus Courmontii by comparing it with a specimen already in the Herbarium of the Pharmaceutical Society.

With this evidence of the possible occurrence of Strophanthus Courmontii in consignments of the official seed, it was felt that a histological examination was called for, and the specimen in the Pharmaceutical Society's Herbarium was submitted to Perredes for examination. In 1901 this worker published a report, the main points of which are briefly, that the seeds have a greater tendency to lanceolate form than those of Strophanthus Kombé. They are smaller in size and measure from 8 to 14 mms. in length, 2.5 to 3.5 mms. in width, and 1 to 2 mms. in thickness. The colour of all the seeds is decidedly brown whether the hairs have been rubbed off or not, but the presence or absence of hairs modifies the tint to some extent, thus if a seed with hairs be viewed from the direction of the base, the brown is golden and sheeny, while if viewed from the other end it is dull and of a reddish hue. There is scarcely any ridge on the ventral face of the seed but when the hairs are removed, a light-coloured line is seen towards the apex and, usually, a light, fusiform /

fusiform patch towards the chalazal end. The hilum is readily seen as a fine scar near the apex of the seed. The hairs are not arranged in longitudinal rows to the same extent as in Strophanthus Kombé seed.

In his report on the microscopical characters of Strophanthus Courmontii seed Perredes states that the outline of the transverse section differs from that of Strophanthus Kombé in being much less wavy though he remarks that this feature may not be of much importance as it may be influenced by the time of collection and method of drying. The epidermal cells are 17 to 19 microns high and 8 to 10 microns wide. The thickening on the anticlinal walls is "more circular in outline". The hairs are very similar to those of Strophanthus Kombé, but the rib on the side of the shaft adjacent to the epidermis is less heavily lignified and "thins out" towards the base of the hair where it joins on to the hoop formed by the thickening on the anticlinal wall of the epidermal cell. Nothing more complicated is reported by Perredes, who considers this to be the reason why the hairs of Strophanthus Courmontii are not so firmly attached as those of Strophanthus Kombé.

Passing to the sub-epidermal tissue, Perredes reported that the cells here were similar to, but more closely packed than those of Strophanthus Kombé and contained an abundance of calcium oxalate crystals which were particularly well seen in surface view. The majority of the crystals are reported to be single and to vary in form — rectangular, six-sided plates, and octahedra being the commonest forms. Some twin crystals /

crystals also occur but cluster crystals are infrequent.

Perredes has little to say regarding the endosperm and cotyledons. In connection with the former he remarks, "the outer walls of the external layer are not infrequently distinctly creased while the remaining cells are rather thicker-walled than in Strophanthus Kombe".

Finally Perredes commented upon the reaction of both the endosperm and the cotyledons with sulphuric acid.

The brown colour of the seed of this species is also insisted on by Payrau (1900) and Gilg (1904) but Mathiesen (1927) states, "In my opinion the seeds of this species are very variable in colour ..... in a sample there were, besides lighter or darker coloured brown, also those which were greenish-brown, brownish-grey-green, or grey-green. The seeds of this last type are not very distinct regarding colour from those of Strophanthus Kombe".

It is also reported by Mathiesen that the seed is less flattened than that of Strophanthus Kombe and that the course of the raphe is visible on the surface of the seed only as a narrow light-coloured band extending from the midpoint of the ventral face to the apex. Linear-lanceolate, flat forms with a conspicuous raphe, such as one finds in Strophanthus Kombe, do not occur in this species. The longitudinal furrows of the seed-coat are not so marked, and it is, for the most part, gently undulating. Many crystals are always present in the seed-coat /

coat and may be strewn throughout the whole tissue or localised in one or more parts of this. Most frequently, single crystals occur, but sometimes twin crystals are seen and also cells filled with a conglomeration of small or large individual crystals.

Crystals are reported to be absent from both the endosperm and the embryo.

Mathiesen concludes by quoting Gilg's results with the sulphuric acid test and, with certain limitations, confirms the latter's conclusion.

In the most recent publication dealing with the seed of Strophanthus Courmontii (Youngken and Simonian 1950), the seeds are described as lanceolate to broadly-lanceolate, mostly brown but sometimes brownish-grey, averaging 9 mms. in length, about 3 mms. in breadth and 1 to 1.5 mms. in thickness. The external surface is covered with light yellow hairs but the covering is not as dense as in Strophanthus Nicholsoni. The raphe is less marked than in Strophanthus Kombé.

Referring to the histology of the seed, Youngken and Simonian reported that the spermoderm in cross section exhibits an epidermis of tabular cells whose radial walls are spindle-shaped, while lignified, non-glandular hairs arise from the outer walls. These latter were found to measure up to 570 microns in length and up to 18.5 microns in diameter at their basal region. At their apices they were soft-pointed. It is also reported by the above workers that the seed-coat contains numerous crystals of calcium oxalate which occur in single prisms, twin prisms, clusters, /

clusters, and conglomerates. The endosperm, however, is said to be devoid of calcium oxalate crystals. The intact cotyledons are reported to be slightly unequal in size and in cross section to taper to slender, pointed edges. Their cells contained no crystals of calcium oxalate.

Sharp (1912) reported that the seeds of this species were similar in physiological effects to those of Strophanthus Kombé but only one-quarter as poisonous to frogs.

There is thus some general agreement amongst previous writers regarding the main features of the seed of Strophanthus Courmontii, but nevertheless there remain many lacunae in the available accounts more particularly when quite authentic material is compared with the wider range of types made available to the present writer. Furthermore, the reactions seen in the tissues of the seed when treated with various diagnostic reagents require a more ample and detailed enquiry.

Strophanthus Courmontii (Specimen S 12).

This specimen is chosen in preference to Specimen S 11 for the reason that it is much better authenticated and a more generous number of seeds are available. The seeds are incomplete in that the awns have been removed prior to dispatch.

Each seed is lanceolate in shape and dorsi-ventrally flattened, though to a lesser extent than those of Strophanthus Kombé. The length varies from 10 to 15 mms., averaging 13 mms., the width from 2.5 to /

to 4 mms., and the thickness from 1 to 2 mms. The ground colour of the testa is reddish-brown masked by a coat of yellowish-white hairs which are rather short and give the seed a slightly furry appearance. In many specimens the central area of both faces of the seed are devoid of hairs where, due to abrasion, the hairs have become detached. Examination, with a lens, of these bare areas reveals the presence of faint longitudinal ridges on the testa. A few of the seeds are dull green or brownish-green in colour. These are probably unripe.

The apical region of the seed is occasionally slightly twisted, and terminates at the broken-off point of the awn. From this region a lighter-coloured, but not excessively prominent, ridge extends along the midline of the ventral face to a point about three-quarters of the distance towards the base. This ridge, parallel with the morphological axis, contains the raphe and at its chalazal end it tends to widen out and become spathulate in shape. The base of the seed varies from rounded to sub-acute. The hilum is just visible as a minute scar situated on this ridge and near to the apex of the seed. The micropyle cannot be distinguished in the dry seed.

Gross Anatomy.

Seeds softened by soaking in 25% alcohol are seen, when dissected, to consist of a large, white embryo which extends nearly the whole length of the seed and is composed of a terete radicle situated at the awned end, and two white plano-convex cotyledons lying /

lying face to face. There is much oil in the tissues. The embryo is surrounded by a thin layer of greyish-white endosperm which is enveloped by the spermoderm. There is no wing at the base of the seed.

Microscopy.

Examination of sections cut transversely to the morphological axis at a level midway between the two extremities are generally ovate in outline and gently undulant. These undulations take position from the longitudinal shallow ridges and furrows seen on the surface of the intact seed. Examination of sections cut transversely at different planes on the longitudinal axis serve to show that as the apex is approached these undulations in the outline of the section become more pronounced as the ridges become more marked. Both the seed-coat tissues and the residual endosperm enter into the formation of these flutings on the surface of the seed.

The epidermis consists of a single layer of nearly isodiametric cells measuring 25 to 30 microns in size. They have moderately thin tangential walls and thickened anticlinal walls, the thickening assuming a broad spindle-shaped form where adjacent epidermal cells meet. Beneath the epidermis is a well-marked region averaging about 15 microns in thickness and consisting of thin-walled tangentially elongated cells of slightly brownish aspect and containing numerous crystals of calcium oxalate. The most frequently-occurring and largest form is the single prism, /

prism, many of which attain 20 microns in size. Other forms seen include twin prisms, clusters, and conglomerates.

At regular intervals around the sections, thin-walled isodiametric or slightly tangentially elongated parenchymatous cells occur in groups lying between the epidermis and the sub-epidermal tissue previously referred to. The individual cells of this tissue measure from 10 to 20 microns in diameter and are presumably derived by the proliferation of the cells of the sub-epidermal tissue. The presence of these groups of cells is partly responsible for the formation of the undulations seen in the outline of the transverse section and therefore, of course, for the ridges seen in the intact seed.

The endosperm consists of from 5 to 9 layers of thick-walled, nearly polygonal cells, each measuring up to 45 microns in diameter and containing fixed oil and protein grains. The outermost outline of this tissue is only very shallowly undulating and follows the undulations of the spermoderm layers. The endosperm in this species, has been described by the authorities referred to earlier (Perredès 1901 and Mathiesen 1927) as free from calcium oxalate crystals: careful examination, however, using polarised light reveals the presence of minute crystals, each only some 2 to 3 microns in size. Confirmation that these crystals do, in fact, consist of calcium oxalate was obtained by chemical tests. They are insoluble in acetic /

acetic acid; soluble without effervescence in hydrochloric acid and in sulphuric acid. In the last case, however, no separation of calcium sulphate is seen but this is not surprising when the minute size of the individual crystals is borne in mind.

The endosperm surrounds two well-developed cotyledons which are plano-convex in outline and lie face to face. No regular inequality in the size of these cotyledons is observed as was reported by Youngken and Simonian (1950).

In transverse section the epidermis of the cotyledon is seen as a single layer of thin-walled tabular cells each about 6 microns by 10 to 15 microns. The mesophyll is composed of thin-walled parenchyma, each cell rounded to polygonal in outline and averaging about 25 microns in diameter. Fixed oil and protein grains are present. A well-marked strand passes medianly down the morphological axis of each cotyledon and represents the midrib. Crystals of calcium oxalate are not seen in these tissues even when polarised light is used.

Surface View of the Spermoderm.

Pieces of spermoderm were treated as described under 'Methods' and examined. In such "surface preparations" the epidermis is seen to consist of elongated cells, individuals varying from 50 to 120 microns in length and from 15 to 30 microns in width. The anticlinal walls are thick (8 to 12 microns), being uniformly and heavily lignified. The outer /

outer tangential wall of nearly every epidermal cell is extended outwards as a unicellular hair bent over near its base so as to be closely appressed to the surface of the seed and directed towards the awned end. Although this is, in general, true, it is noticeable that the hairs often present a somewhat tangled appearance which is not seen in Strophanthus Kombé. Furthermore, there is little indication of the arrangement of the hairs in longitudinal rows as seen in the last-named species. It is also seen that many of the hairs have been rubbed off and the only indication of their one time presence is a round or ovoid scar at the end of the cell which lies nearer to the apex of the seed. The intact hairs measure from 300 to 500 microns in length and up to 18 microns in diameter at their base. They taper gradually and regularly to their apex which is subacute. They are unicellular and have thin walls slightly lignified. In some examples the lignification is uniformly spread over the whole wall while in others it is restricted to a mere rib on that side of the hair which lies adjacent to the seed-surface. The annular thickenings and the septa described by Perrédes are not seen even in the best material, no matter how meticulously it is examined.

Numerous crystals of calcium oxalate, as previously described, are seen in the sub-epidermal tissue.

Surface /

Surface View of Epidermis of Cotyledon.

A cotyledon is prepared for examination as described under 'Methods'. In such preparations the epidermis is seen to consist of thin-walled polygonal cells averaging about 20 microns in diameter. No stomata are seen.

Strophanthus sarmentosus P.DC.

The seeds of this species have been known for many years but until recent times were of little more than academic interest except in so far as they frequently occurred as an adulterant of other species more highly regarded in commercial circles. In 1927 and 1928 Mathiesen published a comprehensive report which included an account of his examination of sixty seven commercial samples of Strophanthus seed which bore dates from 1907 to 1927. He found that Strophanthus Kombé seed frequently contained the seed of Strophanthus sarmentosus and that commercial samples of Strophanthus hispidus consisted either entirely or in large proportion of the seed of Strophanthus sarmentosus.

As referred to earlier, an alleged sample of Strophanthus sarmentosus was chemically examined by Jacobs and Heidelberger (1929) and a new glycoside, which they named sarmentogenin, isolated. Subsequent investigations, made when this glycoside came into prominence as an intermediate in the synthesis of cortisone, leave some doubt as to the botanical origin /

origin of the material with which Jacobs and Heidelberger worked.

Mathiesen reported that his examination of authenticated material showed that very considerable variation in colour occurred and that some individuals were of a uniform red-brown and others of a light brownish-grey. Occasional seeds of the latter colour are said to show "greenish stripes", though in which direction these traverse the seed is not stated. The seeds are reported to be slender and waisted. Crystals are said to be present in the sub-epidermal layer. Hairs on the seeds are mentioned as numerous and are said to emerge from the end of the outer tangential walls of the epidermal cells which are the nearer to the apex of the seed. Crystals are reported not to be present in the endosperm or embryo.

In a more recent and more detailed description of the seed of Strophanthus sarmentosus, Youngken and Simonian (1950) reported that the specimens examined by them were ovate-lanceolate in shape, reddish-brown to brownish-grey in colour and often with a greenish or yellowish tinge. The average length is given as 10 mms., the breadth as 4 mms., and the thickness as about 2 mms. A marked twist in the apical region is noted. The base is said to be obtuse and somewhat flattened, and the whole surface of the seed covered with thin-walled, unicellular hairs of variable length, the apices of which are not very sharp pointed.

Dealing /

Dealing with the histology of Strophanthus sarmentosus, Youngken and Simonian reported that transverse sections cut near the centre of the morphological axis of the seed were elliptical in outline and possessed a slight ridge at each of the extremities of the ellipse, the ridges being formed from the seed-coat tissues alone. The epidermis of the spermoderm is said to consist of a single layer of large tabular cells, each with moderately thin tangential walls and thick anticlinal walls, the thickening assuming a spindle-shaped form where the adjacent epidermal cells meet. Numerous thin-walled, non-glandular, pale yellow hairs, each measuring up to 230 microns in length, are reported to arise as outward extensions of the outer walls of the epidermal cells. Many of these hairs are said to be slightly wavy in appearance and to possess soft-pointed apices. The entire epidermal tissue, including the hairs, is reported to be only slightly lignified and to show a glistening aspect when examined under polarised light while in surface view the cells are elongated and with sinuous anticlinal walls 7.6 to 11 microns in thickness. The middle lamella is said to be darker and more heavily lignified than the remainder of the wall.

Beneath the epidermis a hypodermis is noted, some of the cells of which contain rhombohedral crystals or aggregate clusters of calcium oxalate. This crystal-bearing hypodermis is said to form the outermost layer of the pigmented tissue which, in whole, /

whole, consists of three to five layers of tangentially elongated parenchymatous cells of brownish colouration.

The endosperm is reported to consist of seven to nine layers of cells isodiametric in shape, with thick walls, and containing protein grains and fixed oil.

The endosperm surrounds two well-developed cotyledons, the mesophyll cells of which are reported to contain numerous protein grains and oil globules, together with numerous crystals of calcium oxalate either in the form of clusters or conglomerates but rarely as single crystals.

It is obvious, therefore, that a number of discrepancies exist between the different accounts, the most serious of which refers to the calcium oxalate crystals in the cotyledons; Youngken and Simonian reporting their occurrence and Mathiesen finding none to be present.

Three authentic specimens of Strophanthus sarmentosus are available for the present enquiry. The first (S 38) consists of a complete follicle collected by Dalziel in 1906. It is supported by a Herbarium Sheet in the Royal Botanic Garden, Edinburgh and the identification was confirmed by Monachino of the New York Botanic Garden in 1950. This specimen is used for the description of the awn. The two remaining specimens are of recent date, S 44 being collected in 1949, and S 53 in 1952. These two specimens are used for the remainder of the description which /

which follows, and although they are found to agree very closely in their morphological and histological characters, they differ markedly in their chemical reactions, a feature which will be dealt with in a later section of this report.

Each seed, like many others of the same genus, is provided with a long feathery awn and the total length of the whole unit averages about 8.2 cms. which is made up as follows:- main body of seed 1.5 cms.; pedicel of awn 4 cms.; plume 2.7 cms. in length and with a spread of 9.5 cms. The pedicel is yellowish to yellowish-brown in colour, almost straight and from 0.3 to 0.5 mm. in diameter.

While some of the seeds of the present samples may be said to agree with the description of Youngken and Simonian, it does not, by any means, appear to be sufficiently wide to include all possible appearances of the seed. Some of the seeds are distinctly lanceolate in shape and the length varies from 10 to 15 mms., with an average of 13.5 mms. The width varies from 3 to 4.5 mms. and the thickness from 1.5 to 2 mms. The predominating colour is a soft greyish-brown, the greyish tinge being due to a uniform covering of appressed hairs, all of which are directed towards the apex of the seed and which do not appear to be arranged in longitudinal rows as is seen in the case of Strophanthus Kombé. As figures for the breadth and thickness indicate, the seed is rather flattened and with almost acute edges. The dorsal /

dorsal face of the seed is convex whereas the ventral face is either slightly convex or almost flat. The raphe is, of course, situated on this latter face and takes the form of a yellowish, raised ridge which extends, parallel with the morphological axis, from a point about one-quarter of the total length of the seed away from the base to the apex where it terminates in the broken-off point of the pedicel of the awn. The hilum is visible on this ridge at a point near the apex of the seed and the micropyle, though very difficult to discern, is seen as a minute spot situated laterally to the hilum. The base is obtuse and somewhat flattened. The twist in the apical region, upon which Youngken and Simonian comment, is seen in some of the seeds but does not appear to be sufficiently positive for use as a character upon which to base an identification.

Gross Anatomy.

Seeds softened by soaking in 25% alcohol show, on dissection, a white embryo consisting of a terete radicle pointing towards the apex of the seed and two large, white, plano-convex cotyledons occupying nearly the whole length of the seed. Much oil is contained in the embryo which is surrounded by a thin layer of greyish-white endosperm and the whole is enclosed in a thin spermoderm.

Microscopy.

Examination of transverse sections cut midway between the base and the apex are elliptical in /

in outline. The slight ridge described by Youngken and Simonian as seen externally at each of the points of the ellipse where it is cut by its longest axis, are found not to be constant features of the seed, and when seen are not always confined to the seed-coat tissues as these workers claim. The endosperm here is usually about three cells deeper than elsewhere and forms part of the ridge.

The epidermis of the spermoderm consists of a single layer of tabular cells, each measuring about 20 x 35 microns, with moderately thin tangential walls and thick anticlinal walls, the latter assuming a spindle-shaped form where the adjacent epidermal cells meet. Beneath the epidermis is the sub-epidermal tissue which Youngken and Simonian refer to as the "pigment tissue". As these workers say, this consists of a few rows of thin-walled, tangentially-elongated cells, each of which is found to measure some 30 microns in length and 6 to 9 microns in width. Some of these cells are enlarged and these contain crystals of calcium oxalate either as irregular clusters or single rhombohedral crystals. These crystals, however, do not appear to be confined to the outermost layer of this tissue as is claimed, though they do occur rather more frequently in the outer layers than in the inner. The two forms exist in the ratio cluster: rhombohedral = 10:4. This sub-epidermal region, as a whole, consists of from three to five layers of thin-walled tangential cells of brownish appearance.

The /

The endosperm consists of from seven to ten layers of rather thick-walled cells, polygonal or slightly tangentially elongated in outline and containing protein grains and fixed oil. This endospermic tissue is remarkably uniform in breadth as seen in transverse sections cut in various planes across the long axis, but in those cases where a ridge is present at the points of the ellipse it is almost always two or three cells thicker here than elsewhere and forms part of the ridge.

The endosperm envelops two well-developed cotyledons which are, in general, plano-convex in outline as seen in transverse section, but are often shaped as in figure .

The epidermis of the cotyledon, when seen in transverse view, consists of a single layer of thin-walled tabular cells, the outer walls of which are convex. The mesophyll tissue is composed of thin-walled parenchymatous cells which are polygonal in outline and mostly radially elongated to some extent. Their average size is 30 x 15 microns. These cells contain oil together with protein grains and many cluster crystals of calcium oxalate, some of which attain 20 microns in size. Single crystals in this tissue are of very rare occurrence. This is in agreement with the findings of Youngken and Simonian but not, of course, with those of Mathiesen. A well-marked, procambial strand passes medianly down the morphological axis of each cotyledon and represents the /

the midrib.

Surface View of the Spermoderm.

Pieces of spermoderm were treated as described under 'Methods' and examined. In such "surface preparations" the epidermis is seen to consist of elongated cells, individuals varying from 75 to 150 microns (average 105) in length and from 15 to 45 microns (average 30) in width. The anticlinal walls are some 10 microns thick and lignified, though it is noteworthy that the degree of lignification is not uniform through the wall, the middle lamella being strongly lignified and the remainder of the wall only moderately so.

The outer tangential wall of every epidermal cell is extended outwards as a unicellular hair which bends over near to its base so as to become closely appressed and pointing towards the apex of the seed. The shaft of the intact hair measures from 400 to 700 microns in length, and it is strengthened by a single narrow rib of lignified tissue which extends along the entire length of the side of the hair adjacent to the seed. In the material examined, however, the degree of lignification shown by the hairs was never more than slight and at times barely discernible. At its base the hair averages some 18 microns in diameter and from there it tapers regularly and gradually to the subacute apex.

The crystals in the sub-epidermal region

are /

are well seen when different focal planes through the epidermis are examined microscopically. It was thought that the number of crystals per sq. mm. might prove to be a useful figure in differentiating between the varuous species of Strophanthus seed. It was found, however, that all the crystals could only be seen with certainty by using polarised light. Under such conditions it was not, therefore, practicable to set up a Camera Lucida. Accordingly the diameter of the field seen with the objective/eyepiece combination it was intended to use was measured and the number of crystals present in each of a number of selected fields determined, using the technique originated by Wallis (1936).

Diameter of field = 290 microns = 0.066 sq. mm. area

Average number of crystals per field = 4.2

= 63.6 crystals/sq. mm.

Surface View of the Cotyledon.

A cotyledon is prepared for examination as described under 'Methods'. In such preparations the epidermis is seen to consist of thin-walled polygonal cells averaging about 20 microns in diameter. No stomata are seen. Examination in polarised light reveals the distribution of the calcium oxalate crystals. This is remarkably uniform except near the margins where few crystals are seen. A count made in the same manner as before shows an average of 3.5 per field which corresponds to 53 crystals per sq. mm.

Strophanthus /

Strophanthus sarmentosus var. major Dewèvre

No reference to the seeds of this variety can be found in the literature on Strophanthus. The present sample, consisting of only seven seeds, was obtained from Monachino of the New York Botanical Garden, together with the information that it was collected in January 1951 near Loko, French Equatorial Africa.

The awns had been removed prior to dispatch so that only the main body of the seed was available for examination. Some damage had occurred in transit; the seeds had been crushed so that while still suitable for botanical and chemical examination it was difficult to obtain whole specimens for photographic purposes.

On examination, the seed is seen to be lanceolate in outline and flattened. The length, in so far as it can be ascertained in the small sample available, varies from 10 to 19 mm., the width from 3 to 4.5 mms., and the thickness from 1 to 2 mm. They are of a dull earthy-brown colour and are not noticeably hairy though examination with a lens does reveal the presence of a relatively small number of rather long, lighter coloured hairs together with a larger number of smaller hairs which impart a somewhat furry texture to the testa. Both faces of the seed are slightly convex and bear very faint longitudinal ridges which are rather more conspicuous in the apical region than elsewhere. The edges of the seed are

almost /

almost acute. The apex of the seed is acute and terminates in the broken-off point of the awn. Continuous with this and extending along the midline of the ventral face of the seed is a paler brown, though not otherwise conspicuous, ridge which reaches to a point about three-quarters of the distance towards the base of the seed. This ridge contains the raphe. The hilum is discernible with difficulty and takes the form of a minute scar situated on the ridge near to the apex of the seed. The micropyle is not distinguishable. The base of the seed is rounded to subacute and there is no evidence of the presence of a wing.

Comparing the macroscopical features of Strophanthus sarmentosus var. major with those of Strophanthus sarmentosus P.DC., the following differences are observed:-

(a) The former is larger and attains 19 mms. in length as against 15 mms.;

(b) No apical twist is observed in major though it must be borne in mind that only a few seeds of this variety are available for examination and, furthermore, by no means all specimens of Strophanthus sarmentosus show this feature;

(c) The colour of major is appreciably darker;

(d) Though Strophanthus sarmentosus is not a particularly hairy seed, var. major is much less so.

Gross /

Gross Anatomy.

Seeds softened by soaking in 25% alcohol show, on dissection, a white embryo consisting of a terete radicle pointing towards the apex of the seed and two large, white, plano-convex cotyledons occupying nearly the whole length of the seed. Much oil is contained in the embryo which is surrounded by a thin layer of greyish-white endosperm and the whole is enclosed by a thin spermoderm.

Microscopy.

Examination of transverse sections cut midway between the two extremities are elliptical to almost ovate in outline, with regularly-spaced and very gentle undulations just visible. The epidermis consists of a single layer of cells, most of which are slightly tangentially elongated as in the previous species described, but some are approximately isodiametric. These cells vary from 15 to 18 microns in depth and from 30 to 40 microns in length. The tangential walls of the epidermal cells are moderately thin, the outer ones in many cases being concave though in a few it is extended outwards as a unicellular hair. The anticlinal walls of the epidermal cells are conspicuously thickened, the thickening assuming a very broad spindle-shaped form where the adjacent epidermal cells meet.

Lying within the epidermis is a well-developed sub-epidermal layer varying from 8 to 24 microns in thickness and consisting, as before, of thin-walled tangentially elongated cells. The thicker /

thicker regions of this tissue are characterised by the presence of tangentially-elongated schizogenic cavities caused by groups of the cells splitting away from one another. This feature is seen in some other species but not to the same extent as here. Beneath the very slight ridges previously referred to, the cells of this sub-epidermal region are different in character and mostly polygonal in outline. In the apical region of the seed these groups of cells are more pronounced and correspond in position with the ridges which are more prominent in that region of the seed. Furthermore, in this apical region a somewhat larger group of these polygonal parenchymatous cells is present at each of the pointed ends of the section forming a ridge which, in some cases, takes the form of a slight wing.

Careful examination of the spermoderm in polarised light reveals no crystals of calcium oxalate, this being in marked contrast to the spermoderm of Strophanthus sarmentosus P.DC.

The endosperm consists of from seven to ten layers of moderately thick-walled cells, each polygonal in outline, and each containing oil and protein grains. No well-defined crystals of calcium oxalate are seen in this tissue but careful examination reveals a large number of minute specks not more than 2 microns in diameter. These are almost certainly calcium oxalate because they persist after treatment of fresh sections with acetic acid, but are not seen after /

after treatment with hydrochloric or sulphuric acids. After treatment with the latter, needles of calcium sulphate should be seen, but these were not observed, and it is thought that this is not surprising when the minute size of the original crystals is borne in mind.

The endosperm envelops two well-developed, plano-convex cotyledons which, in the present material, are unusual in being decidedly unequal in size. In every seed but one of the sample the cotyledons were seen lying face to face, and in this exception one of the cotyledons was folded at one edge.

The epidermis of the cotyledon as seen in transverse view, consists of a single layer of thin-walled, slightly tangentially elongated cells averaging 12 x 9 microns in size. The mesophyll consists of rather thin-walled parenchyma, the cells being rounded to polygonal in outline and averaging about 25 microns in diameter. The cells contain oil and protein grains in rather smaller quantity than has been observed before. Examination in polarised light reveals the presence of numerous crystals of calcium oxalate, some in the form of well-defined clusters and others as conglomerates measuring up to 25 microns in size. A well-marked procambial strand passes medianly down the morphological axis of each cotyledon and represents the midrib.

Surface View of the Spermoderm.

Pieces of spermoderm were treated as described under 'Methods' and examined. In such 'surface preparations' the epidermis is seen to consist of elongated cells, individuals varying from 90 to 150 microns /

microns (average 120) in length and from 25 to 50 microns (average 35) in width. The anticlinal walls vary from 9 to 12 microns and are strongly but not uniformly lignified: as in Strophanthus sarmentosus P.DC. a central and sharply-delineated region measuring from one-quarter to one-third of the thickness of the wall is very strongly lignified while the remainder of the wall is only moderately lignified.

The outer tangential wall of many of the epidermal cells is extended outwards as a unicellular hair which bends over near to its base so as to become appressed and pointing towards the apex of the seed. These hairs, however, are not very numerous and since only a few of the non-hair-bearing cells show a scar the statement that this variety of Strophanthus sarmentosus possesses only a small number of hairs may be taken as valid.

An interesting and unusual feature of those hairs which do occur is that they may be divided into two groups according to their length. In one group the hairs are relatively short and measure from 100 to 500 microns long: the majority of the hairs fall into this class. In the other and smaller group the hairs are all long and average about 1000 microns in length. In hairs of both classes the cell wall is moderately thin and either non-lignified or only very slightly and uniformly lignified. At its base the hair measures from 15 to 18 microns in diameter and from there tapers gradually and regularly to the subacute apex.

Surface /

Surface View of the Cotyledon.

A cotyledon is prepared for examination as described under 'Methods'. In such preparations the epidermis is seen to consist of thin-walled polygonal cells averaging about 25 microns in size. No stomata are seen. Calcium oxalate crystals, as already described, are seen, but owing to the thickness of the tissue their form is not readily discernible in this preparation.

Strophanthus Emini Aschers

Up to the present, the seeds of this species have not been employed medicinally and are only of interest as an adulterant of the seeds of other species which are of commercial value.

Mathiesen (1928) reported that the seeds of Strophanthus Emini frequently appeared in some of the sixty seven commercial samples dated from 1907 to 1927, which he examined. In his description of the seed Mathiesen noted that they are reminiscent of the shorter forms of Strophanthus Kombé but were markedly thicker and the raphe less elevated. The basic colour of the seeds is stated to be light yellowish-brown and they are said to be covered with shining golden-yellow hairs. He found no crystals either in the seed-coats or in the embryo.

Denston (1936) gave a rather fuller account of both the fruit and the seed, the significant points of which are included in the following:- the fruit consists /

consists of two follicles which diverge at the base as ripening occurs. Each follicle narrows somewhat towards the base and gradually to the apex, which is swollen. They therefore resemble very closely the follicles seen in other species of Strophanthus. The specimens examined by this author varied from 24.5 to 29.5 cms. in length, 3.0 to 9.0 cms. in width at the widest part and 2.3 to 4.0 cms. in width at the base. The bulbous apex was 3 to 12 mms. in diameter. The dorsal surface of the follicle varies from convex (in a follicle which has not opened), to slightly concave in an open follicle. The surface is dull greyish-brown with longitudinal ridges, and is densely covered with paler lichens. The pericarp is 1.5 to 2.0 mms. thick and the inner surface (endocarp) is glossy and pale, bright yellowish-brown in colour. The mesocarp is green.

A single follicle was reported by Denston to contain 175 seeds resembling, in general structure, those of Strophanthus Kombe. The awns were 9 to 13 cms. long, the shaft of the awn being 3.5 to 5 cms. in length. The seeds themselves varied from 13 to 20 mms. long, with an average of 17 mms. More than 80% of the seeds lay between 16 and 19 mms. The width of the seed varied from 3 to 4.5 mms. and the thickness from 1.5 to 2 mms. In outline the seed is reported to be bluntly-lanceolate to lanceolate, with a few seeds elongated-rhomboidal. The surface is said to be silky golden-yellow due to the numerous appressed hairs which are directed towards the apex, but the ground-colour of the testa is yellowish-brown /

brown except over the raphe which is paler in colour. The raphe is said to extend from the apex to the centre of the ventral surface. The seeds contained a very narrow endosperm surrounding large, white, oily cotyledons.

It was at one time considered that the seed of Strophanthus Emini would be suitable for inclusion in the British Pharmacopoeia as the species is found growing in Tanganyika Territory and thus an outlet would be provided for an Empire Product. Accordingly, the Director of the Imperial Institute requested the Pharmacopoeia Commission to investigate the qualities of the seed. In a composite report published in 1935 on behalf of this Commission it was shown that the pharmacological activity of Strophanthus Emini seed varied from about 48% to almost 100% of that of Strophanthus Kombe. Clinical trials carried out by Fraser using e-strophanthin (the glycoside extracted from the seeds of Strophanthus Emini) are reported. From these the conclusion was reached that the action of e-strophanthin is qualitatively and quantitatively indistinguishable from that of k-strophanthin (the glycoside extracted from the seeds of Strophanthus Kombe.

Embodied in the report referred to above is a description by Wallis of the pharmacognostical characters of the seed. He says "the seeds of Strophanthus Emini Aschers are bluntly-lanceolate to lanceolate, about 11 to 17 mms. long, 3 to 4 mms. broad, and 1.5 to 2 mms. thick at the widest part. They are covered /

covered with shining golden-yellow, appressed hairs directed towards the apex, which bears the scar left by the removal of the awn. The ground-colour of the testa is yellowish-brown, and a yellowish-brown, not very conspicuous, ridge extends over the raphe from the apex to the centre of the testa on the ventral face. In the general arrangement of its parts the seed closely resembles that of Strophanthus Kombé. Calcium oxalate crystals are absent from all the tissues of the seed."

So far then as this species is concerned, there is general agreement regarding the characters of its seeds and this is supported and amplified by the data now to be presented.

The sample available (S 48) was received in January 1950 from Tabora, Tanganyika, and its identification is confirmed by Monachino of New York. Only the main body of the seed is available, the awns having been removed prior to dispatch.

Superficially the seeds bear little resemblance to those of Strophanthus Kombé. They are lanceolate to ovate-lanceolate in outline and most are pale golden-brown in colour, which is due to a thick covering of woolly hairs. In most cases the hairs are directed towards the apex of the seed, but many of them project outwards, giving the seed a somewhat shaggy appearance which is in sharp contrast to the smooth silky appearance of Kombé seed. The hairs, in the case of these mature seeds of Strophanthus Emini, are very loosely attached and easily rubbed off. /

off. The underlying testa in the present mature material is distinctly reddish-brown in colour and not yellowish-brown as reported by previous workers. Occasional seeds show a distinct greenish tinge, but this is probably indicative of immaturity as the hairs are more firmly attached in such seeds.

The seeds vary in length from 13 to 16 mms., averaging 13.8 mms.; in width from 3.5 to 4.5 mms. and in thickness from 2.0 to 2.5 mms. The apex is acute to subacute and terminates in the broken-off point of the awn. From here a quite inconspicuous and only very slightly-raised, pale-coloured ridge extends downwards on the midline of the ventral aspect to a point about two-thirds of the distance towards the base of the seed. This ridge contains the raphe and it is very noticeable that at the end nearer to the base of the seed it widens out to a spathulate shape. This terminal broadening is seen in a few of the other species of Strophanthus seed but has not been so clearly marked. The hilum again takes the form of a minute scar situated on the ridge just referred to and near the apex of the seed. The micropyle is not distinguishable. The base of the seed is rounded to subacute and is not winged.

Gross Anatomy.

Seeds softened by soaking in 25% alcohol show, on dissection, a white, oily, embryo composed of a short terete radicle pointing towards the apex of the seed and two large white plano-convex cotyledons extending nearly to the base of the seed. The

embryo /

embryo is surrounded by a thin layer of greyish-white endosperm and the whole is enveloped by a thin spermoderm.

Microscopy.

Examination of transverse sections cut midway between the two extremities of the seed show that these are ovate in outline and that the ventral face of the seed is rather less convex than the dorsal one. Apart from the slight ridge which contains the raphe, no peripheral ridges or undulations are present.

The epidermis of the spermoderm consists of a single layer of nearly isodiametric cells 25 to 30 microns in diameter which are only poorly defined in the case of a mature seed, though quite clear in one which is not fully ripe. This degeneration of the epidermis when the seed is fully mature is presumably the explanation of the hairs being readily detached in the ripe seed while remaining firmly attached in the immature seed.

The outer tangential wall of each epidermal cell is extended outwards as a unicellular hair. The anticlinal walls of the epidermal cells are conspicuously thickened, the thickening assuming a broad spindle-shaped form where the adjacent epidermal cells meet.

Lying within the epidermis is a well-defined sub-epidermal layer varying from 9 to 12 microns in thickness and consisting, for the most part, of a few layers /

layers of thin-walled, tangentially-elongated parenchyma. The cells of the innermost or the innermost two layers of this tissue are, in some cases, seen to be nearly isodiametric. This has not been seen before but in the present material it is a very variable feature and not likely to serve for diagnostic purposes. Calcium oxalate crystals are not seen in any of the spermoderm tissues.

The endosperm consists of from five to twelve layers of moderately thick-walled, polygonal cells averaging about 30 microns in diameter and containing oil and protein grains. No calcium oxalate crystals are seen.

The endosperm envelops two well-developed, plano-convex cotyledons lying face to face.

The epidermis of the cotyledon, as seen in transverse view, consists of a single layer of thin-walled tabular cells averaging 14 x 9 microns. The mesophyll is composed of thin-walled parenchyma, the cells varying in shape from rounded to polygonal. Each is about 25 microns in diameter and contains oil and protein grains. A well-marked procambial strand passes medianly down the morphological axis of each cotyledon and represents the midrib. Careful examination in polarised light fails to reveal any crystals of calcium oxalate.

Surface View of the Spermoderm.

Pieces of spermoderm were treated as described under 'Methods' and examined. In such 'surface preparations' the epidermis is seen to consist of elongated /

elongated cells, individuals varying from 90 to 150 microns in length (average 115) and from 30 to 60 microns in width (average 40). The anticlinal walls vary from 6 to 9 microns in thickness and are strongly and uniformly lignified.

The outer tangential wall of each epidermal cell is extended outwards as a unicellular hair. Most of these hairs are bent over at a point near the base and so come to be closely appressed to the seed and directed towards its apex. The intact hairs measure up to 1000 microns in length. Each is unicellular, thin-walled, and about 15 microns in diameter at its base, from which it tapers gradually and regularly to the subacute apex. In general, the hair-wall is only slightly lignified, but there is a rather more strongly lignified rib on that side of the shaft which is adjacent to the seed.

Surface View of the Cotyledon.

A cotyledon is prepared for examination as described under 'Methods'. In such preparations the epidermis is seen to consist of thin-walled polygonal cells averaging about 20 microns in diameter. No stomata are seen.

Strophanthus hispidus P.DC.

The seeds of this species are employed medicinally and, although not recognised by the British Pharmacopoeia, are admitted by the Pharmacopee Francaise (1937) and by the National Formulary of the United /

United States of America.

Reference to seeds of this species is frequently made in the early literature on Strophanthus but the data is most confusing and incomplete. The two main points which emerge are (a) the difficulty of obtaining genuine samples of the material and (b) the fact that these seeds often occur in samples of the seeds of other species.

These two points are emphasised by Mathiesen (1927-28) who reported that his examination of the sixty seven commercial specimens previously referred to and dating from 1907 to 1927 showed that Strophanthus hispidus seed occurred as an adulterant of both Strophanthus gratus and Strophanthus sarmentosus, and also that samples alleged to be genuine Strophanthus hispidus seed frequently consisted of the seed of Strophanthus gratus or Strophanthus sarmentosus.

Mathiesen gave no account of the morphology or histology of the seed, but Wagenaar (1952), in a comparison of the external features of the seeds of Strophanthus Kombé with those of Strophanthus hispidus, stated that those of the former species were greenish-grey in colour and bore a large number of epidermal hairs, whereas those of the latter species were more brownish-grey and possessed fewer epidermal hairs.

In connection with the histology of the two species just referred to, Wagenaar reported that in both cases the spermoderm consisted of a hairy epidermis within which was a subepidermal layer and that the /

the endosperm contained oil, protein grains and small, single needle crystals of calcium oxalate. A difference was, however, reported regarding the cotyledonous tissue. In the case of Strophanthus Kombé the mesophyll cells are said to contain oil and protein grains but no crystals of calcium oxalate, while the corresponding tissue of the seeds of Strophanthus hispidus is reported to contain oil, protein grains and calcium oxalate in the form of cluster crystals.

A fuller account of the seeds of Strophanthus hispidus is given by Perrot (1943) in one of the standard works on Pharmacognosy. He states "the seeds are fusiform in shape and flattened on both sides. They are rounded at the base and vary from 12 to 18 mms. in length. The length of the intact seed (i.e. including the awn) varies from 3 to 5 cms." Later in his description Perrot reports "the length of the main body of the seed varies from 10 to 15 mms., the width from 2 to 3 mms. and the thickness from 1 to 1.5 mms. The colour is russet-brown, more or less yellowish-gold in parts and with a lustrous reflection. The seed is silky to the touch owing to the presence of the yellowish epidermal hairs which are short, closely appressed and always point towards the apex of the seed. The raphe is situated on the convex side of the seed and the hilum is just visible as a minute scar situated on the raphe and near the apex of the seed."

In his account of the microscopical features /

features of this seed, Perrot says "the epidermis consists of cells with thin tangential walls and thickened anticlinal walls, the thickening having a characteristic lenticular form. The outer tangential wall is concave and frequently prolonged into a hair which is bent over at right angles and often more or less broken. Beneath the epidermis is parenchymatous tissue. The endosperm is composed of thick-walled polygonal cells. The cotyledons are large, flattened, and folded back upon themselves. The mesophyll cells contain oil and protein."

This account by Perrot is strongly reminiscent of some of the reports in the early literature on the seed of Strophanthus hispidus and it varies markedly from the features observed in authentic material which is in the possession of the present writer.

A somewhat different description is given in the Pharmacopée Francaise (1937). Here the seeds are reported to be 10 to 15 mms. in length and up to 3 mms. in width. They are said to be narrowly fusiform in shape, shortly attenuated at the base, and with an elongated apex which carries an awn 9 to 10 cms. long and which consists of a slender stalk bearing on its upper part a fan-shaped tuft of silvery-white hairs 3 to 5 cms. in length. The ground-colour of the testa is given as brown but this is said to be obscured by patches of golden-yellow hairs which, in the apical region of the seed, are rather stiff.

One /

One of the faces of the seed is reported to be more convex than the other, and on this latter the raphe is borne and is visible as a ridge on the upper part.

The description in the Pharmacopée Francaise concludes by stating that a thick endosperm occurs under the integument and within the endosperm is an embryo composed of two cotyledons lying face to face.

These descriptions of the seed of Strophanthus hispidus are regarded as too incomplete and at too great variance to enable them to be used for the purpose of comparing the seed with those of other species, and it is proposed to give a description of authentic material, two specimens of which are in the present writer's possession.

The first specimen (S 31) consists of complete follicles and was collected by Dalziel in Northern Nigeria in 1906. Its identity is confirmed (1950) by Monachino of New York. The second (S 60) is of recent date and was collected on the Gold Coast in 1950. Again the identity is confirmed by Monachino.

The follicles average 37 cms. in length. They are fusiform in shape and, prior to dehiscence, 1.5 to 3 cms. in diameter near the middle which is the widest part. They taper rather abruptly towards the base and more gradually towards the apex which is slightly bulbous. Externally the follicles are of

a /

a dull reddish-brown colour, rough, and longitudinally wrinkled. They bear numerous yellowish spots 0.5 to 1.0 mm. in diameter. These are superficial and simulate patches of lichen. The pericarp is hard and woody and is seen to be from 2 to 3 mms. thick in dehiscing follicles. Each follicle contains a large number of awned seeds, the awns pointing towards the apex of the follicle.

The measurement of a number of seeds gives an average total length of 6.5 cms., which is made up as follows:- main body of seed 13 mms., awn 5.2 cms. (plume 3 cms., pedicel 2.2 cms.). The pedicel is cylindrical, yellowish-brown in colour and rather less than 0.5 mm. in diameter. The plume of the awn consists of white, silky hairs and has a total spread of 8 to 10 cms.

One interesting point which emerges from these measurements is that the awn of Strophanthus hispidus is much shorter in relation to the length of the seed than is usually the case, and this makes the seed easily distinguishable from that of Strophanthus Kombe with which it is reported to be easily confused. Unfortunately this feature is of little value in so far as commercial samples are concerned, as these are almost invariably imported free from awns.

Characters of the Main Body of the Seed.

The seeds are distinctly lanceolate in shape and the length varies from 7 to 13 mms., with an average of 9.5 mms. The width varies from 2 to 3.5 mms. and the thickness from 1 to 1.5 mms. As these figures indicate, the seed is appreciably smaller than that /

that of Strophanthus Kombé; it is very much flattened and the edges are acute. The predominating colour is a soft greenish- or yellowish-brown but this is due to a uniform covering of closely appressed and apparently rather short hairs, all of which are directed towards the apex of the seed and which impart a slightly furry appearance. This uniform covering, however, is only seen in seeds which have been carefully preserved after removal from the follicle or in those which are not fully mature, as the hairs are readily detached, and in those which have been allowed to rub against one another bare areas are to be seen. Such areas show the ground-colour of the testa to be reddish-brown. It is noteworthy that the hairs do not appear to be arranged in longitudinal rows as is the case in Strophanthus Kombé. Both faces of the seed are slightly convex. The raphe is situated on the ventral surface and takes the form of an inconspicuous and only slightly raised ridge which, on careful removal of the covering of hairs, is seen to extend along the morphological axis from the apex of the seed to a point about three-quarters of the distance towards the base. The hilum is not seen, as the minute scar which might be expected to indicate its position, is evidently obliterated as a result of the slight scraping which is necessary to remove the covering of hairs so that a search may be made. However, careful examination of a dehiscing follicle shows that the funicle is attached to the seed at the usual point, viz. on the ridge containing the raphe and /

and situated near the apex of the seed.

Gross Anatomy.

Seeds softened by soaking in 25% alcohol show, on dissection, a white embryo consisting of a terete radicle situated near the apex of the seed and two large white plano-convex cotyledons lying face to face and extending nearly to the base of the seed. The embryo is surrounded by a thin layer of greyish-white endosperm and the whole is enveloped by a thin spermoderm.

Microscopy.

Examination of transverse sections cut mid-way between the two extremities of the seed shows that these are elliptical in outline and have no peripheral undulations, with the exception of a slight ridge containing the raphe situated at the mid-point of the ventral face.

The epidermis of the spermoderm consists of a single layer of nearly isodiametric cells, each about 25 microns in size. These have moderately thin tangential walls, the outer one of which is, in the case of nearly all, extended outwards as a unicellular hair. The anticlinal walls of the epidermal cells are conspicuously thickened, the thickening assuming a spindle-shaped form where the adjacent epidermal cells meet.

Lying within the epidermis is well-defined sub-epidermal region 12 to 15 microns thick and consisting of three to five layers of thin-walled tangentially elongated parenchyma.

Calcium /

Calcium oxalate crystals are not seen in any of the spermoderm tissues.

The endosperm consists of from seven to ten layers of thick-walled polygonal cells averaging about 30 microns in diameter and containing oil and protein grains. Occasional aggregate crystals of calcium oxalate are also seen in the endosperm, but the number of such is small. This is not in agreement with the finding of Wagenaar (1932) who reported the presence of single needle crystals of calcium oxalate.

The endosperm envelops two well-developed, plano-convex cotyledons lying face to face.

The epidermis of the cotyledon, as seen in transverse view, consists of a single layer of thin-walled tabular cells averaging 12 x 9 microns. No stomata are seen. The mesophyll is composed of thin-walled polygonal parenchyma averaging nearly 30 microns in diameter. These cells contain oil and protein grains, but careful examination in polarised light fails to reveal any crystals of calcium oxalate. This again is in disagreement with the finding of Wagenaar who reported cluster crystals of calcium oxalate in this tissue. A well-marked procambial strand passes medianly down the morphological axis of each cotyledon and represents the midrib.

Surface View of the Spermoderm.

Pieces of spermoderm were treated as described under 'Methods' and examined. In such 'surface preparations' the epidermis is seen to consist of elongated cells, individuals varying from 65 to 120 microns in length (average 90) and from 20 to

40 /

40 microns in width (average 26). The anticlinal walls vary from 7 to 9 microns in thickness and are uniformly and rather heavily lignified.

The outer tangential wall of nearly every epidermal cell is extended outwards as a unicellular hair which is bent near its base so as to become closely appressed to the seed and directed towards its apex. The intact hairs measure from 300 to 650 microns in length. Each is unicellular, thin-walled and about 15 microns in diameter at the base from which it tapers gradually and regularly to the acute apex. In general, the hair wall is uniformly but only lightly lignified, but in some cases the lignification is confined to a rib on the side of the shaft which is adjacent to the epidermis of the seed.

Calcium oxalate crystals are not seen in any of the spermoderm cells.

Surface View of the Cotyledon.

A cotyledon is prepared for examination as described under 'Methods'. In such preparations the epidermis is seen to consist of thin-walled polygonal cells varying from 15 to 25 microns in diameter. No stomata are seen.

Strophanthus Nicholsoni Holmes

So far as can be traced, the seed of this species has neither been used for medicinal purposes nor does its chemistry (apart from colour reactions) and pharmacology appear to have been investigated.

Little /

Little more than passing reference is made to it in any of the standard works.

This lack of interest, in so far as the botanical characters of the seed are concerned, is most probably due to its outstanding appearance. It is recorded by Mathiesen (1928) as a frequent adulterant of other species of Strophanthus seed, but he always found its presence very obvious by reason of its woolly appearance. It is commonly known as "Woolly Strophanthus", and it is thought very probable that references in the early literature to "White Strophanthus" and "White Zambesi Seed" also refer to this species.

Mathiesen (1928) in a very brief description of the seeds of Strophanthus Nicholsoni, reported that they are white or pale brownish-white in colour and sufficiently characterised by the thick woolly covering of hairs which they bear. Calcium oxalate crystals are claimed to be absent from all the tissues of the seed.

Youngken and Simonian (1950) described the seeds as broadly-lanceolate in shape, averaging 15 mms. in length, 5 mms. in breadth, and 3 mms. in thickness. The surface of the seed is said to be densely covered with long, white to pale yellow, glistening hairs, and the colour of the seed to be white when viewed from the base and yellowish-brown when viewed from the apex.

Youngken and Simonian also reported that in transverse section the spermoderm is characterised by 'numerous irregular ridges projecting outwards', and each ridge is claimed to represent an outgrowth of the epidermis and sub-epidermal tissue. The endosperm and the mesophyll of the cotyledons are said to consist of thin-walled, isodiametric, parenchymatous cells containing fixed oil and protein grains.

It is thought that while the above-mentioned characters are doubtless sufficient to distinguish the seeds of Strophanthus Nicholsoni from those of previously described species, much additional data is required to enable a comparison to be made with the larger number of species available to the present writer.

Only one recent (1950) authentic specimen (S 16) of Strophanthus Nicholsoni is available for examination, and this consists of the main body of the seed, the awns having been removed prior to dispatch.

The seeds of the present sample are yellowish-white in colour due to a dense tangled covering of long, white, silky hairs which are, on the whole, directed towards the apex of the seed and which impart a very characteristic, woolly appearance. The ground-colour of the testa, as seen when the hairs are very carefully scraped off, is fawn but often shows a greenish-yellow tinge. The testa bears a number of regularly-spaced, slightly-raised ridges which are parallel with the morphological axis of the seed.

The seed is lanceolate in shape and somewhat flattened /

flattened dorsiventrally. The length varies from 11 to 16 mms.; the width from 3 to 4.5 mms. and the thickness from 2 to 3 mms. Both the dorsal and the ventral faces of the seed are convex. The raphe is, of course, situated on the latter and takes the form of a yellowish, slightly-raised ridge which extends, parallel with the morphological axis, from a point about one-quarter of the length of the seed distant from the base to the apex where it terminates in the broken-off point of the awn. The raphe is conspicuous in spite of the dense covering of hairs which the seed bears, as it does not appear to bear any hairs itself. The edges of the seed are rounded and the base obtuse.

Gross Anatomy.

Seeds softened by soaking in 25% alcohol show, on dissection, a white embryo consisting of a terete radicle pointing towards the apex of the seed and two large, white, plano-convex cotyledons occupying nearly the whole length of the seed. Much oil is contained in the embryo which is surrounded by a thin layer of greyish-white endosperm. The whole is enveloped by a thin spermoderm.

Microscopy.

Sections cut transversely to the morphological axis at a level midway between the two extremities are ovate to broadly-ovate and conspicuously undulant in outline. These undulations take position from the longitudinal ridges and furrows seen on the surface of the /

the intact seed and the level of the former is frequently 150 microns above the level of the latter. Both the spermoderm and the residual endosperm enter into the formation of these ridges.

The epidermis consists of a single layer of nearly isodiametric cells averaging about 30 microns in size. They have moderately thin tangential walls and thickened anticlinal walls, the thickening assuming a spindle-shaped form where the adjacent epidermal cells meet. The outer tangential wall of apparently every epidermal cell is extended outwards as a unicellular hair which will be described later.

Within the epidermis is a well-marked region, averaging 15 microns in thickness, and consisting, for the most part, of brownish, thin-walled, tangentially-elongated cells. This tissue shows ridges and furrows which correspond in position with those seen on the epidermis but they are less pronounced owing to the occurrence under each epidermal ridge of a small group of thin-walled, nearly isodiametric parenchymatous cells.

Examination in polarised light reveals no crystals in the spermoderm tissues.

The endosperm is composed of 5 to 10 layers of moderately thick-walled cells which are mostly polygonal in outline but sometimes rounded. They average about 35 microns in size and contain both fixed oil and protein grains. The outer surface of the endosperm is seen to be slightly sinuous, the undulations corresponding in position with the ridges and furrows /

furrows exhibited by the spermoderm.

Examination in polarised light shows no crystals of calcium oxalate in the endosperm tissue.

The endosperm surrounds two well-developed plano-convex cotyledons which lie face to face. In transverse section the epidermis of the cotyledon consists of a single layer of thin-walled, tabular cells each measuring about 12 x 9 microns. No stomata are seen. The mesophyll is composed of thin-walled parenchyma, each cell polygonal or rounded in outline and measuring from 20 to 30 microns in diameter. Fixed oil and protein grains are present. A well-marked strand passes medianly down the morphological axis of each cotyledon and represents the midrib. No crystals are seen in these tissues.

Surface View of the Spermoderm.

Pieces of spermoderm were treated as described under 'Methods' and examined. In such 'surface preparations' the epidermis is seen to consist of elongated cells, individuals measuring from 45 to 120 microns in length and from 20 to 30 microns in width. The anticlinal walls average 10 microns in thickness and are heavily and uniformly lignified. The outer tangential wall of each epidermal cell is extended outwards as a unicellular hair bent over near its base so as to be appressed to the surface of the seed and directed towards the awned end. This orientation of the hairs is not, however, always clear and occasionally they present a somewhat tangled /

tangled appearance. The intact hairs are of considerable length and although the longest which could be measured was just over 1900 microns in length, it is estimated that some may attain 2500 microns. At the base the shaft of the hair varies from 15 to 25 microns in diameter and from here they taper gradually and regularly to the acute apex. The hairs have a moderately thick and quite heavily lignified wall. No crystals are seen in the epidermal or sub-epidermal tissues.

Surface View of the Cotyledon.

A cotyledon is prepared for examination as described under 'Methods'. In such preparations the epidermis is seen to consist of thin-walled polygonal cells averaging about 20 microns in diameter. Despite careful examination no stomata are seen.

Strophanthus gratus (Wall & Hook) Franchet

The seed of this species has long been known and is frequently referred to in the earlier literature as an adulterant of the seed of other species of Strophanthus which, at that time, were regarded as being of greater commercial significance. In more recent years, however, the seed of Strophanthus gratus has attained prominence in medicine and this change is reflected in the composition of present-day samples of Strophanthus seed.

Mathiesen (1927-28) in his examination of a large number of commercial samples of Strophanthus seed found that in samples dated prior to 1925 the seeds of Strophanthus gratus were frequently admixed with /

with those of either Strophanthus Kombé or Strophanthus hispidus, whereas in samples dated between 1925 and 1927 no such admixture occurred. The universal opinion of present-day workers is that Strophanthus gratus is one of the few species of Strophanthus seed which can be relied upon to be pure itself and not liable to occur in commercial samples of other species of Strophanthus seed. The truth of the former statement was confirmed by examining two commercial specimens purchased from different sources and in neither case was there the slightest evidence of the seeds of any other species of Strophanthus known to the present writer. This high degree of purity is thought to be due, only in part, to the inherent commercial value of the seed because its morphological characters mark it off very sharply from those of other species of the genus and consequently it can be identified by relatively unskilled workers.

According to the United States Dispensatory (1950) the pharmacology of the seed of Strophanthus gratus was extensively studied during the period 1927 to 1936, and it was found to possess certain very desirable features. The active constituent is the glycoside ouabain (g-strophanthin) of which Bush & Taylor (1952) found 3.6% in the seed. This glycoside is a single stable compound and not a mixture as is the case with k-strophanthin from the seed of Strophanthus Kombé. The two strophanthins referred to exhibit similar pharmacological properties.

Ouabain is recognised by the Pharmacopoeias of many countries including those of Britain, France and /

and America, and it is also included in the International Pharmacopoeia of 1951. In addition to this use which it finds in medicine it is now the accepted standard for determining the pharmacological activity of pharmaceutical preparations made from the seeds of other species of the genus Strophanthus. It is, perhaps, of passing interest to record that ouabain is also present in the wood of various species of Acokanthera, of which one, Acokanthera Schimperi A.DC. (Schweinf.) is recognised by the British Pharmacopoeia 1948 as an additional source of the glycoside.

In spite of the amount of chemical and pharmacological information which has been accumulated relating to the seed of Strophanthus gratus, the botanical data is neither extensive nor is there agreement in all respects between tworelatively recent descriptions. It is felt, therefore, that it might be profitable to make a morphological and histological examination of an authenticated sample of the seed.

Mathiesen (1927-28) reported that the seeds are practically glabrous, compressed, and usually somewhat twisted. The edge is said to be acute and almost winged, and the surface of the testa covered with a fine anastomosis of indentations. The colour is reported as uniform light brown except for the raphe which is somewhat lighter. On microscopic examination Mathiesen found the testa to possess short, fine hairs up to 80 microns in length. Crystals are reported not to occur in any part of the seed.

Youngken and Simonian (1950) gave a similar description /

description of the morphological characters of the seed and quoted the length as from 15 to 19 mms., the width as 2.5 to 3 mms., and the thickness as 1 to 1.5 mms. Transverse sections are said to be elliptical in outline and to possess an undulate margin. The epidermis is described as being devoid of hairs and the anticlinal walls of the epidermal cells are said to possess "spherical to lenticular thickenings". The endosperm is reported to consist of from 9 to 16 layers of cells and to surround an embryo which exhibits two slightly S-shaped cotyledons. Calcium oxalate crystals are reported to be absent from all tissues of the seed.

Only one authenticated sample (S 61) of the seed of Strophanthus gratus is available for examination, and this consists of only the main body of the seed, the awns having been removed prior to receipt. It was collected in French Cameroon, Africa in 1949 and received via Monachino of the New York Botanical Garden, by whom its identity is confirmed.

The seeds of the present sample are very uniform in colour and of a dull, light reddish-brown. To the naked eye they appear to be quite devoid of hairs. Examination with a lens shows that the testa bears a large number of regularly-spaced, very slightly-raised ridges which are, in general, parallel with the morphological axis of the seed.

The seeds are lanceolate in shape and conspicuously flattened dorsiventrally. They vary in length from 14 to 18 mms. (average 16.5); in width

from /

from 4 to 5 mms.; and in thickness from 1.0 to 1.5 mms. The dorsal surface of the seed is flat or very slightly convex and the ventral surface is slightly convex. The raphe is, of course, situated on the midline of the latter and takes the form of a pale yellowish-brown, slightly raised ridge which extends, parallel with the morphological axis of the seed from a point about one-third of the length of the seed away from the base to the apex where it terminates in the broken-off point of the awn. The hilum is visible on this ridge as a small scar situated near the apex of the seed. In the majority of seeds the micropyle can be distinguished as a minute spot situated to one side of the hilum. In each seed of the present sample the dorsal surface also shows a raised ridge which corresponds in position to that present on the ventral face but differs from that containing the raphe in being of the same colour as the adjoining portions of the testa and only extending from near the apex to a point rather short of half the length of the seed. This ridge overlies the terete radicle. The apex of the seed is acute, the base rounded, and the edges acute. There is, however, little evidence of the seeds being twisted as Mathiesen (1928) and Youngken & Simonian (1950) claimed. It is only occasionally that such a seed is seen.

Gross Anatomy.

Seeds softened by soaking in 25% alcohol show, on dissection, a white embryo consisting of a terete /

terete radicle pointing towards the apex of the seed and two large, white, planoconvex cotyledons lying face to face and extending nearly to the base. Much oil is contained in the embryo which is surrounded by a thin layer of greyish-white endosperm. The whole is enveloped by a thin spermoderm.

Microscopy.

Sections cut transversely to the morphological axis of the seed at a point midway between the two extremities are elliptical in outline and the periphery is almost devoid of undulations.

The epidermis consists of a single layer of nearly isodiametric cells about 30 microns in size but in many parts considerable disorganisation is seen, and it is only in a few parts that the characters of the individual cells can be discerned. In those cells which are well defined the tangential walls are moderately thin and in a very few cases the outer wall is seen to be prolonged into a short hair which will be described later. The anticlinal walls are conspicuously thickened, the thickening assuming a broadly spindle-shaped or ovate form where the adjacent epidermal cells meet.

Within the epidermis is a well-defined region measuring about 15 microns in thickness and consisting of a few layers of thin-walled, tangentially elongated cells of brownish aspect.

Crystals of calcium oxalate are not seen in any of the spermoderm tissues.

The endosperm is composed of 6 to 10 layers

of /

of moderately thin-walled, polygonal cells measuring from 25 to 45 microns in diameter and containing fixed oil and protein grains. Crystals of calcium oxalate are not seen on examination in polarised light.

The endosperm envelops two large plano-convex cotyledons which lie face to face. In transverse section the epidermis of the cotyledon is seen to consist of a single layer of thin-walled cells averaging about 15 microns in size. No stomata are seen. The mesophyll is composed of thin-walled, polygonal, parenchymatous cells, each averaging about 30 microns in size. All the mesophyll cells contain protein grains and fixed oil but crystals of calcium oxalate are not seen on examination in polarised light. A well marked strand passes medianly down the morphological axis of each cotyledon and represents the midrib.

Surface View of the Spermoderm.

Pieces of spermoderm were treated as described under 'Methods' and examined. In such 'surface preparations' the epidermis is seen to consist of elongated cells, individuals varying from 65 to 165 microns in length and from 15 to 45 microns in width. The anticlinal walls are from 9 to 12 microns in thickness and though strongly lignified, the middle lamella stands out as the most heavily lignified portion of the wall. The epidermis is almost glabrous but in a few cases the outer tangential wall is extended outwards as a unicellular hair bent over somewhat near its base and directed towards the apex of the seed. These hairs are very characteristic; each /

each is unicellular and from 70 to 90 microns in length. At the base of the hair the shaft averages about 15 microns in diameter and from this point it tapers only slightly to its rounded apex. The wall of the hair is very thin and shows no evidence of lignification. This description of the hairs is in agreement with the findings of Mathiesen (1927-28) but not with those of Youngken & Simonian (1950), who reported the seed as glabrous.

Surface View of the Cotyledon.

A cotyledon is prepared for examination as described under 'Methods'. In such preparations the epidermis isseen to consist of thin-walled, polygonal cells averaging about 15 microns in diameter. No stomata are seen.

Strophanthus mirabilis Gilg

Very few references to this species of Strophanthus can be found in the literature. Monachino (1950) reported that the plant is a greatly-branched bush found growing in Central Africa and it is known to occur in Kenya where the material used for the present work was collected.

The seed does not appear to have been employed in medicine and no pharmacological data relating to it can be traced in the literature.

Chemical investigation appears to have been confined to the identification, by a chromatographic method, of the aglycones produced upon the hydrolysis of the glycosides. Bush and Taylor (1952) who performed /

performed this work, found 0.48% of strophanthidin together with smaller amounts of strophanthidol and periplogenin. This would lead one to expect a much less powerful cardiac action from the seeds of Strophanthus mirabilis than from those of Strophanthus Kombe in which the above workers found 2.4% of strophanthidin together with some strophanthidol. No references can be found relating to the colour reactions of Strophanthus mirabilis when treated with chemical reagents.

Only one authenticated sample (S 10)of this seen is available for examination, and it consists of only the main body of the seed, the awns having been removed prior to receipt. It was received from the National Institute for Medical Research and is part of a collection made within the last few years, though the actual date is not supplied. The identification is confirmed by Kew Botanic Garden where a Herbarium Specimen is retained.

The great majority of the seeds of the present sample are pale yellowish-brown in colour and possess a distinct silvery sheen due to a uniform covering of silky appressed hairs, which are of appreciable length and all of which are directed towards the apex of the seed. The ground-colour of the testa, as seen when the hairs are very carefully scraped off, is of a very pale fawn colour. Careful examination with a lens shows that the tests bears a number of regularly-spaced, slightly-raised ridges which /

which are parallel with the morphological axis of the seed. A few of the seeds are pale olive-green in colour and bear hairs similar to those already described. When these hairs are removed, the ground-colour of the testa is of a stronger green and it bears longitudinal ridges which take the same form as before. It is thought probable that these green seeds are immature.

The seeds are lanceolate in shape and only slightly flattened dorsiventrally. They vary in length from 11 to 17 mms. (average 13 mms.); in width from 2 to 3 mms., and in thickness from 1.5 to 2 mms. Both the ventral and dorsal faces of the seed are convex. The raphe is, of course, situated on the mid-line of the former and takes the form of a pale yellow, very slightly-raised ridge which is parallel with the morphological axis of the seed and which extends for a point situated one-third of the length of the seed distant from the base, to the apex where it terminates in the broken-off point of the awn. The raphe is not readily seen until the hairs have been removed, when it becomes conspicuous by reason of its paler colour. As might be expected, therefore, the hilum is almost impossible to distinguish as it is almost always obliterated during the careful scraping necessary to expose the testa. Occasionally, however, it can be seen on the intact seed and then takes the usual form of a minute scar situated on the raphe and near the apex of the seed. The micropyle is not distinguishable. The apex of the seed is acute and although, as mentioned earlier, only the main body of the seed is available /

available for examination, a few seeds of the present sample still have a sufficient length of the pedicel of the awn attached to show that the latter is not sessile as in some species of Strophanthus. The base of the seed is also acute and, as will be mentioned later, this is due to a "wing" of spermoderm.

Gross Anatomy.

Seeds softened by soaking in 25% alcohol show, on dissection, a white embryo consisting of a terete radicle pointing towards the awned end of the seed and two large white plano-convex cotyledons lying face to face, occupying nearly the whole length of the seed. Much oil is contained in the embryo which is surrounded by a thin layer of greyish-white endosperm. The whole is enveloped by a thin spermoderm which is prolonged at the base of the seed and forms the 'wing', to which reference has already been made.

Microscopy.

Sections cut transversely to the morphological axis of the seed at a point midway between the two extremities are ovate in outline and the periphery is undulant. These undulations take position from the longitudinal ridges and furrows seen on the surface of the intact seed and the former are about 100 microns above the level of the latter. In this species these undulations are confined to the spermoderm tissues.

The epidermis consists of a single layer of nearly isodiametric cells measuring about 25 microns in /

in size. They have moderately thin tangential walls and thickened anticlinal walls, the thickening assuming a spindle-shaped form where the adjacent epidermal cells meet and measuring about 6 microns at the widest part. The outer tangential wall of nearly every epidermal cell is extended outwards as a unicellular hair which will be described later.

Within the epidermis is a well-defined sub-epidermal region measuring 10 to 15 microns in thickness and consisting, for the most part, of brownish, thin-walled, tangentially-elongated cells, measuring 25 to 30 microns in length and 4 to 7 microns in width. This tissue does not exhibit the undulations referred to in the case of the epidermis; the whole area beneath each ridge being occupied by a group of thin-walled, more or less polygonal, parenchymatous cells. It was decided to investigate these ridges at various levels on the morphological axis of the seed. Accordingly, transverse sections were prepared at various points between the two extremities. It was seen that as the apex of the seed is approached, the ridges and furrows become reduced to mere sinuosities in the outline of the section and in these both the spermoderm tissues and the endosperm play a part. No thin-walled, isodiametric parenchyma occur between the epidermis and the sub-epidermal tissue. This is also true of transverse sections cut near the base of the seed. Examination in polarised light shows that calcium oxalate crystals are not present in the spermoderm tissues.

The /

The endosperm is composed of from 4 to 7 layers of moderately thick-walled cells which are mostly polygonal in outline. They average about 35 microns in size and contain both fixed oil and protein grains. The outer face of the endosperm is not sinuous as seen in transverse section, except in the extreme apical and basal regions. Crystals of calcium oxalate are not seen on examination in polarised light.

The endosperm envelops two well-developed cotyledons which are plano-convex in outline and which lie face to face. In transverse section the epidermis of the cotyledon consists of a single layer of thin-walled tabular cells measuring 12 to 20 microns in length and about 9 microns in depth. No stomata are seen. The mesophyll is composed of thin-walled parenchyma, each cell polygonal or rounded in outline and averaging some 20 microns in diameter. All the mesophyll cells contain protein grains and fixed oil but crystals are not seen on examination in polarised light. A well-marked strand passes medianly down the morphological axis of each cotyledon and represents the midrib.

Surface View of the Spermoderm.

Pieces of spermoderm were treated as described under 'Methods' and examined. In such 'surface preparations' the epidermis is seen to consist of elongated cells, individuals varying from 60 to 110 microns in length and from 9 to 24 microns in width. The anticlinal walls average 6 microns in thickness and are uniformly and heavily lignified.

The /

The outer tangential wall of each epidermal cell is extended outwards as a unicellular hair bent over near its base so as to be closely appressed to the surface of the seed and directed towards the awned end. The intact hairs measure from 300 to 600 microns in length. At the base of the hair the shaft averages 15 microns in diameter and from this point it tapers gradually and regularly to the subacute apex. The hairs are rather thin-walled and show little, if any, indication of lignification except for a narrow rib of thickening along the side of the shaft which is adjacent to the epidermis of the seed. This shows slight lignification.

Surface View of the Cotyledon.

A cotyledon is prepared for examination as described under 'Methods'. In such preparations the epidermis is seen to consist of thin-walled, polygonal cells averaging about 15 microns in diameter. Despite careful examination no stomata are seen.

Strophanthus petersianus Klotzsch

Very little information relating to this species can be traced in the literature. Holmes (1893) made a very brief reference to the plant and inferred that the seed is of commercial significance. On the other hand, Mathiesen (1927-28) did not report the seed as occurring in any of the numerous commercial samples which he subjected to examination. It may /

may be remarked, however, that its presence might possibly pass unnoticed as the seed bears a close resemblance to those of certain other species of Strophanthus and no detailed description of it appears to have been published.

So far as can be ascertained, the seed has never been employed in medicine nor has any pharmacological data relating to it been compiled. Chemical investigation appears to have been limited to the identification, by a chromatographic method, of the aglycones produced when the glycosides are completely hydrolysed. By this means Bush and Taylor (1952) found 0.1% of sarmentocymarin. No references can be found which refer to the colour reactions of the seed of Strophanthus petersianus when treated with chemical reagents.

Holmes (1893) reported the plant to be an erect shrub which occurred in Mozambique, and it is known to occur in Nyassaland where the material employed for the present work was collected.

Only one authenticated sample (S 13) of the seed of Strophanthus petersianus is available for examination. It consists of only the main body of the seed, the awns having been removed prior to receipt. It was received from the National Institute for Medical Research and is part of a collection made in 1950. The identity is confirmed by Kew Botanic Garden where a Herbarium Specimen is retained.

Although some variation in colour is noticeable amongst the seeds of the present sample, the majority /

majority are of a dull brown. This is due to the presence of a covering of hairs which are of appreciable length and which are directed towards the apex of the seed. This hair-covering, however, is by no means uniform as many of the seeds show bare patches and a few are practically glabrous. This is presumably due to the hairs being only loosely attached in the mature seed and readily rubbed off by mutual friction. The ground-colour of the testa is of a somewhat dark reddish-brown, and careful examination shows that the surface is not quite smooth but that it bears a number of rather broad, regularly spaced, very slightly raised ridges which are parallel with the morphological axis of the seed. A few of the seeds in the present sample are of a pale olive-green colour. These bear a uniform covering of almost white, silky hairs which are firmly attached to the testa. Such seeds are considered to be immature.

The seeds are lanceolate in shape and noticeably flattened dorsiventrally. They vary from 11 to 14 mms. (average 12.7) in length, from 3.5 to 5 mms. in width, and are mostly about 2 mms. in thickness. Both the ventral and dorsal faces of the seed are convex. The raphe is situated on the midline of the former and takes the form of a slightly-raised ridge which is parallel with the morphological axis of the seed and which extends from a point one-third of the length of the seed distant from the base, to the apex where it terminates in the broken-off point of the awn. In mature seeds the raphe /

raphe is not readily seen unless the hair-covering has been removed. The hilum is difficult to distinguish but when seen it takes the usual form of a minute scar situated on the raphe and near the apex of the seed. The micropyle is not distinguishable. The apex of the seed is acute, the base rounded, and the edges subacute to rounded.

Gross Anatomy.

Seeds softened by soaking in 25% alcohol show, on dissection, a whitish embryo consisting of a terete radicle pointing towards the awned end and two large, white, plano-convex cotyledons lying face to face and occupying nearly the whole length of the seed. Much oil is contained in the embryo which is surrounded by a thin layer of greyish-white endosperm. The whole is enclosed by a thin spermoderm.

Microscopy.

Sections cut transversely to the morphological axis of the seed at a point midway between the two extremities are broadly ovate in outline and the periphery is slightly undulant. These undulations take position from the shallow ridges and furrows seen on the surface of the intact seed. The average height of each ridge above the general level of the epidermis is 75 microns and the breadth, taken as the distance between two adjacent furrows, is about 800 microns. They are, therefore, not prominent but unusually broad. In this species these undulations

are /

are confined to the spermoderm tissues.

The epidermis consists of a single layer of nearly isodiametric cells measuring from 20 to 30 microns in size. When clearly seen, these cells have moderately thin tangential walls and very conspicuously thickened anticlinal walls, the thickening assuming a broad spindle-shaped form where the adjacent epidermal cells meet and varying from 6 to 9 microns at the widest part. The outer tangential wall of each epidermal cell is extended outwards as a unicellular hair which will be described later. In some cases, however, the cells of this epidermal tissue are disorganised, and it is seen as a narrow, brown layer devoid of hairs and without any discernible structure. It is thought that this is the condition reached at which the hairs are readily detached.

Beneath the epidermis is a well-marked, sub-epidermal region 12 to 15 microns in thickness and consisting, as in previous cases, of a few layers of brownish, thin-walled, tangentially-elongated cells. This tissue does not display the sinuosities seen in the epidermis in transverse section, the area beneath each ridge being occupied by a group of thin-walled, somewhat tangentially-elongated, almost colourless, parenchymatous cells. On examination in polarised light, crystals are not seen in any of the spermoderm tissues but, as will be remarked later, they /

they do occur in very small numbers.

The endosperm consists of from 6 to 10 layers of thick-walled, polygonal cells measuring from 30 to 70 microns in size. These cells contain both fixed oil and protein grains but no crystals are seen on examination in polarised light.

The endosperm envelops two well-developed, plano-convex cotyledons which lie face to face. In transverse section, the epidermis of the cotyledon consists of a single layer of thin-walled tabular cells measuring 10 to 20 microns in length and about 10 microns in depth. No stomata are seen. The mesophyll is largely composed of thin-walled, polygonal cells, but a few are radially elongated. The cells contain fixed oil and protein grains, but no crystals of calcium oxalate are seen on examination in polarised light. A well-marked strand passes medianly down the morphological axis of each cotyledon and represents the midrib.

Surface View of the Spermoderm.

Pieces of spermoderm were treated as described under 'Methods' and examined. In such 'surface preparations' the epidermis is seen to consist of elongated cells which vary from 60 to 135 microns in length and from 21 to 36 microns in width. The anticlinal walls are from 9 to 12 microns thick and are lignified. The degree of lignification is only moderately strong and though, for the most part, uniform, striae are sometimes seen and occasionally the middle lamella is seen to be the most heavily lignified /

lignified region. The outer tangential wall of each epidermal cell, except where the disorganisation previously referred to has occurred, is extended outwards as a unicellular hair bent over near its base so as to be closely appressed to the surface of the seed and directed towards the awned end. The intact hairs measure from 450 to 670 microns in length. The shaft of the hair averages 15 microns in diameter at the base and from this point it tapers gradually and regularly to the acute apex. The hairs are thin-walled and show little evidence of lignification except for aslightly-lignified rib of thickening on the side of the shaft adjacent to the epidermis of the seed.

An occasional ill-defined aggregate of calcium oxalate is seen when the preparation is examined in polarised light. This is not evident in transverse section but the crystals are so few in number that the possibility of their being seen in such preparations is somewhat remote.

Surface View of the Cotyledon.

A cotyledon is prepared for examination as described under 'Methods'. In such preparations the epidermis is seen to consist of thin-walled, polygonal cells. Despite careful examination no stomata are seen.

Strophanthus amboensis Engl. & Pax

References to the seed of this species of Strophanthus /

Strophanthus are few and incomplete. Holmes (1893), in discussing the strophanthus seeds of commerce, referred to it, but the information given relates to the identification of the whole plant. Gilg and Schuster (1919) and Mathiesen (1927 and 1928) reported the colour reactions of the seed when treated with sulphuric acid, but in neither case is any account given of the morphological or histological characters except that the latter worker did report the occurrence of "somewhat frequent crystals" in the seed-coat.

The seed of Strophanthus amboensis is not known to have been employed in medicine nor can any pharmacological data be traced. It is probable, however, that it does possess some degree of cardiac activity as Bush & Taylor (1952) found sarverogenin and a trace of sarmentogenin in the seed.

Two authenticated specimens of Strophanthus amboensis are available for examination, viz. S 14 and S.46. S 14 was received from the National Institute for Medical Research. It was collected in Angola in January 1951. S 46 was received from the New York Botanical Garden, together with the information that it was collected in November 1951 at Sptizkuppen, South West Africa. In both cases the awns had been removed prior to receipt so that only the main body of the seed is available for examination.

Report on Specimen S 14.

Very little variation in colour is seen amongst the seeds of this sample. They are fawn in colour /

colour but a slight olive-green tinge is sometimes evident. This colour is due to a uniform covering of hairs which are closely appressed to the seed and which are directed towards its apex. They impart a very characteristic, velvety appearance. The ground-colour of the testa, as seen when the hairs are carefully scraped off, is medium brown. Examination with a lens fails to reveal any longitudinal ridges such as have been observed in the seeds of some other species.

The seeds are lanceolate in outline and conspicuously flattened dorsiventrally. They vary from 11 to 14 mms. (average 12.5 mms.) in length, from 3.5 to 4 mms. in width, and from 1.5 to 2 mms. in thickness. Both the ventral and dorsal surfaces of the seed are slightly convex. The raphe is situated on the former and takes the form of a slightly elevated ridge which extends along the midline of the ventral face from a point about one-third of the length of the seed from the base to the apex where it terminates in the broken-off point of the awn. This ridge is seldom seen until the covering of hairs has been scraped off and then appears of a lighter brown than the testa. Neither the hilum nor the micropyle can be distinguished at this stage. The apex of the seed is acute, the base subacute to rounded, and the edges subacute.

The examination of Specimen S 46 confirms the above characters in every respect though it is noticed that the colour is not quite so uniform. Some of the seeds show a distinct greenish tinge which is, in all probability, indicative of immaturity. A

few /

few are somewhat darker than the majority.

Gross Anatomy.

Both specimens show an identical structure. Seeds softened by soaking in 25% alcohol show, on dissection, a whitish embryo consisting of a terete radicle pointing towards the apex of the seed and two large plano-convex cotyledons lying face to face and occupying nearly the whole length of the seed. Oil is contained in the embryo which is surrounded by a thin layer of greyish endosperm. The whole is enveloped by a thin spermoderm.

Microscopy.

Examination of sections cut transversely to the morphological axis at a point midway between the two extremities are seen to be elliptical in outline. Peripheral undulations are absent except for the ridge containing the raphe which is seen in the centre of the ventral face and is only slightly raised above the surface of the adjacent tissue.

The epidermis is composed of a single layer of nearly isodiametric cells measuring from 25 to 30 microns in size. These cells have moderately thin tangential walls and thickened anticlinal walls, the thickening assuming a spindle-shaped form which is less prominent than in those species previously considered. At its widest part it measures from 6 to 7 microns. The outer tangential wall of each epidermal cell is extended outwards as a unicellular hair which will be described later.

Within /

Within the epidermis is a conspicuous sub-epidermal region about 12 microns in depth and consisting of brownish, thin-walled, tangentially-elongated cells. In a few cases, however, the innermost layer of this sub-epidermal tissue is seen to be composed of much wider cells which have the appearance of thin-walled parenchyma, of which the anticlinal walls are conspicuously oblique. These cells average 30 microns in depth and 75 to 150 microns in length. On examination in polarised light, calcium oxalate crystals are not seen in any of the spermoderm tissues. This is not in agreement with Mathiesen (1927-28) who reported the presence of crystals but did not give any account of the form which they took.

The endosperm is composed of from 6 to 10 layers of moderately thick-walled, polygonal cells which contain oil and protein grains. Calcium oxalate crystals are not seen in any of these cells.

The endosperm envelops two well-developed, plano-convex cotyledons which lie face to face. In transverse section the epidermis of the cotyledon consists of a single layer of thin-walled, tabular cells which show more variation in size than has been observed in the species previously examined. Their length varies from 12 to 18 microns and their depth from 6 to 12 microns. No stomata are seen. The mesophyll consists of thin-walled, rounded to polygonal parenchymatous cells which average 20 microns in diameter and /

and which contain oil and protein grains. Calcium oxalate crystals are not seen in the cotyledonous tissues. A well-marked strand passes medianly down the morphological axis of each cotyledon and represents the midrib.

Surface View of the Spermoderm.

Pieces of spermoderm were treated as described under 'Methods' and examined. In such 'surface' preparations the epidermis is seen to consist of elongated cells which vary from 50 to 100 microns in length and from 30 to 40 microns in width. The anticlinal walls measure up to 8 microns in thickness and are uniformly but not heavily lignified. The outer tangential wall of each epidermal cell is extended outwards as a unicellular hair bent over near its base so as to be closely appressed to the seed and directed towards its apex. The intact hairs measure from 250 to 750 microns in length and each is about 20 microns in diameter at its base. They taper gradually and regularly to the subacute apex. The hairs are thin-walled and show no evidence of lignification. As previously reported, no crystals of calcium oxalate are seen.

Surface View of the Cotyledon.

A cotyledon is prepared for examination as described under 'Methods'. In such preparations the epidermis is seen to consist of thin-walled, polygonal cells averaging about 20 microns in size. Despite careful examination, no stomata are seen.

Both /

Both the Specimens of Strophanthus amboensis agree in all respects with the microscopical description given above and it is noticeable that neither shows the crystals of calcium oxalate to which Mathiesen (1927-28) made reference.

Strophanthus Barteri Franchet

Few references to this species of Strophanthus can be traced in the literature. Monachino (1950) reported that it is a relatively rare plant found in Tropical Africa. Mathiesen (1927-28) made brief reference to the seed and reported finding "somewhat frequent crystals". This latter worker also examined the colour reactions of the seed when treated with sulphuric acid and compared his findings with those of Gilg and Schuster (1919), who had performed this same work some twenty years earlier.

The seed does not appear to have been employed in medicine nor can any pharmacological data be traced. It is, however, reported by Bush and Taylor (1952) to contain the aglycone strophanthidin and might be expected, therefore, to possess some degree of cardiac activity.

Only one authenticated specimen (S 15) of the seed is available for examination. It was supplied by the National Institute for Medical Research, together with the information that it had been collected in March 1950 near Ibadan, S. Nigeria. The awns had been removed prior to receipt.

The external features of the seed of Strophanthus Barteri are very characteristic and are sufficient /

ient to distinguish it very sharply from the seeds of the other species of this genus at present in the present writer's possession.

The seeds of the present sample are of a uniform, dull, reddish-brown colour and to the naked eye slightly rough but not noticeably hairy. Examination with a lens fails to reveal any longitudinal ridges on the surface of the testa. They are lanceolate in outline and conspicuously flattened dorsi-ventrally. They vary in length from 8.5 to 10 mms. (average 9.35 mms.), in width from 2 to 2.5 mms., and in thickness about 1 mm. The dorsal surface of the seed is slightly convex and the ventral either flat or slightly convex. The raphe is, of course, situated on the latter and takes the form of a slightly raised ridge which extends along the midline and parallel with the morphological axis of the seed from a point about one-third of the length of the seed away from the base, to the apex where it terminates in the broken-off point of the awn. The hilum is difficult to distinguish but occasionally it can be seen as a minute scar situated on the ridge containing the raphe and near to the apex of the seed. The micropyle is not seen. The apex of the seed is sharply acute and it is a feature of the present sample that many of the seeds still have a portion of the pedicel of the awn, which measures from 0.5 to 2 cms. in length. In these the pedicel is seen to be pale yellowish-brown in colour, cylindrical and about 0.5 mm. in diameter. This demonstrates that the awn is not sessile. /

sessile. The edges of the seed are subacute and the base rounded to subacute.

Gross Anatomy.

Seeds softened by soaking in 25% alcohol show, on dissection, a whitish, oily embryo consisting of a terete radicle pointing towards the awned end and two white, plano-convex cotyledons lying face to face and extending nearly the whole length of the seed. The embryo is surrounded by a thin layer of greyish-white endosperm which is, in turn, enveloped by a thin brown spermoderm.

Microscopy.

Sections of the seed cut transversely to the morphological axis at a point midway between the two extremities are narrowly-ovate in outline and the periphery is free from undulations, except for the slightly raised ridge containing the raphe which is seen on the ventral face.

The epidermis consists of a single layer of nearly isodiametric cells which are smaller than usual and only measure some 20 microns in size. The tangential walls of these cells are thin, and those of the outer are extended outwards as unicellular hairs which will be described later. The anticlinal walls of the epidermal cells are thickened, the thickening assuming a spindle-shaped form where the adjacent epidermal cells meet.

Within the epidermis is a well-marked region averaging about 9 microns in thickness and consisting of /

of poorly-differentiated, brownish, thin-walled, tangentially-elongated cells. The innermost layer of cells of this tissue are sometimes seen to be split off from the remainder but this is a very variable feature and not thought to be of any diagnostic significance.

Crystals of calcium oxalate are not seen in any of the spermoderm cells.

The endosperm consists of from 8 to 12 layers of moderately thick-walled isodiametric cells which are mostly polygonal in outline but sometimes rounded. These cells contain fixed oil and protein grains but no crystals of calcium oxalate are seen in polarised light.

Within the endosperm are two large, plano-convex cotyledons. In transverse section the epidermis of the cotyledon is seen to consist of a single layer of thin-walled tabular cells measuring about 12 x 8 microns. No stomata are seen. The mesophyll is composed of thin-walled, parenchymatous cells measuring 20 to 40 microns in size and varying in outline from polygonal to rounded. Again oil and protein grains are seen but no crystals of calcium oxalate.

Surface View of the Spermoderm.

Pieces of spermoderm are treated as described under 'Methods' and examined. In such 'surface' preparations the epidermis is seen to consist of elongated cells, individuals varying from 90 to 200 microns in length and from 20 to 30 microns in width

The /

The anticlinal walls average 9 microns in thickness and are uniformly and strongly lignified. The outer tangential wall of each epidermal cell is extended outwards as a unicellular hair bent over near its base so as to be directed towards the awned end of the seed but closely appressed as is usually the case. The intact hairs are relatively short and measure only 90 to 150 microns in length. At the base of the shaft they vary in diameter from 15 to 25 microns and from here they taper gradually and regularly to the acute apex. The cell-wall is thin but seldom shows any lignification. Occasionally, however, a slightly lignified rib is seen on the side of the shaft adjacent to the epidermis of the seed. As previously reported in connection with the transverse section, crystals of calcium oxalate are not seen. This is not in agreement with Mathiesen (1927-28) who reported the presence of crystals.

Surface View of the Cotyledon.

A cotyledon is prepared for examination as described under 'Methods'. In such preparations the epidermis is seen to consist of thin-walled, polygonal cells averaging about 20 microns in size. No stomata are seen.

Strophanthus Arnoldianus Wildem & Th. Dur.

The few references to this species of Strophanthus which can be traced refer, in nearly every case, to the plant itself and no description of the seed can be found. It does not appear to have been employed /

employed in medicine and no pharmacological data can be traced.

Bush & Taylor (1952) reported that their examination of the seed revealed only a trace of the aglycone strophanthidol so that the glycoside content of the seed is apparently small.

Mathiesen (1927-28) made a brief reference to the seed. He reported the colour reaction on treatment with sulphuric acid and also the occurrence of "somewhat frequent crystals" in the seed-coat.

Only one authenticated sample (S 47) of the seed of Strophanthus Arnoldianus is available for examination and it consists of only the main body of the seed, the awns having been removed prior to receipt. This sample was received from Monachino of the New York Botanical Garden, by whom its identity is confirmed. It was collected in 1949 in Kisantu, Belgian Congo.

The seeds of the present sample are of a uniform, dull yellowish-green colour, but at certain angles they present a greyish tinge. This external colour is largely due to a thin covering of apparently rather short hairs which are not arranged in longitudinal rows but which, as in the other hair-bearing species of Strophanthus seeds, are closely appressed and directed towards the apex of the seed. The ground-colour of the testa, as seen when the hairs are carefully scraped off, is pale reddish-brown. Examination with a lens fails to reveal any of the longitudinal ridges on the surface of the testa such as have been seen in a number of other species. /

species.

The seeds are lanceolate in shape and somewhat flattened dorsiventrally. They vary in length from 10 to 13 mms. (average 11 mms.); in width they are about 3 mms. and in thickness about 1 mm. The dorsal surface of the seed is convex and the ventral surface either flat or very slightly convex. The raphe is situated on the latter and takes the form of a slightly-raised, yellowish ridge which extends, parallel with the morphological axis, from a point about one-quarter of the length of the seed distant from the base, to the apex where it terminates in the broken-off point of the awn. The hilum is readily visible on this ridge as a small scar situated near the apex of the seed. The micropyle is only seen with great difficulty and takes the usual form of a minute point situated to one side of the ridge containing the raphe. The apex of the seed is acute, the base rounded or truncate, and the edges acute.

Gross Anatomy.

Seeds softened by soaking in 25% alcohol show, on dissection, a white oily embryo consisting of a terete radicle pointing towards the awned end of the seed and two large white, plano-convex cotyledons lying face to face and extending nearly to the base. The embryo is surrounded by a thin layer of greyish-white endosperm and the whole is enveloped by a thin spermoderm.

Microscopy.

Sections cut transversely to the morphological /

ical axis at a point midway between the two extremities are elliptical in outline and without peripheral undulations except for the ridge containing the raphe which is seen in the centre of the ventral face.

The epidermis consists of a single layer of cells which are somewhat elongated radially, a feature which has not been observed in any of the species previously examined. They average some 30 microns in height and some 18 microns in length. These epidermal cells have thin tangential walls and the outer wall of each cell is extended outwards as a unicellular hair which will be described later. The anticlinal walls of the epidermal cells are thickened, the thickening assuming the usual spindle-shaped form and being about 6 microns thick at its widest point. Owing, however, to the radial elongation of the cell, it tends to present a narrower appearance than is the case with other species previously examined. Beneath the epidermis is a well-defined region, the greater part of which averages about 15 microns in thickness. Occasionally, however, it is considerably greater in thickness and sometimes reaches 60 microns. This wide variation in the thickness of this sub-epidermal region is not associated with a corresponding variation in the number of cells in the layer but is almost entirely due to the cells of the innermost layers possessing larger cell cavities. At the pointed ends of the transverse section some proliferation of the hypodermal tissue does occur and it takes the form of an isosceles-triangle-shaped group of thin-walled, isodiametric, parenchymatous cells situated between the /

the epidermis and the sub-epidermal tissue. This is responsible for the acute edge which is seen in the majority of the seeds examined. Examination of the spermoderm in polarised light reveals the presence of calcium oxalate crystals in the sub-epidermal tissue. The number present is relatively small and they occur either as single cubical crystals about 20 microns in size or as conglomerates of about the same size or slightly larger. The two types are present in approximately equal numbers.

The endosperm is composed of from 7 to 12 layers of moderately thick-walled cells which are mostly polygonal in outline and measure from 20 to 30 microns in diameter. They contain both fixed oil and protein grains. Examination in polarised light reveals no well-defined crystals of calcium oxalate but a large number of minute doubly-refracting specks are seen. These average about 2 microns in diameter and are probably crystals of calcium oxalate.

Within the endosperm are two large cotyledons, plano-convex in outline and lying face to face. In transverse section the epidermis of the cotyledon is seen to consist of a single layer of thin-walled, nearly isodiametric cells measuring about 12 microns in size. No stomata are seen. The mesophyll is composed of thin-walled, parenchymatous cells which are rounded to polygonal in outline and which average about 25 microns in size. The mesophyll cells contain fixed oil and protein grains but no crystals of calcium oxalate are seen on examination in polarised light. /

light. A well-marked strand passes medianly down the morphological axis of each cotyledon and represents the midrib.

Surface View of the Spermoderm.

Pieces of spermoderm were treated as described under 'Methods' and examined. In such 'surface preparations' the epidermis is seen to consist of somewhat elongated cells, individuals varying from 45 to 110 microns in length and from 25 to 45 microns in width. They therefore appear to be less elongated than is the case with previous species examined. The anticlinal walls of the cells vary from 6 to 8 microns in thickness and are strongly and uniformly lignified. The outer tangential wall of each epidermal cell is extended outwards as a unicellular hair bent over near its base so as to be closely appressed to the seed and directed towards its apex. The intact hairs are of moderate length and measure from 250 to 350 microns. At the base of the hair the shaft averages 20 microns in diameter and from this point it tapers gradually and regularly to the apex which varies from acute to subacute. The hairs are thin-walled and either only very slightly lignified or non-lignified.

Surface View of the Cotyledon.

A cotyledon is prepared for examination as described under 'Methods'. In such preparations the epidermis /

epidermis is seen to consist of thin-walled, polygonal cells measuring from 15 to 20 microns in diameter. No stomata are seen.

Strophanthus Boivini Baill.

Very little information relating to this species of Strophanthus is to be found in the literature. The plant is known to occur in Madagascar where the material used in the present investigation was collected. It is also reported by Monachino (1950) to have been cultivated in Calcutta and on the island of Reunion in the Indian Ocean.

No medical, pharmacological, chemical, or botanical data relating to the seed can be traced.

Only one specimen (S 49) of the seed of Strophanthus Boivini is available for examination, and this consists of the main body of the seed, the awns having been removed prior to receipt. It was received from Monachino of the New York Botanical Garden, by whom its identity is confirmed, with the information that it was collected in Madagascar about December 1950.

The seeds of the present sample are of a dull green to greenish-brown colour and possess a silvery-grey sheen due to a covering of rather short, silky hairs. These hairs are closely appressed to the seed and are directed towards its apex. The ground-colour of the testa, as seen when the hairs are carefully scraped off, is pale reddish-brown, and /

and careful examination of this surface fails to reveal any longitudinal ridges and furrows such as have been seen in a number of previous species.

The seeds are lanceolate in shape and conspicuously flattened dorsiventrally. They vary in length from 8 to 10 mms. (average 9.6 mms.), their width is about 3 mms. and their thickness slightly under 1 mm. Both the ventral and dorsal surfaces of the seed are slightly convex. The raphe is situated on the former and is seen as a slightly-raised, lighter-coloured ridge which extends along the midline from a point about one-fifth of the length of the seed distant from the base, to the apex where it terminates in the broken-off point of the awn. Its position is obvious even before the surface hairs have been scraped off the testa and the hilum can be seen on it as a minute scar situated near the apex of the seed. The micropyle cannot be distinguished. The apex of the seed is acute, the base rounded to subacute, and the edges acute.

Gross Anatomy.

Seeds softened by soaking in 25% alcohol show, on dissection, a white oily embryo consisting of a terete radicle pointing towards the awned end of the seed and two large, white, plano-convex cotyledons lying face to face and occupying nearly the whole length of the seed. The embryo is surrounded by a thin layer of greyish-white endosperm and the whole is enveloped by a thin spermoderm.

Microscopy. /

Microscopy.

Sections cut transversely to the morphological axis of the seed at a point midway between the two extremities are seen to be narrowly-ovate in outline and no peripheral undulations are present with the exception of the raised ridge containing the raphe which is seen in the centre of the ventral face of the seed.

The epidermis of the spermoderm consists of a single layer of nearly isodiametric cells measuring 25 to 30 microns in size and possessing one very unusual feature. In the seeds of those species of Strophanthus previously reported upon, the tangential walls of the epidermal cells have been found to be moderately thin, and while this is true here of the outer tangential walls, it is seen that the inner shows a marked irregularity in thickness. This condition cannot be investigated in the transverse section and is deferred until later in this report. The outer tangential walls of the epidermal cells are also a little unusual in that in some of the cells this wall is seen to have collapsed while in others it is extended outwards to a slight extent and part of it is prolonged into a unicellular hair which will be described later. The anticlinal walls of the epidermal cells are thickened, the thickening assuming a moderately broad spindle shape where the adjacent epidermal cells meet.

Beneath the epidermis is a well-defined region about 15 microns thick and consisting, as in previous /

previous cases, of a few layers of very narrow, thin-walled, tangentially-elongated cells of brownish aspect. The only other tissue seen in the spermoderm is a group of thin-walled, isodiametric, parenchymatous cells which occur at each of the pointed ends of the transverse section between the epidermis and the sub-epidermal tissue. Examination in polarised light shows that crystals of calcium oxalate are not present in any of the spermoderm cells.

The endosperm consists of from 6 to 13 layers of moderately thick-walled cells which vary from 15 to 40 microns in size. The majority of these cells are polygonal in outline but a few are rounded. They all contain fixed oil and protein grains. Crystals of calcium oxalate are not seen when the endosperm is examined in polarised light.

The endosperm envelops two well-developed, plano-convex cotyledons which lie face to face. In transverse section the epidermis of the cotyledon is seen to consist of a single layer of thin-walled, tabular cells which are some 9 microns in depth and from 9 to 12 microns in length. No stomata are seen. The mesophyll is composed of thin-walled parenchyma, each cell rounded or polygonal in outline and averaging about 25 microns in diameter. They contain protein grains and fixed oil. In polarised light the mesophyll tissue is seen to contain numerous well-defined crystals of calcium oxalate. These all occur as cluster crystals and measure from 10 to 15 microns in diameter. A well-marked strand passes medianly /

medianly down the morphological axis of each cotyledon and represents the midrib.

Surface View of the Spermoderm.

Pieces of spermoderm were treated as described under 'Methods' and examined. In such 'surface preparations' the epidermis is seen to consist of elongated cells, individuals varying from 30 to 80 microns in length and from 15 to 30 microns in width. Their anticlinal walls average 9 microns in thickness and they are strongly but not uniformly lignified. The middle lamella being the most heavily lignified part. In this preparation an explanation is readily seen for the irregularity of the inner tangential wall which was remarked upon in the description of the transverse section. Reticulately arranged ribs of thickening, 3 to 5 microns wide, are present on this wall but these differ from the thickening on the anticlinal walls of the cells in not being lignified. The outer tangential wall of many, but by no means all, of the epidermal cells is extended outwards as a unicellular hair bent over near to its base so as to be closely appressed to the seed and directed towards its apex. The intact hairs measure from 250 to 350 microns in length. At the base of the hair the shaft averages 15 microns in diameter and from this point it tapers gradually and regularly to its subacute apex. The hairs are thin-walled and, in general, non-lignified, though occasionally slight but uniform lignification is seen in the basal half or one-third of the shaft.

Surface /

Surface View of the Cotyledon.

A cotyledon is prepared for examination as described under 'Methods'. In such preparations the epidermis is seen to be composed of thin-walled, polygonal cells measuring from 15 to 20 microns in diameter. Despite careful examination no stomata are seen. The crystals of calcium oxalate referred to in the report of the transverse section are again seen and a count of these was made in the same manner as for Strophanthus sarmentosus.

Field Counts - 41; 47; 39; 41; 43.

Mean = 42

Diameter of Field = 290 microns = 0.063 sq. mm.

Therefore the number of crystals per sq. mm. = 667.

Strophanthus Gossweilerii Hess

This is a new species of Strophanthus, the botanical description of which Dr. Hess plans to publish at an early date. The material was collected in Vila Arriaga, Angola during 1951 and a sample (S 50) of seed received from Monachino of the New York Botanical Garden. No complete seeds are available for examination, the awns having been removed prior to dispatch.

All the seeds of the present sample are of a golden-brown colour and possess a very distinct sheen which is obvious when the seed is viewed from the base or the apex but not when it is seen from the side. This sheen is due to a uniform covering of /

of silky appressed hairs which appear to be of appreciable length and all of which are directed towards the apex of the seed. The ground colour of the testa as seen when the hairs are carefully scraped off is a rather dark reddish-brown and this is the colour which is often evident when the intact seed is viewed laterally. Careful examination of the exposed testa also shows that it is without longitudinal ridges except in the apical region of the seed. Here, such ridges can be seen though they are not conspicuous.

The seeds are lanceolate in shape and somewhat flattened dorsiventrally. They vary from 10 to 13 mms. (average 11.6 mms.) in length, from 3 to 3.5 mms. in breadth and are about 2 mms. in thickness. Both the dorsal and ventral surfaces of the seed are convex. The raphe is situated on the latter and takes the form of a rather inconspicuous, slightly raised ridge along the midline and parallel with the morphological axis of the seed from a point about one-quarter of the length of the seed away from the base to the apex where it terminates in the broken-off point of the awn. The raphe becomes a little more conspicuous when the hairs have been removed. Neither the hilum nor the micropyle are visible. The apex of the seed is acute, the base subacute, and the edges rounded.

It will be noticed that, in so far as the above macroscopical characters are concerned, this seed bears quite a close resemblance to that of Strophanthus amboensis.

Gross /

Gross Anatomy.

Seeds softened by soaking in 25% alcohol show, on dissection, a white embryo composed of a terete radicle pointing towards the apex of the seed and two large, white, plano-convex cotyledons lying face to face and occupying nearly the entire length of the seed. The embryo is surrounded by a thin layer of greyish-white endosperm which is, in turn, enveloped by a thin spermoderm.

Microscopy.

Sections cut transversely to the morphological axis of the seed at a point midway between the two extremities are ovate in outline and devoid of peripheral undulations. The epidermis is composed of a single layer of nearly isodiametric cells measuring about 30 microns in size. They have moderately thin tangential walls and the outer is, in nearly every case, extended outwards as a unicellular hair which will be described later. The anticlinal walls are thickened, the thickening assuming a spindle-shaped form where the adjacent epidermal cells meet and being about 9 microns thick at the centre which is its widest part.

Within the epidermis is a well-developed, brownish coloured region 10 to 30 microns in thickness and composed of thin-walled, tangentially-elongated cells.

Examination in polarised light reveals that calcium oxalate crystals are not present in any of the spermoderm tissues referred to above.

Owing to the occurrence of the slight longi-

tudinal /

tudinal ridges previously referred to as present on the testa in the apical region of the seed, it was decided to investigate their structure as seen in transverse section. Accordingly, sections were prepared in the same manner as before and examined. It was seen that the ridges are almost entirely confined to the epidermis. There is no proliferation of the sub-epidermal tissue previously mentioned and the tissue beneath each raised portion of the epidermis consists of a small group of thin-walled, isodiametric, parenchymatous cells.

The endosperm consists of from 5 to 12 rows of moderately thick-walled cells, most of which are polygonal in outline and measure between 15 and 45 microns in diameter. These cells contain fixed oil and protein grains but calcium oxalate crystals are not seen when the tissue is examined in polarised light.

The endosperm envelops two well-developed, plano-convex cotyledons which lie face to face. The epidermis of the cotyledon as seen in transverse section consists of a single layer of thin-walled, tabular cells, individuals measuring about 9 microns in depth and from 9 to 15 microns in length. No stomata are seen. The mesophyll is composed of thin-walled parenchyma, each cell polygonal or rounded in outline and averaging about 25 microns in diameter. All the mesophyll cells contain protein grains and some fixed oil but crystals of calcium oxalate are not seen when the tissue is examined in polarised light. /

light. A well-marked strand passes medianly down the morphological axis of each cotyledon and represents the midrib.

Surface View of the Spermoderm.

Pieces of spermoderm were treated as described under 'Methods' and examined. In such 'surface preparations' the epidermis is seen to consist of elongated cells, individuals varying from 45 to 100 microns in length and from 10 to 30 microns in width. The anticlinal walls are about 9 microns in thickness and are only very slightly lignified. The outer tangential wall of each epidermal cell is extended outwards as a unicellular hair bent over near its base so as to be closely appressed to the seed and directed towards the awned end. The intact hairs measure up to 500 microns in length. At the base of the hair the shaft is about 15 microns in diameter and from this point it tapers regularly and gradually to its acute apex. The hairs are thin-walled and only very slightly but uniformly lignified.

Surface View of the Cotyledon.

A cotyledon is prepared for examination as described under 'Methods'. In such preparations the epidermis is seen to consist of thin-walled, polygonal cells measuring from 15 to 20 microns in size. Despite careful examination no stomata are seen.

Strophanthus divaricatus Wall .

Only a few references to this species of Strophanthus /

Strophanthus can be traced in the literature. It is reported by Kerklots (1948) to be common in the Orient and frequently to be seen in South China and in the Hong Kong area where it may occur as a high climber or as a small branched shrub according to the particular conditions.

The seed is referred to by Holmes (1893) as a species of Strophanthus found in South China but no further information is given.

Little, if any, subsequent interest appears to have been taken in the seeds and, so far as can be traced, they have never been reported as occurring admixed with the seeds of any other species of Strophanthus.

Two specimens of Strophanthus divaricatus are available for examination. The first, (S 30), consists of a pair of dehiscing follicles. It is part of a collection made by J. M. Dalzell in China in 1901 and was obtained from the Herbarium of the Royal Botanic Garden, Edinburgh. Owing to its age, its seed is considered unsuitable for the present work, though a brief account of the features of the pericarp and of the awn which seed bears, are included. The second specimen (S 51) consists of only the main body of the seed. It was collected in December 1950 at Hong Kong and received in May 1952 from Monachino of the New York Botanical Garden by whom its identity is confirmed. This latter specimen is employed for all purposes other than those previously mentioned.

The fruit consists of two follicles which diverge from one another by rather more than 180°.

Each /

Each measures 11 cms. in length. Externally they are dark reddish-brown in colour and bear numerous conspicuous, longitudinal wrinkles. The widest part of the follicle is below its centre where it measures some 2.5 cms. in diameter. From this point it tapers regularly to the acute apex but only slightly towards the base. The pericarp is hard and woody; 7 mms. thick at the base of the follicle and gradually decreasing to 3 mms. in thickness near the apex.

The seeds bear the characteristic awn but this is short and only averages some 2 cms. in length. Of this total length the upper 1.5 cms. is plumose and bears a very large number of fine, white, glistening hairs which give a spread of 7 cms.

The seeds of specimen S 51 are of a dull, greenish-brown colour and, so far as can be seen with a hand-lens, devoid of hairs. The testa bears a number of regularly-spaced, slightly-raised ridges which are parallel with the morphological axis of the seed but these are more conspicuous on the dorsal surface of the seed than they are on the ventral.

The seeds are lanceolate in shape and conspicuously flattened dorsiventrally. They vary in length from 16 to 17 mms.; in width from 2 to 3.5 mms. and in thickness from 1 to 1.5 mms. It is noticed, however, that they are less regularly lanceolate than is usually the case and many of the seeds are rather sinuous in outline. The ventral face of the seed is convex but the dorsal varies from almost flat to convex. The raphe is situated on the former and takes the form of a very conspicuous, slightly-raised, pale yellowish-brown /

yellowish-brown ridge which extends along the midline and parallel with the morphological axis of the seed from a point about one-sixth of the length of the seed distant from the base, to the apex where it terminates in the broken-off point of the awn. The hilum is easily seen on this ridge as a small scar situated near the apex of the seed. The micropyle is visible as a minute point at one side of the hilum. The apex of the seed is acute, the base subacute to rounded, and the edges acute.

Gross Anatomy.

Seeds softened by soaking in 25% alcohol show, on dissection, a white embryo consisting of a rather short, terete radicle pointing towards the awned end of the seed and two large, thin, plano-convex cotyledons lying face to face and extending almost to the base of the seed. The embryo is surrounded by a thin layer of greyish-white endosperm and the whole enveloped by a thin spermoderm.

Microscopy.

Sections cut transversely to the morphological axis at a point midway between the two extremities are elliptical in outline and the periphery is conspicuously undulant on the dorsal side of the seed but less so on the ventral. These undulations take position from the longitudinal ridges and furrows seen on the surface of the intact seed but in this species the thickness of the spermoderm is practically constant around the transverse section and the undulations referred to are caused by the occurrence of longitudinal ridges on the outer face of /

of the endosperm. This is the first case where these ridges have been caused solely by the configuration of the endosperm.

The epidermis of the spermoderm consists of a single layer of cells, the radial dimensions of which vary from 15 to 18 microns. In a tangential direction, however, they show a wide variation and are seen to measure from 15 to 40 microns. They are, therefore, the longest epidermal cells which have been encountered in any species of Strophanthus up to the present. The tangential walls of these cells are moderately thin and in a few cases the outer wall is extended outwards as a unicellular hair. These will be described later, but it is noticed here that they do not appear to be of any appreciable length. The anticlinal walls of the epidermal cells are thickened but the thickening does not always assume the characteristic spindle-shaped form which is seen in all the species previously examined. The spindle-shaped form of thickening is seen in those epidermal cells which do not exceed about 30 microns in length but in those which exceed this figure the thickening, which occasionally measures as much as 15 microns where two adjacent epidermal cells meet, is parallel with the anticlinal wall and tapers very abruptly when the tangential wall is approached.

Beneath the epidermis is a well marked, brownish region varying from 10 to 14 microns in thickness and composed of thin-walled, tangentially elongated cells. This hypodermal tissue shows a tendency to split near the centre of its thickness forming narrowly elliptical, /

elliptical, tangentially-elongated cavities.

Examination in polarised light shows that calcium oxalate crystals are not present in any of the spermoderm tissues.

The endosperm is composed of from 7 to 12 layers of moderately thick-walled, polygonal cells averaging about 30 microns in diameter except for the innermost layer which consists of almost tabular cells and resembles an epidermis. As previously mentioned, the outer edge of the endosperm, as seen in transverse section, is undulant. The endosperm cells contain much fixed oil and protein grains but calcium oxalate crystals are not seen when the tissue is examined in polarised light.

Within the endosperm are two well-developed, plano-convex cotyledons lying face to face. As seen in transverse section they are longer and narrower than has been seen before. The epidermis of the cotyledon consists of a single layer of thin-walled tabular cells averaging about 12 x 9 microns in size. No stomata are seen. The mesophyll is composed of thin-walled parenchyma, each cell polygonal or rounded in outline and measuring from 15 to 20 microns in diameter. All the mesophyll cells contain protein grains and fixed oil but calcium oxalate crystals are not seen when examined in polarised light. A well-marked strand passes medianly down the morphological axis of each cotyledon and represents the midrib.

Surface View of the Spermoderm.

Pieces of spermoderm were treated as described under 'Methods' and examined. In such 'surface preparations' /

preparations' the epidermal cells are seen to vary widely both in size and shape. Many of these cells are long and narrow, measuring up to 120 microns in length and from 6 to 21 microns in width; others are nearly isodiametric and measure from 20 to 60 microns in diameter; a few are transversely elongated and measure up to 50 x 20 microns. The anticlinal walls of the epidermal cells measure from 10 to 15 microns in thickness and although all parts of the wall are strongly lignified, it is noticeable that the middle lamella is the most heavily lignified portion. A few ribs of thickening are also seen on the inner tangential wall of each cell. In general appearance these resemble the ribs seen on the corresponding wall of the epidermal cells of Strophanthus Boivini but they differ in that they are less conspicuous, only about 5 microns in width and, although generally non-lignified, they sometimes show slight lignification. No reticulate arrangement of these ribs is seen.

The outer tangential wall of a few of the epidermal cells is extended outwards as a unicellular hair. These hairs differ from those seen on all previously examined species of Strophanthus, with the exception of Strophanthus gratus, in being short, stubby structures. The intact hairs measure from 25 to 40 microns in length. At the base of the hair the shaft averages 20 microns in diameter and from this point it tapers sharply to the blunt apex. Owing to their shortness it is not possible to say that the hairs are definitely directed towards the apex of the seed, /

seed, but the majority do exhibit a tendency to point in that direction. They are thin-walled and non-lignified.

Surface View of the Cotyledon.

A cotyledon is prepared for examination as described under 'Methods'. In such preparations the epidermis is seen to consist of thin-walled, polygonal cells measuring from 15 to 20 microns in diameter. Despite careful examination, no stomata are seen.

Strophanthus intermedius Pax

Very little information relating to the seed of this species of Strophanthus can be traced in the literature. Holmes (1893) referred to it as an Angolian species, and its occurrence there is confirmed by the fact that the material used for the present work was collected in that region of Africa. Little subsequent interest appears to have been taken in the seed and no further data can be found which refers to it except a report by Bush & Taylor (1952) that its glycoside, on hydrolysis, yields the aglycone sarverogenin.

One specimen (S 52) of the seed of Strophanthus intermedius is available for examination and this consists of only the main body of the seed, the awns having been removed prior to receipt. It was collected near Vila Mariano, Angola in August 1950 and received in May 1952 from Monachino of the New York Botanical Garden by whom its identity is confirmed. /

ed.

The seeds of this sample are, in general, dull in appearance and of a light to medium reddish-brown colour. This, however, is actually the ground-colour of the testa which bears, over some parts, a covering of golden-yellow hairs. These appear to be of appreciable length and are readily detached from the testa.

The seeds are lanceolate in shape and flattened dorsiventrally. They vary in length from 11 to 14 mms. (average 12.5 mms.), in width from 3 to 3.5 mms. and in thickness from 1.25 to 1.5 mms. Both the ventral and dorsal surfaces of the seed are convex. The raphe is situated on the former and takes the form of a rather inconspicuous, slightly-raised, light brown ridge which extends along the midline and parallel with the morphological axis of the seed from a point about one-quarter of the length of the seed distant from the base, to the apex where it terminates in the broken-off point of the awn. The hilum is difficult to discern but in some seeds it is seen as a minute scar situated on this ridge and near the apex of the seed. The micropyle is not distinguishable. The apex of the seed is acute, the base rounded and the edges subacute to rounded.

Gross Anatomy.

Seeds softened by soaking in 25% alcohol show, on dissection, a white embryo consisting of a terete radicle pointing towards the apex of the seed and /

and two plano-convex cotyledons lying face to face and extending nearly to the base. The embryo is surrounded by a thin layer of greyish-white endosperm and the whole enveloped by a thin spermoderm.

Microscopy.

Sections cut transversely to the morphological axis at a point midway between the two extremities are narrowly ovate in outline and the periphery is gently undulant. The undulations take position from the very slight longitudinal ridges and furrows which are seen on very careful examination of the testa of the intact seed. These undulations appear to be due entirely to the configuration of the subepidermal tissue which will be referred to later.

The epidermis consists of a single layer of cells measuring about 15 microns in a radial direction and from 15 to 25 microns tangentially. The tangential walls of these cells are thin and the outer is sometimes extended outwards as a unicellular hair which will be described later. The anticlinal walls are thickened, the thickening assuming a broad spindle-shaped form where adjacent epidermal cells meet. Within the epidermis is a brownish region which averages about 10 microns in thickness. It is composed of very narrow, thin-walled, tangentially elongated cells. The outermost layers of this tissue are closely coherent but the inner layers show a tendency to split away from one another forming small, tangentially-elongated, schizogenous cavities. One /

One of these cavities is present under each spermodermal ridge and appears to be almost solely responsible for its formation. Occasionally, however, the outer face of the endosperm is seen to be very slightly undulant and then plays a part in the ridge formation.

No crystals of calcium oxalate are seen in any of the spermoderm cells when the tissue is examined in polarised light.

The endosperm consists of from 6 to 12 layers of moderately thick-walled, polygonal cells measuring from 20 to 45 microns in diameter and containing fixed oil and protein grains. No well-defined crystals are seen when this tissue is examined in polarised light, but each cell contains one shining speck about 2 microns in size. This may be a minute crystal.

Within the endosperm are the two plano-convex cotyledons. The epidermis of the cotyledon as seen in transverse section consists of a single layer of thin-walled, tabular cells measuring about 9 microns in a radial direction and from 9 to 12 microns tangentially. The mesophyll is composed of thin-walled parenchyma, each cell polygonal or rounded in outline and measuring from 15 to 25 microns in diameter. They contain oil and protein grains but no crystals of calcium oxalate are seen in polarised light. A well-marked strand passes medianly down the morphological axis of each cotyledon and represents the midrib.

Surface View of the Spermoderm.

Pieces of spermoderm were treated as described under 'Methods' and examined. In such

'surface /

'surface preparations' the epidermis is seen to consist of elongated cells, individuals varying from 35 to 100 microns in length and from 15 to 40 microns in width. The anticlinal walls are seen to be about 9 microns thick and to be uniformly but only slightly lignified. There is no evidence of any ribs of thickening on the inner tangential wall of these cells. Examination of the outer tangential walls of the epidermal cells shows that each cell either bears a unicellular hair or has, at one time, borne such a structure as a scar is readily visible. The intact hairs measure up to 510 microns in length and each measures about 15 microns at its base. From this point each hair tapers gradually and regularly to its subacute apex. The hairs are thin-walled and non-lignified.

Surface View of the Cotyledon.

A cotyledon is prepared for examination as described under 'Methods'. In such preparations the epidermis is seen to consist of thin-walled, polygonal cells measuring from 15 to 20 microns in diameter. No stomata are seen.

Strophanthus Tholloni Franchet

The seed of this species of Strophanthus is frequently mentioned in the earlier literature on the subject but recent references to it are relatively few in number. The species was first described by Franchet (1894), but only a very brief reference is made there to the actual seed which is stated to be glabrous. /

glabrous.

It would appear that, at one time, the seed of Strophanthus Tholloni was often confused with that of Strophanthus gratus and Gilg, Thoms, and Schedel (1904) published a combined paper which served to clear up this difficulty and also added considerably to the then existing knowledge of the chemistry and pharmacology of Strophanthus gratus. In the paper referred to, Gilg, who dealt with the botanical aspect of the subject, described the seed of Strophanthus Tholloni as "very long and narrowly spindle-shaped, tapering above and below and moderately covered with tiny yellowish-brown hairs". The shaft of the awn is reported to be 5 to 7 mms. in length and the plumed portion 9 to 12 mms.

This brief account by Gilg is undoubtedly sufficient to distinguish between the seeds of the two species mentioned, and it is difficult to understand at the present day how they came to be confused with one another. The description, however, is not considered to be sufficiently detailed to enable the seed of Strophanthus Tholloni to be separated from that of some of the species of Strophanthus available to the present writer, and it is proposed to make a morphological and histological examination of an authenticated specimen.

Little work appears to have been published on the pharmacology and chemistry of the seed. Sharp (1912) reported that its therapeutic action was very similar to that of Strophanthus Kombe/ Bush and Taylor (1952) /

(1952) identified, by a chromatographic method, the aglycone ouabagenin after hydrolysing the glycoside.

One specimen (S 54) of the seed of Strophanthus Tholloni is available for examination. It consists of only the main body of the seed, the awns having been removed prior to receipt. It was collected in the Cameroons in 1951 and received in May 1952 from Monachino of the New York Botanical Garden by whom its identity is confirmed.

All the seeds of the present sample are of a soft brownish-green colour and have a uniform covering of dull, rather lighter-coloured hairs which are closely appressed to the seed and which are directed towards the awned end. Careful examination of the testa, after the hairs have been scraped off, fails to reveal any longitudinal ridges such as have been reported in many of the species previously examined.

The seeds are conspicuously lanceolate in outline and flattened dorsiventrally. They vary in length from 15 to 21 mms. (average 18.5), from 2 to 3 mms. in width, and are about 1 mm. in thickness. This is, therefore, a very long, narrow, and rather conspicuously flattened seed. The dorsal surface of the seed is either flat or slightly convex while the ventral is always slightly convex and bears the raphe. This takes the form of a not very prominent slightly raised ridge which extends along the midline and parallel with the morphological axis from a point about one-quarter of the length of the seed distant from the base, to the apex where it terminates in the broken-off point of the awn. The apex of the seed tapers /

tapers very gradually and finally consists of only the commencement of the shaft of the awn surrounded by spermoderm which forms an inconspicuous wing on either side. Although only the main body of the seed is available for the present examination, it was found that two of the seeds of this specimen possessed a sufficient length of awn to demonstrate that the plume commences immediately above the apex of the seed and that there is no actual shaft. The total length of the plume could not be measured as none was complete, but the spread in one case was 2.8 cms. The edges of the seed are subacute and the base acute and conspicuously winged. This wing, as will be mentioned later, is composed entirely of the spermoderm tissues.

Gross Anatomy.

Seeds softened by soaking in 25% alcohol show, on dissection, a white embryo composed of a terete radicle pointing towards the apex of the seed and two long, narrow, plano-convex cotyledons lying face to face and extending nearly to the base of the seed. The embryo is surrounded by a thin layer of greyish-white endosperm. Much oil is contained in both the embryo and the endosperm. The whole is enveloped by a thin spermoderm which is prolonged at the base of the seed to form a conspicuous membranous wing.

Microscopy.

Sections cut transversely to the morphological axis of the seed at a point midway between the two /

two extremities are narrowly ovate in outline and the periphery is devoid of undulations except for the ridge containing the raphe which is situated in the centre of the ventral face.

The epidermis consists of a single layer of tangentially elongated cells which measure about 15 microns in depth and 40 microns in length. They have moderately thin tangential walls, and the outer wall of nearly every cell is extended outwards as a unicellular hair which will be described later. The anticlinal walls are prominently thickened, the thickening assuming the rather square form previously seen only in Strophanthus divaricatus.

Within the epidermis is a brownish region about 15 microns thick and consisting of narrow, thin-walled, tangentially elongated cells.

Examination in polarised light shows that calcium oxalate crystals are not present in any of the spermoderm tissues.

The endosperm is composed of from 7 to 12 layers of thick-walled, polygonal cells averaging about 30 microns in diameter and containing both fixed oil and protein grains. Examination in polarised light does not reveal any calcium oxalate crystals of discernible form but each endosperm cell is seen to contain one or more minute crystal 2 to 3 microns in size.

Within the endosperm are the two plano-convex cotyledons lying face to face. In transverse section the epidermis of the cotyledon is seen to consist /

consist of a single layer of thin-walled cells measuring about 9 microns in a radial direction and 6 to 12 microns tangentially. No stomata are seen. The mesophyll is composed of polygonal cells, the walls of which, though thin, are rather thicker than has been seen before in this tissue. The mesophyll cells contain fixed oil and prominent protein grains, but calcium oxalate crystals are not seen on examination in polarised light. A well-marked strand passes medianly down the morphological axis of each cotyledon and represents the midrib.

Surface View of the Spermoderm.

Pieces of spermoderm were treated as described under 'Methods' and examined. In such 'surface preparations' the epidermis is seen to consist of elongated cells measuring from 45 to 220 microns in length and from 12 to 40 microns in width. These cells show two unusual features. In the first place they are characterised by having conspicuously sinuous, anticlinal walls. In a less prominent form this has been seen in an occasional cell of other species but has not been considered of sufficient importance to record. Secondly, these elongated epidermal cells are sometimes seen to be variously orientated towards one another. The anticlinal walls vary from 7 to 10 microns in thickness and are strongly but not uniformly lignified; the middle lamella always stands out as the most heavily lignified region. The outer tangential wall of the majority of the cells is extended outwards as a unicellular hair, which is bent over /

over near its base so as to be closely appressed to the seed and directed towards its apex. The intact hairs measure from 300 to 500 microns in length. At the base of the shaft the hair averages about 20 microns in diameter and from this point it tapers gradually and uniformly to its subacute apex. The hairs are thin-walled and non-lignified. Careful examination of the inner tangential wall of the epidermal cells reveals the presence of very slightly-lignified ribs of thickening some 4 or 5 microns wide. These ribs may cross the cell in any direction. Not more than two are to be seen in any cell and many show no evidence of them at all.

Surface View of the Cotyledon.

A cotyledon is prepared for examination as described under 'Methods'. In such preparations the epidermis is seen to be composed of thin-walled, polygonal cells averaging about 10 microns in diameter. Despite careful examination no stomata are seen.

Strophanthus Wightianus Wall

No data relating to this species of Strophanthus can be traced in any of the recent literature on the subject, but Holmes (1893) referred to its occurrence in Java, and Rama (1914) reported its presence in Travancore in the South of India. The material used for the present work was also collected in India. No record can be found of the occurrence of Strophanthus Wightianus in Africa, which probably explains why it has not been reported as occurring admixed /

admixed with the seeds of other species of Strophanthus. In consequence, little interest appears to have been taken in it during the last three or four decades.

There is no record of its having been employed in medicine nor can any botanical or chemical data relating to the seed be traced.

One specimen (S 55) of Strophanthus Wightianus is available for examination. This consists of only the main body of the seed, the awns having been removed prior to receipt. It was collected in India in February 1951 and received from Monachino of the New York Botanical Garden by whom its identity is confirmed.

The seeds of the present sample are yellowish-brown in colour and rather woody in appearance. It therefore bears a strong resemblance to the seed of Strophanthus divaricatus. Careful examination with a lens shows that the testa is apparently devoid of hairs but it is seen to bear a number of inconspicuous and slightly-raised ridges which are parallel with the morphological axis of the seed.

The seeds are lanceolate to broadly-lanceolate in shape and conspicuously flattened dorsiventrally. They vary in length from 12.5 to 16 mms. (average 14.7 mms.), in width from 2.5 to 3.5 mms., and are about 1.5 mms. in thickness. Both the ventral and dorsal faces of the seed are flat to slightly convex. The raphe is situated on the former and takes the form of a pale yellowish-brown, slightly-raised ridge which is parallel with the morphological axis of the seed /

seed and extends along the midline from a point about one-quarter of the length of the seed distant from the base, to the apex where it terminates in the broken-off point of the awn. The hilum is visible as a small scar situated on this ridge and near the apex of the seed. The micropyle is only seen on an occasional seed and appears as a minute point situated to one side of the hilum. The apex of the seed is acute and often twisted; the base is acute to sub-acute and appears to terminate in a small membranous 'wing'. The edges of the seed are almost acute.

Gross Anatomy.

Seeds softened by soaking in 25% alcohol show, on dissection, a white embryo consisting of a terete radicle pointing towards the apex of the seed and two large, plano-convex cotyledons lying face to face and extending nearly to the base. The embryo is surrounded by a thin layer of greyish-white endosperm and the whole enveloped by a thin brown spermoderm which is very slightly prolonged at the base and forms the 'wing' to which reference has already been made.

Microscopy.

Sections cut transversely to the morphological axis of the seed at a point midway between the two extremities are elliptical in outline and the periphery is slightly undulant. These undulations take position from the slight ridges seen on the surface of the intact seed and to which reference has already been made. The ridges are due almost entirely to the configuration of the endosperm.

The /

The epidermis consists of a single layer of cells which measure some 25 microns in a tangential direction and which are characterised by being partially or almost completely collapsed and little of the cell-cavity is seen. The tangential walls of these cells are moderately thick and it would appear that the outer tangential wall of some of the cells is extended out in the form of a hair. If this is correct, the form of the hair is unusual and cannot be determined with any degree of accuracy in the present preparation. The anticlinal walls of the epidermal cells are thickened, the thickening assuming a broad, spindle-shaped or almost ovate form where the adjacent epidermal cells meet.

Within the epidermis is a brownish region some 10 microns in thickness and consisting of very narrow, tangentially-elongated, thin-walled cells.

Examination in polarised light shows that calcium oxalate crystals are not present in any of the spermoderm cells.

The endosperm is composed of from 7 to 10 layers of thick-walled cells, each cell rounded or somewhat tangentially elongated and averaging some 30 microns in size. They contain fixed oil and prominent groups of protein grains. Crystals of calcium oxalate are not seen on examination in polarised light.

The endosperm envelops two large, well-developed cotyledons which are plano-convex in outline and /

and which lie face to face. The epidermis of the cotyledon as seen in transverse section is composed of a single layer of thin-walled, nearly isodiametric cells measuring about 12 microns in size. No stomata are seen. The mesophyll is composed of thin-walled parenchyma, each cell polygonal or rounded in outline and averaging about 30 microns in diameter. All the mesophyll cells contain fixed oil and protein grains but calcium oxalate crystals are not seen when examined in polarised light. A well-marked strand passes medianly down the morphological axis of each cotyledon and represents the midrib.

Surface View of the Spermoderm.

Pieces of spermoderm were treated as described under 'Methods' and examined. In such 'surface preparations' the epidermis is seen to consist of straight-walled elongated cells, individuals varying from 50 to 150 microns in length and from 15 to 45 microns in width. The anticlinal walls of the cells are from 10 to 15 microns in thickness and, although strongly lignified, the middle lamella stands out as the most heavily lignified portion of the wall. It is now seen that the outer tangential wall of a number of the epidermal cells is extended outwards but the hair so formed can only be described as rudimentary. They take the form of short, bluntly-conical protuberances with thin slightly-warty walls. They are non-lignified, measure from 15 to 35 microns in length and each measures about 20 microns in diameter at its base. Careful examination of the inner tangential wall /

wall fails to reveal the presence of any ribs of thickening.

Surface View of the Cotyledon.

A cotyledon is prepared for examination as described under 'Methods'. In such preparations the epidermis is seen to consist of thin-walled, polygonal cells measuring from 10 to 15 microns in diameter. Despite careful examination no stomata are seen.

Strophanthus congoensis Franch.

Very few references to this species of Strophanthus can be traced in the literature. Franchet (1893) published a notice of the species but no description of the seed was given. The species is known to occur in Africa, where the material used for the present work was collected, but its seed has not been reported as an adulterant of that of other species of Strophanthus which are valued commercially. It is thought probable, however, that this may be due to the superficial similarity which the seed of Strophanthus congoensis bears to that of some samples of Strophanthus sarmentosus and to the fact that no description of the former has been published. Its presence, therefore, may have been overlooked in commercial material.

No subsequent useful references to the seed of Strophanthus congoensis can be found until 1952 when Bush & Taylor reported the finding of the aglycone sarverogenin in the mixture obtained when the glycosidal content of the seed was hydrolysed.

One specimen (S 57) of Strophanthus congoensis is available for examination. It consists of only the main body of the seed, the awns having been removed prior to receipt. It was collected in the French Cameroons in January 1950 and received in August 1952 from Monachino of the New York Botanical Garden by whom its identity is confirmed.

The seeds of the present sample are of a uniform, dark reddish-brown colour and are devoid of any sheen. They bear a conspicuous covering of dull, appressed hairs which appear to be of appreciable length and which are directed towards the apex of the seed. These impart a distinctly furry appearance to the seed. The ground-colour of the testa, as seen when the hairs are carefully scraped off, is of the same colour as previously reported for the intact seed. The surface of the testa bears numerous minute corrugations but no longitudinal ridges are seen.

The seeds are lanceolate in shape and somewhat flattened dorsiventrally. They vary in length from 13 to 17 mms. (average 15.5 mms.), in width from 3 to 4 mms., and in thickness from 1.5 to 2 mms. The dorsal surface of the seed is convex and the ventral either flat or slightly convex. The raphe is situated on the latter and takes the form of a slightly-raised ridge which is parallel with the morphological axis of the seed and which extends along the midline from a point about one-fifth of the length of the seed away from the base to the apex where it terminates in the broken-off point of the awn. This ridge exhibits one feature which has not been seen before. The lower

half is less conspicuous than the upper and displays minute undulations which are at right angles to the surface of the seed. The hilum can only be discerned in an occasional seed and micropyle cannot be distinguished in any of the seeds. The apex of the seed is acute,the base rounded, and the edges subacute.

Gross Anatomy.

Seeds softened by soaking in 25% alcohol show, on dissection, a white embryo consisting of a terete radicle pointing towards the apex of the seed and two large plano-convex cotyledons lying face to face and extending nearly to the base. Oil is contained in the embryo which is enveloped by a thin layer of greyish-white endosperm. The whole is enclosed by a thin, brown spermoderm.

Microscopy.

Sections cut transversely to the morphological axis of the seed at a point midway between the two extremities are ovate in outline and the periphery is devoid of undulations.

The epidermis consists of a single layer of tangentially-elongated cells which measure from 33 to 51 microns in length and about 15 microns in depth. They have moderately thin, tangential walls and thickened anticlinal walls, the thickening a spindle-shaped form where the adjacent epidermal cells meet and measuring about 9 microns at its widest point. The outer tangential wall of apparently every cell is extended outwards as a unicellular hair which will be described later.

Within the epidermis is a well-defined region averaging 15 microns in thickness and consisting of brownish, thin-walled, tangentially-elongated cells.

Calcium oxalate crystals are not seen in any of the spermoderm tissues.

The endosperm consists of from 6 to 12 layers of thick-walled cells which are mostly polygonal in outline and measure from 25 to 45 microns in diameter. They contain fixed oil and protein grains. Clearly-defined crystals of calcium oxalate are not seen in the endosperm but there are numerous doubly-refracting specks visible which may be composed of calcium oxalate. These measure rather less than 2 microns in size.

The endosperm encloses two well-developed, plano-convex cotyledons which lie face to face. In transverse section the epidermis of the cotyledons is seen to consist of a single layer of very thin-walled, nearly isodiametric cells averaging about 12 microns in diameter. No stomata are seen. The mesophyll is composed of thin-walled, parenchymatous cells, each cell rounded or polygonal in outline and averaging about 15 microns in diameter. All the mesophyll cells contain fixed oil and protein grains but no crystals of calcium oxalate are seen when the tissue is examined in polarised light. A well-marked strand passes medianly down the morphological axis of each cotyledon and represents the midrib.

Surface View of the Spermoderm.

Pieces of spermoderm were treated as described /

cribed under 'Methods' and examined. In such 'surface preparations' the epidermis is seen to consist of elongated cells, individuals varying from 30 to 105 microns in length and from 12 to 33 microns in width. The anticlinal walls are from 7 to 9 microns in thickness and are uniformly but not heavily lignified. The outer tangential wall of each epidermal cell is extended outwards as a unicellular hair bent over near its base so as to be closely appressed to the surface of the seed. In general, these hairs are directed towards the apex of the seed but it is noticeable that they often present a somewhat tangled appearance. The intact hairs measure from 300 to 500 microns in length. At its base the shaft of the hair measures from 20 to 25 microns in diameter and from this point it tapers gradually and regularly to its acute apex. The majority of the hairs are thin-walled but a few are seen with somewhat thicker walls and one hair was seen which possessed a distinct transverse septum. In most cases the hairs are non-lignified but occasionally slight uniform lignification is seen on the cell-wall.

Surface View of the Cotyledon.

A cotyledon is prepared for examination as described under 'Methods'. In such preparations the epidermis is seen to consist of thin-walled, polygonal cells averaging about 18 microns in diameter. No stomata are seen.

TABLE 1.

SUMMARY OF THE MORPHOLOGICAL AND ANATOMICAL FEATURES OF THE SPECIES OF STROPHANTHUS SEED EXAMINED.

	GENERAL CHARACTERS	RAPHE	BASAL WING	LONGITUDINAL RIDGES ON TESTA	SIZE OF SEED	GENERAL CHARACTERS OF TRANSVERSE SECTION.
1. Strophanthus Kombe Oliver	Greyish-green to greenish-fawn. Numerous silky hairs present which are arranged in longitudinal rows. Linear-lanceolate to lanceolate in shape, somewhat flattened and obtusely-edged. Base winged.	Slightly raised. Two-thirds of length of seed.	Present but not conspicuous. Formed of spermoderm only.	Present.	Length 8-25 mms. Width 2.5-5 mms. Thickness 0.5-2 mms.	Narrowly ovate in outline. Periphery undulant. Undulations extend to outer face of endosperm. Thickness of spermoderm more or less constant.
2. Strophanthus Courmontii Sacleux	Slightly furry in appearance owing to covering of rather short yellowish-white hairs. Hairs readily detached from both faces showing reddish-brown testa. Somewhat flattened though less so than S. Kombe. Edges obtuse. Base rounded to sub-acute.	Lighter-coloured but not prominent. Three-quarters of length of seed. Tends to become spathulate at chalazal end.	Absent.	Present but faint.	Length 10-15 mms. Width 2.5-4 mms. Thickness 1 - 2 mms.	Ovate in outline. Periphery gently undulant. Undulations mainly due to groups of sub-epidermal parenchyma but endosperm also plays a part.
3. Strophanthus sarmentosus P.DC.	Soft greyish-brown. Uniform covering of hairs. Distinctly lanceolate. Somewhat flattened. Edges almost acute. Base obtuse.	Yellowish and raised. Three-quarters of length of seed.	Absent.	Absent.	Length 10-15 mms. Width 3-4.5 mms. Thickness 1.5-2 mms.	Elliptical in outline. No peripheral undulations.
4. Strophanthus sarmentosus var. major Dewevre	Earthy-brown. Not noticeably hairy but slightly furry. Lanceolate and flattened. Edges almost acute. Base rounded to sub-acute.	Pale brown and not conspicuous. Three-quarters of length of seed.	Absent.	Faint but more conspicuous near apex.	Length 10-19 mms. Width 3-4.5 mms. Thickness 1-2 mms.	Elliptical to ovate in outline. Peripheral undulations present but very faint.

	EPIDERMIS IN TRANSVERSE VIEW	EPIDERMIS IN SURFACE VIEW	EPIDERMAL HAIRS	SUB-EPIDERMAL LAYER
1. Strophanthus Kombé Oliver	Single layer of nearly isodiametric cells 18 - 30 microns in size. Tangential walls moderately thin; outer wall of each cell prolonged into a hair. Anticlinal walls spindle-shaped, averaging 6 microns in thickness at centre.	Cells nearly isodiametric or axially elongated and with undulating anticlinal walls. Lignification moderately strong and uniform. Middle lamella distinct but not more heavily lignified than the thickening on cell-wall. Hairs numerous and arranged in longitudinal rows.	500 - 800 microns in length. Unicellular, thin-walled, 12 - 15 microns in diameter at base of shaft. Shaft non-lignified except for a narrow rib on side adjacent to epidermis of seed.	9 - 12 microns in thickness. Composed of thin-walled, tangentially elongated, radially-compressed cells except where immediately subjacent to epidermal ridge. In such positions a small group of polygonal parenchymatous cells occurs.
2. Strophanthus Courmontii Sacleux	Single layer of nearly isodiametric cells 25 - 30 microns in size. Tangential walls moderately thin; outer wall of each cell prolonged into a hair. Anticlinal walls spindle-shaped, averaging 8 microns in thickness at the centre.	Cells elongated 50 - 120 microns in length and 15 - 30 microns in width. Anticlinal walls uniformly and strongly lignified, 8 - 12 microns thick. Hairs numerous and often somewhat tangled.	300 - 500 microns in length and up to 18 microns in diameter at base of shaft. Apex sub-acute. Unicellular. Cell-wall thin and either slightly and uniformly lignified or lignified only on side acjacent to epidermis of seed.	About 15 microns in thickness. Composed of a few layers of thin-walled, tangentially-elongated, radially compressed cells supplemented by a small group of thin-walled polygonal parenchymatous cells under each epidermal ridge.
3. Strophanthus sarmentosus P.DC.	Single layer of tangentially elongated cells averaging 20 x 35 microns. Tangential walls moderately thin; outer wall of each cell prolonged into a hair. Anticlinal walls spindle-shaped.	Cells elongated, 75 - 150 microns in length and 15 - 45 microns in width. Anticlinal walls about 10 microns thick. Middle lamella very strongly lignified; remainder of wall only moderately lignified. Hairs numerous.	400 - 700 microns in length and average 18 microns in diameter at base of shaft. Apex sub-acute. Unicellular. Cell-wall thin and non-lignified except for a very slightly lignified rib on the side of the shaft acjacent to epidermis of the seed.	About 12 microns in thickness and composed of a few layers of thin-walled, tangentially elongated, radially-compressed cells. Some of the crystal-containing cells much enlarged.
4. Strophanthus sarmentosus var. major Dewèvre	Single layer of tangentially elongated cells varying from 30 - 40 microns in length and from 15 - 18 microns in depth. Tangential walls moderately thin; outer wall of many of the cells seen to be prolonged as a hair, others with collapsed outer walls. Anticlinal walls very broadly spindle-shaped.	Cells elongated, 90 - 150 microns in length and 25 - 50 microns in width. Anticlinal walls 10 - 15 microns thick. Middle lamella strongly lignified and sharply delineated; remainder of cell-wall less strongly lignified. Hairs not numerous (confirmed by lack of hair-scars).	May be divided into two groups according to their length. The majority are 100 - 300 microns in length; the others are all about 1000 microns long. In all cases unicellular, thin-walled and either non-lignified or uniformly and very slightly lignified. Base of shaft 15 to 18 microns in diameter. Apex sub-acute.	Varies from 8 to 24 microns in thickness. Composed of thin-walled, elongated cells but tissue characterised, in regions of greater thickness, by conspicuous, tangentially-elongated, schizogenic cavities. A small group of thin-walled polygonal, parenchymatous cells present under each epidermal ridge.

	CRYSTALS IN SPERMODERM	ENDOSPERM	EMBRYO
1. Strophanthus Kombe Oliver	Small number present in sub-epidermal tissue. Mainly in the form of cluster crystals but prismatic crystals occasionally occur.	Outer face undulant in transverse section. Tissue five to ten cells thick. Cells polygonal in outline, 30 - 35 microns in diameter. No crystals present.	Very thin-walled, isodiametric cells averaging 25 microns in diameter. No crystals present.
2. Strophanthus Courmontii Sacleux	Numerous. Mostly single prisms measuring up to 20 microns in size but a few twin-prisms and conglomerates are also seen.	Five to nine cells thick. Cells polygonal and up to 45 microns in diameter. Numerous minute crystals 2 - 3 microns in size present.	Very thin-walled, isodiametric cells 10 to 15 microns in diameter. No crystals present.
3. Strophanthus sarmentosus P.DC.	Numerous. Irregular cluster crystals and single rhombohedral crystals both occur. Crystal ratio cluster/rhombohedral = 10/4.	Seven to ten cells thick except at apices of ellipse of transverse section. Here it is two to three cells thicker than elsewhere and forms a ridge. No crystals present.	Thin-walled, radially-elongated cells averaging 30 x 15 microns. Many of these cells contain a cluster crystal of calcium oxalate up to 20 microns in diameter. Single crystals are of very rare occurrence.
4. Strophanthus sarmentosus var. major Dewèvre	Absent.	Seven to ten layers of moderately thick-walled, polygonal cells which measure up to 50 microns in diameter. Numerous minute crystals (up to 2 microns in size) present.	Thin-walled, polygonal cells averaging 25 microns in diameter. Numerous well-defined crystals of calcium oxalate up to 25 microns present in the form of clusters or conglomerates.

	GENERAL CHARACTERS	RAPHE	BASAL WING	LONGITUDINAL RIDGES ON TESTA	SIZE OF SEED	GENERAL CHARACTERS OF TRANSVERSE SECTION
5. Strophanthus Emini Aschers	Pale golden-brown. Thick covering of woolly hairs which give seed a shaggy appearance. Hairs liable to become detached showing reddish-brown testa. Lanceolate or ovate-lanceolate, somewhat flattened. Edges obtuse. Base rounded to sub-acute.	Pale and conspicuous. Slightly raised and spathulate at chalazal end. Two-thirdsof length of seed.	Absent.	Absent.	Length 13 to 16 mms. Width 3-4.5 mms. Thickness 2-2.5 mms.	Ovate in outline but ventral face less convex than dorsal. No peripheral undulations.
6. Strophanthus hispidus P.DC.	Greenish or yellowish-brown and slightly furry owing to covering of rather short hairs which are readily detached showing reddish-brown testa. Lanceolate and much flattened. Edges almost acute. Base rounded.	Inconspicuous and only slightly raised. Three-quarters of length of seed.	Absent.	Absent.	Length 7-13 mms. Width 2-3.5 mms. Thickness 1-1.5 mms.	Elliptical in outline. No peripheral undulations.
7. Strophanthus Nicholsoni Holmes	Yellowish-white due to a dense, tangled covering of very long hairs which impart a characteristic woolly appearance. Ground colour of testa fawn but may show a greenish tinge. Lanceolate and somewhat flattened. Edges rounded. Base obtuse.	Yellowish and slightly raised. Three-quarters of length of seed. Conspicuous in spite of dense hair covering owing to absence of hairs in this region.	Absent.	Numerous and quite conspicuous after removal of hairs.	Length 11 to 16 mms. Width 3 to 4.5 mms. Thickness 2 to 3 mms.	Ovate to broadly-ovate in outline. Periphery conspicuously undulant. Both spermoderm and endosperm enter into formation of ridges.
8. Strophanthus gratus (Wall & Hook) Franchet	Dull, light reddish-brown. Apparently glabrous. Lanceolate and conspicuously flattened. Edges acute. Base rounded.	Pale yellowish-brown and slightly raised. Two-thirds of length of seed. Slight ridge also present in the corresponding position on dorsal face of seed but formed of spermoderm. This ridge is half length of seed.	Absent.	Present but inconspicuous.	Length 14 to 18 mms. Width 4 to 5 mms. Thickness 1 to 1.5 mms.	Elliptical in outline. Periphery almost devoid of undulations.

	EPIDERMIS IN TRANSVERSE VIEW	EPIDERMIS IN SURFACE VIEW	EPIDERMAL HAIRS	SUB-EPIDERMAL LAYER
5. Strophanthus Emini Aschers	Single layer of poorly-defined, nearly isodiametric cells 25 - 30 microns in size. Tangential walls, where seen, thin and outer prolonged as a hair. Anticlinal walls broadly spindle-shaped.	Cells elongated, 90 - 150 microns in length and 30 - 60 microns in width. Anticlinal walls 6 - 9 microns thick and strongly and uniformly lignified. Hairs numerous but glabrous areas seen where epidermis is disorganised.	Up to 1000 microns in length and average 15 microns in diameter at the base of the shaft. Unicellular, thin-walled and only slightly lignified but a more strongly lignified rib is present on the side of the shaft adjacent to the epidermis of the seed. Apex subacute.	9 - 12 microns in thickness. Composed of thin-walled, tangentially elongated cells but the innermost two layers are often nearly isodiametric
6. Strophanthus hispidus P.DC.	Single layer of nearly isodiametric cells averaging 25 microns in size. Tangential walls thin; outer prolonged as a hair. Anticlinal walls with conspicuous spindle-shaped thickening.	Cells elongated, 65 - 120 microns in length and 20 - 40 microns in width. Anticlinal walls 7 - 9 microns thick, uniformly and rather strongly lignified. Hairs numerous.	300 - 650 microns in length and average 15 microns in diameter at the base of the shaft. Unicellular, thin-walled and only slightly lignified. Occasionally the lignification is confined to a rib on the side of the shaft adjacent to the epidermis of the seed.	12 - 15 microns in thickness and composed of a few layers of thin-walled, tangentially elongated cells.
7. Strophanthus Nicholsoni Holmes	Single layer of isodiametric cells about 30 microns in size. Tangential walls moderately thin; outer wall of each cell prolonged as a hair. Anticlinal walls spindle-shaped.	Cells elongated; 45 to 120 microns in length and 20 to 30 microns in width. Anticlinal walls average 10 microns in thickness and are strongly and uniformly lignified. Hairs very numerous but orientation obscure. Very tangled.	Very long, may attain 2500 microns in length and measure 15 to 25 microns in diameter at base of shaft. Unicellular and with a moderately thick lignified wall.	About 15 microns in thickness and composed of a few layers of thin-walled, tangentially elongated cells. Small group of thin-walled, polygonal, parenchymatous cells situated under each epidermal ridge.
8. Strophanthus gratus (Wall & Hook) Franchet	Single layer of isodiametric cells averaging 30 microns in size. Cells often disorganised. Tangential walls thin and outer wall of a few of the cells extended out as a short hair. Anticlinal walls broadly spindle-shaped to ovate.	Cells elongated; 65 to165 microns in length and 15 to 45 microns in width. Anticlinal walls 9 to12 microns in thickness and, although strongly lignified throughout, the middle lamella is the most strongly lignified part. Hairs very few in number.	Very short, 70 to 90 microns in length and 15 microns in diameter at base of shaft. Unicellular, very thin-walled and non-lignified.	About 15 microns in thickness and composed of a few layers of thin-walled, tangentially elongated cells.

	CRYSTALS IN SPERMODERM	ENDOSPERM	EMBRYO
5. Strophanthus Emini Aschers	Absent.	Five to twelve cells in thickness. Cells polygonal and average 30 microns in diameter. No crystals present.	Thin-walled, rounded to polygonal cells averaging 25 microns in diameter. No crystals present.
6. Strophanthus hispidus P.DC.	Absent.	Seven to ten cells in thickness. Cells polygonal and average about 30 microns in diameter. Occasional aggregate crystals present.	Thin-walled, polygonal cells averaging 30 microns in diameter. No crystals present.
7. Strophanthus Nicholsoni Holmes	Absent.	5 to 10 layers of cells thick. Cells rounded to polygonal in outline and average about 35 microns in diameter. Outer face undulant in transverse section. No crystals present.	Thin-walled cells measuring 20 to 30 microns in size, No crystals present.
8. Strophanthus gratus (Wall & Hook) Franchet	Absent.	Composed of 6 to 10 layers of moderately thin-walled cells. Cells polygonal and 25 to 45 microns in diameter. No crystals present.	Thin-walled cells averaging 30 microns in size. No crystals present.

	GENERAL CHARACTERS	RAPHE	BASAL WING	LONGITUDINAL RIDGES ON TESTA	SIZE OF SEED	GENERAL CHARACTERS OF TRANSVERSE SECTI
9. Strophanthus mirabilis Gilg	Pale yellowish-brown and with a distinct silvery sheen due to covering of silky hairs. Ground colour of testa pale fawn. Lanceolate. Only slightly flattened dorsi-ventrally. Edges obtuse. Base acute.	Pale yellow and only slightly raised. Two-thirds of length of seed. Not readily seen while hairs present.	Present. Formed of spermoderm only.	Present.	Length 11 to 17 mms. Width 2 to 3 mms. Thickness 1.5 to 2 mms.	Ovate in outline. Periphery undulant. Undulations confined to spermoderm. Outer face of endosperm devoid of undulations.
10. Strophanthus petersianus Klotzsch	Dull brown where hair-covering present but dark reddish-brown testa seen where hairs have been rubbed off. Lanceolate. Noticeably flattened. Edges subacute to rounded. Base rounded.	Slightly raised and inconspicuous. Two-thirds of length of seed.	Absent.	Present. Only slightly raised but broader than usual.	Length 11 to 14 mms. Width 3.5 to 5 mms. Thickness 2 mms.	Broadly-ovate in outline. Periphery with slight but widely spaced undulations.
11. Strophanthus amboensis Engl. & Pax	Fawn but often shows olive-green tinge. Colour due to a uniform covering of velvety hairs. Ground colour of testa medium brown. Lanceolate. Conspicuously flattened. Edges subacute. Base subacute to rounded.	Very slightly raised and inconspicuous until hairs removed, then seen to be a paler brown than testa. Two-thirds of length of seed.	Absent.	Absent.	Length 11 to 14 mms. Width 3.5 to 4 mms. Thickness 1.5 to 2 mms.	Elliptical in outline. No peripheral undulations.
12. Strophanthus Barteri Franchet	Very characteristic. Uniform dull reddish-brown, slightly rough but not noticeably hairy. Ground colour of testa medium brown. Lanceolate. Conspicuously flattened. Edges subacute. Base subacute to rounded.	Slightly raised but not conspicuous. Two-thirds of length of seed.	Absent.	Absent.	Length 8.5 - 10 mms. Width 2 - 2.5 mms. Thickness abt. 1 mm.	Narrowly ovate in outline. No peripheral undulations.

	EPIDERMIS IN TRANSVERSE VIEW	EPIDERMIS IN SURFACE VIEW	EPIDERMAL HAIRS	SUB-EPIDERMAL LAYER
9. Strophanthus mirabilis Gilg	Single layer of isodiametric cells averaging 25 microns in size. Tangential walls moderately thin; outer wall of each cell extended outwards as a hair. Anticlinal walls spindle-shaped.	Cells elongated; 60 to 110 microns in length and 9 to 24 microns in width. Anticlinal walls average 6 microns in thickness and are strongly and uniformly lignified. Hairs numerous.	300 to 600 microns in length and 15 microns in diameter at base of shaft. Unicellular and thin-walled except for a narrow lignified rib on the side of the hair shaft adjacent to the epidermis of the seed.	10 to 15 microns in thickness and composed of a few layers of thin-walled, tangentially elongated cells. Small group of thin-walled, polygonal, parenchymatous cells situated under each epidermal ridge.
10. Strophanthus petersianus Klotzsch	Single layer of isodiametric cells varying from 20 to 30 microns in size. Tangential walls moderately thin and outer wall of each cell prolonged as a hair. Epidermis sometimes disorganised and then hairs absent. Anticlinal walls broadly spindle-shaped.	Cells elongated; 60 to 135 microns in length and 21 to 36 microns in width. Anticlinal walls 9 to 12 microns in thickness and lignified. This lignification is moderately strong and generally uniform but the middle lamella is sometimes seen to be the most strongly lignified part. Hairs numerous.	450 to 670 microns in length and 15 microns in diameter at base of shaft. Unicellular and thin-walled. Cell-wall non-lignified except for a narrow, slightly lignified rib on the side of the shaft adjacent to the epidermis of the seed.	12 to 15 microns in thickness and composed of a few layers of thin-walled, tangentially elongated cells. Small group of thin-walled parenchymatous cells situated under each epidermal ridge.
11. Strophanthus amboensis Engl. & Pax	Single layer of isodiametric cells 25 to 30 microns in size. Tangential walls moderately thin and outer wall of each cell prolonged as a hair. Anticlinal walls spindle-shaped but not conspicuously so.	Cells elongated; 50 to 100 microns in length and 30 to 40 microns in width. Anticlinal walls from 5 to 8 microns in thickness and uniformly but not strongly lignified Hairs numerous.	250 to 750 microns in length and about 20 microns in diameter at base of shaft. Unicellular, thin-walled, and non-lignified.	About 12 microns in thickness and composed of a few layers of thin-walled, tangentially elongated cells.
12. Strophanthus Barteri Franchet	Single layer of isodiametric cells averaging 20 microns in size. Tangential walls thin and outer wall of each cell extended outwards as a hair. Anticlinal walls spindle-shaped.	Cells elongated; 90 to 200 microns in length and 20 to 30 microns in width. Anticlinal walls average 9 microns in thickness and are strongly and uniformly lignified. Hairs numerous.	Relatively short; 90 to 150 microns in length and about 25 microns in diameter at base of shaft. Unicellular, thin-walled and non-lignified. Occasionally a slightly lignified rib is seen on the side of the hair-shaft which is adjacent to the epidermis of the seed.	About 9 microns in thickness and composed of very poorly differentiated cells. Innermost layer often split away from the others.

	CRYSTALS IN SPERMODERM	ENDOSPERM	EMBRYO
9. Strophanthus mirabilis Gilg	Absent.	4 to 7 layers of cells thick. Cells polygonal and average 35 microns in diameter. No crystals present.	Thin-walled cells averaging 15 microns in diameter. No crystals present.
10. Strophanthus petersianus Klotzsch	A few ill-defined aggregates present but these, though visible in surface view, are not readily seen in transverse section.	6 to 10 layers of cells thick. Cells thick-walled, polygonal in outline and 30 to 70 microns in diameter. No crystals present.	Thin-walled cells 10 to 20 microns in diameter. No crystals present.
11. Strophanthus amboensis Engl. & Pax	Absent.	6 to 10 layers of cells thick. Cells moderately thick-walled and polygonal in outline. No crystals present.	Thin-walled cells averaging 20 microns in diameter. No crystals present.
12. Strophanthus Barteri Franchet	Absent.	8 to 12 layers of polygonal cells in thickness. No crystals present.	Thin-walled cells 20 to 40 microns in diameter. No crystals present.

	GENERAL CHARACTERS	RAPHE	BASAL WING	LONGITUDINAL RIDGES ON TESTA	SIZE OF SEED	GENERAL CHARACTERS OF TRANSVERSE SECTION
13. Strophanthus Arnoldianus Wildem. & Th. Dur.	Uniform, dull yellowish-green, sometimes with a greyish tinge. Colour due to covering of rather short hairs. Ground-colour of testa pale reddish-brown. Lanceolate, somewhat flattened. Edges acute. Base rounded or truncate.	Slightly raised and yellowish in colour. Three-quarters of length of seed.	Absent.	Absent.	Length 10-13 mms. Width 3 mms. Thickness 1 mm.	Elliptical in outline. No peripheral undulations.
14. Strophanthus Boivini Baill.	Dull green to greenish-brown with a silvery sheen due to a covering of rather short silky hairs. Ground-colour of testa pale reddish-brown. Lanceolate. Conspicuously flattened. Edges acute. Base rounded to subacute.	Slightly raised and lighter coloured. Conspicuous even while hairs present. Four-fifths of length of seed.	Absent.	Absent.	Length 8-10 mms. Width 3 mms. Thickness less than 1 mm.	Narrowly ovate in outline. No peripheral undulations.
15. Strophanthus Gossweilerii Hess	Golden brown with very distinct sheen when viewed from base or apex. Bears uniform covering of long silky hairs. Ground-colour of testa rather dark reddish-brown. This colour also seen when intact seed is viewed laterally. Lanceolate. Somewhat flattened. Edges rounded. Base subacute. Bears a very close resemblance to S. amboensis.	Slightly raised but not conspicuous even when hairs removed. Three-quarters of length of seed.	Absent.	Absent.	Length 10-13 mms. Width 3-3.5 mms. Thickness about 2 mms.	Ovate in outline. No peripheral undulations.
16. Strophanthus divaricatus Wall	Dull greenish-brown and apparently glabrous. Lanceolate. Conspicuously flattened. Edges acute. Base subacute to rounded.	Very conspicuous; slightly raised; pale yellowish-brown. Five-sixths of length of seed.	Absent.	Present. More conspicuous on dorsal than on ventral face of seed.	Length 16-17 mms. Width 2-3.5 mms. Thickness 1-1.5 mms.	Elliptical in outline. Conspicuously undulant on dorsal side but less so on ventral. Undulations caused by longitudinal ridges on outer face of endosperm and not by variations in the thickness of the spermoderm.

	EPIDERMIS IN TRANSVERSE VIEW	EPIDERMIS IN SURFACE VIEW	EPIDERMAL HAIRS	SUB-EPIDERMAL LAYER
13. Strophanthus Arnoldianus Wildem. & Th. Dur.	Single layer of radially elongated cells averaging 30 x 18 microns. Tangential walls thin; outer wall of each cell prolonged as a hair. Anticlinal walls spindle-shaped and about 6 microns thick at centre.	Cells elongated; 45 to 110 microns in length and 25 to 45 microns in width. 6 to 8 microns thick and strongly and uniformly lignified. Numerous hairs present.	250 - 350 microns in length and average 20 microns in diameter at base of shaft. Unicellular and with a thin non-lignified or with a slightly lignified cell-wall.	Normally about 15 microns in thickness and composed of tangentially elongated, radially compressed cells but sometimes this layer may attain 60 microns in thickness due entirely to abnormally large cell-cavities.
14. Strophanthus Boivini Baill.	Single layer of nearly isodiametric cells varying from 25 to 30 microns in size. Outer tangential wall irregular in thickness. Anticlinal walls broadly spindle-shaped.	Cells elongated; 30 to 80 microns in length and 15 to 30 microns in width. Anticlinal walls average 9 microns in thickness and are strongly but not uniformly lignified. The middle lamella stains noticeably deeper than the thickening on the cell-wall. Outer tangential wall of many of the cells is prolonged as a hair. The inner tangential wall shows non-lignified, reticulately arranged ribs of thickening. Numerous hairs present.	250 - 350 microns in length and average 15 microns in diameter at base of shaft. Unicellular and with a thin wall which is either non-lignified or shows slight uniform lignification in the basal half of the shaft.	About 15 microns in thickness and composed of a few layers of thin-walled, tangentially elongated, radially compressed cells.
15. Strophanthus Gossweilerii Hess	Single layer of nearly isodiametric cells averaging 30 microns in size. Tangential walls moderately thin; outer wall of each cell prolonged as a hair. Anticlinal walls spindle-shaped and 9 microns thick.	Cells elongated; 45 to 100 microns in length and 10 to 30 microns in width. Anticlinal walls 9 microns thick and only slightly lignified. Hairs numerous.	Up to 500 microns in length and average 15 microns in diameter at base of shaft. Unicellular and with a thin, slightly lignified cell-wall.	Varies from 10 to 30 microns in thickness. Composed of a few layers of tangentially elongated cells.
16. Strophanthus divaricatus Wall	Single layer of cells which vary from 15 to 40 microns tangentially and from 15 to 18 microns radially. Tangential walls moderately thin; outer wall of each cell sometimes prolonged as a hair. Thickening of anticlinal walls spindle-shaped where the cells do not exceed 30 microns tangentially but almost rectangular where the cells measure from 30 to 40 microns tangentially.	Wide variation in shape and size. Many cells axially elongated and up to 120 microns x 6 to 21 microns. Other cells nearly isodiametric and 20 to 60 microns in diameter. A few cells are transversely elongated and measure up to 50 x 20 microns. The anticlinal walls are 10 to 15 microns in thickness and, though strongly lignified, the middle lamella stains the deepest. Outer tangential wall sometimes prolonged as a hair. A few inconspicuous ribs of thickening are seen on inner tangential wall. Relatively few hairs present.	Short and stubby. 25 to 40 microns long and about 20 microns in diameter at base. Unicellular and with a thin non-lignified wall. Orientation variable but exhibit a slight tendency to point towards the apex of the seed.	Varies from 10 to 14 microns in thickness. Composed of a few layers of thin-walled, tangentially elongated cells. Tissue shows a tendency to split near its centre forming elliptical cavities.

	CRYSTALS IN SPERMODERM	ENDOSPERM	EMERYO
13. Strophanthus Arnoldianus Wildem. & Th. Dur.	Small number present in the form of single crystals about 20 microns in size or as conglomerates 20 to 25 microns in diameter.	7 to 12 layers of cells thick. Cells polygonal in outline and 20 to 30 microns in diameter. No well-defined crystals present but numerous minute crystals about 2 microns in size occur.	Thin-walled cells 20 to 25 microns in diameter. No crystals present.
14. Strophanthus Boivini Baill.	Absent.	6 to 13 layers of polygonal cells each 15 to 40 microns in diameter. No crystals present.	Thin-walled cells about 25 microns in diameter. Numerous well-defined cluster crystals varying from 10 to 15 microns in diameter.
15. Strophanthus Gossweilerii Hess	Absent.	5 to 12 layers of polygonal cells each 15 to 45 microns in diameter. No crystals present.	Thin-walled cells about 25 microns in diameter. No crystals present.
16. Strophanthus divaricatus Wall	Absent.	7 to 12 layers of polygonal cells each about 30 microns in diameter. Outer face of tissue longitudinally ridged. No crystals present.	Thin-walled cells 15 to 20 microns in diameter. No crystals present.

	GENERAL CHARACTERS	RAPHE	BASAL WING	LONGITUDINAL RIDGES ON TESTA	SIZE OF SEED	GENERAL CHARACTERS OF TRANSVERSE SECTION
17. Strophanthus Intermedius Pax	Dull light to medium reddish-brown but readily-detachable, golden-yellow hairs are present on parts of testa. Lanceolate. Flattened. Edges subacute to rounded. Base rounded.	Slightly raised, light brown in colour but not conspicuous. Three-quarters of length of seed.	Absent.	Present but very inconspicuous.	Length 11-14 mms. Width 3-3.5 mms. Thickness 1.25-1.5 mms.	Narrowly ovate in outline. Periphery very slightly undulant.
18. Strophanthus Tholloni Franchet	Soft brownish-green in colour with a uniform covering of dull hairs. Ground-colour of testa greenish-brown. Conspicuously lanceolate. Flattened. Edges subacute. Base acute. A very long, rather conspicuously flattened, seed.	Slightly raised but not conspicuous. Three-quarters of length of seed.	Very prominent. Composed entirely of spermoderm tissue.	Absent.	Length 15-21 mms. Width 2-3 mms. Thickness about 1 mm.	Narrowly ovate in outline. No peripheral undulations.
19. Strophanthus Wightianus Wall	Yellowish-brown in colour; woody and apparently glabrous. Lanceolate to broadly lanceolate and conspicuously flattened. Edges almost acute. Base acute to subacute. Apex acute and often twisted.	Pale yellowish-brown and slightly raised. Three-quarters of length of seed.	Small and membranous.	Present but not conspicuous.	Length 12.5-16 mms. Width 2.5-3.5 mms. Thickness about 1.5 mms.	Elliptical in outline. Periphery slightly undulant. Undulations due almost entirely to longitudinal ridges on outer face of endosperm.
20. Strophanthus congoensis Franchet	Uniform dull, dark, reddish-brown and with a distinct furry appearance. Lanceolate and conspicuously flattened. Edges subacute. Base rounded.	Slightly raised but not conspicuous. The lower half exhibits minute undulations at right angles to the surface of the testa.	Absent.	Absent but surface noticeably rugose.	Length 13-17 mms. Width 3-4 mms. Thickness 1.5-2 mms.	Ovate in outline. No peripheral undulations.

	EPIDERMIS IN TRANSVERSE VIEW	EPIDERMIS IN SURFACE VIEW	EPIDERMAL HAIRS.	SUB-EPIDERMAL LAYER
17. Strophanthus Intermedius Pax	Single layer of cells measuring 15 microns radially and from 15 to 25 microns tangentially. Tangential walls thin and outer wall may be prolonged as a hair. Anticlinal walls broadly spindle-shaped.	Cells elongated; 35 to 100 microns in length and 15 to 40 microns in width. Anticlinal walls 9 microns thick and only slightly lignified. Outer tangential wall of each cell bears either a hair or hair-scar.	Up to 510 microns in length and average 15 microns in diameter at base of shaft. Unicellular and with thin, non-lignified cell-walls.	About 10 microns in thickness and composed of a few layers of thin-walled tangentially elongated cells. Outer layers closely coherent but inner layers tend to split apart forming tangentially elongated cavities. One such cavity is present under each epidermal ridge and is responsible for its formation.
18. Strophanthus Tholloni Franchet	Single layer of tangentially elongated cells about 15 x 40 microns. Tangential walls thin; outer wall of each cell prolonged as a hair. Anticlinal walls with prominent thickening of rectangular form as seen in Strophanthus divaricatus.	Cells elongated; 45 to 220 microns x 12 to 40 microns. Show two unusual features (a) conspicuously sinuous anticlinal walls (b) cells sometimes variously orientated. Anticlinal walls 7 to 10 microns thick and, though strongly lignified, the middle lamella is the most heavily lignified region. Outer tangential wall of each cell usually prolonged as a hair. Inner tangential wall with a few slightly lignified ribs of thickening.	300 - 500 microns in length and average 20 microns in diameter at base of shaft. Unicellular and with thin, non-lignified cell-walls.	About 15 microns in thickness and composed of a few layers of thin-walled tangentially elongated cells.
19. Strophanthus Wightianus Wall	Single layer of cells averaging 25 microns tangentially. Cells partially or almost completely collapsed. Tangential walls moderately thick and outer wall of a number of cells apparently prolonged as hair. Anticlinal walls broadly spindle-shaped.	Cells elongated; 50 to 150 microns in length and 15 to 45 microns in width. Anticlinal walls 10 to 15 microns thick and strongly lignified: middle lamella stains deepest. The outer tangential wall of a number of the cells is extended out as a rudimentary hair.	Rudimentary; take the form of bluntly conical protuberances 15 to 35 microns in length and about 20 microns in diameter near their base. Unicellular and with thin, slightly warty, non-lignified cell-walls.	About 10 microns in thickness and composed of a few layers of thin-walled, tangentially elongated, radially compressed cells.
20. Strophanthus congoensis Franchet	Single layer of tangentially elongated cells varying from 33 to 51 microns by about 15 microns. Tangential walls moderately thin; outer wall of each cell prolonged as a hair. Anticlinal walls spindle-shaped.	Cells elongated; 30 to 105 microns in length and 12 to 33 microns in width. Anticlinal walls 7 to 9 microns thick and uniformly but not strongly lignified. Outer tangential wall of each cell prolonged as a hair.	300 to 500 microns in length and 20 to 25 microns in diameter at base of shaft. Unicellular and with thin walls which are usually non-lignified but occasionally show slight uniform lignification. Occasionally hairs with rather thicker walls are seen.	About 15 microns in thickness and composed of a few layers of thin-walled, tangentially elongated, radially compressed cells.

	CRYSTALS IN SPERMODERM	ENDOSPERM	EMBRYO
17. Strophanthus Intermedius Pax	Absent.	6 to 12 layers of rather thick-walled polygonal cells varying from 20 to 45 microns in diameter. No well-defined crystals present but each cell contains one minute crystal about 2 microns in size.	Thin-walled cells 15 to 25 microns in diameter. No crystals present.
18. Strophanthus Tholloni Franchet	Absent.	7 to 12 layers of thick-walled polygonal cells each about 30 microns in diameter. No well-defined crystals present but each cell contains one or more minute crystals 2 to 3 microns in size.	Polygonal cells about 25 microns in diameter with slightly thicker walls than usually seen in this tissue. No crystals present.
19. Strophanthus Wightianus Wall	Absent.	7 to 10 layers of thick-walled polygonal cells each about 30 microns in diameter. No crystals present.	Thin-walled cells averaging 30 microns in size. No crystals present.
20. Strophanthus congoensis Franchet	Absent.	6 to 12 layers of thick-walled polygonal cells varying from 25 to 45 microns in diameter. No well-defined crystals but minute crystals each less than 2 microns in size occur.	Thin-walled cells averaging about 15 microns in size. No crystals present.

COLOUR REACTIONS OF STROPHANTHUS SEEDS.

Early in the study of the seeds of various species of Strophanthus it was realised that morphological similarities made their identification a matter of very great difficulty and in order to enable workers to separate the seeds of species of known medicinal value, from those known to be worthless, attempts were made to develop a rapid and certain method of identification. This need led to the study of the colours produced when the freshly cut seed or an extract of it was treated with one of various chemical reagents.

One of the earliest papers dealing with this aspect of the Strophanthus was published by Fraser (1889), who treated seeds which he had under investigation with chemical reagents such as concentrated sulphuric acid, 10% sulphuric acid, sulphuric acid and potassium dichromate, and nitric acid. With some of these reagents he reported the development of distinctive colours.

Although this report by Fraser is of historical interest, his conclusions are of somewhat doubtful value. Ostensibly he was investigating the seeds of Strophanthus hispidus and in the course of his report stated that Strophanthus Kombe was not a distinct species but merely a "race" of hispidus. It is now well established that these two species are quite distinct from one another. From certain other observations /

observations which Fraser made it now appears more than probable that his material was, in fact, derived from Strophanthus Kombe.

In the subsequent early literature many conflicting references are made to the colour reactions of the seeds of various species of Strophanthus, but little amplification or extension of these colour tests appears to have been made until a much later date and even at the present time there is marked disagreement amongst the different workers as to the colours developed when the seeds of some well known species are treated with sulphuric acid.

Tiffeneau (1923) reported the results of a number of colour tests with h-strophanthin and ouabain (g-strophanthin). He found that concentrated sulphuric acid gave a green colour with h-strophanthin and a rose-red or yellow-brown with ouabain. On diluting the sulphuric acid to 65% v/v he found that the green colour was still given by h-strophanthin but no colour was given by ouabain. Tiffeneau also reported the same results with a mixture of sulphuric and tungstic acids as with 65% v/v sulphuric acid. Sulphuric acid and phosphomolybdic acid together are said to produce a blue colour with h-strophanthin and sulphuric acid and vanadic acid together an intense green colour with ouabain. A solution of phenol is reported to give a violet colour with h-strophanthin but when resorcinol was used the colour was rose-red.

Mathiesen (1927-28) reported on the colour reactions of eleven of the species which are the subject of the present investigation but he confined his /

his work to the examination of the colour produced by means of sulphuric acid. The technique adopted by Mathiesen was to place a moderately thick transverse section of the seed under examination on a microscope slide, cover the specimen with 80% w/w sulphuric acid and then follow the course of the reaction by transmitted light, using good daylight and a magnification of forty diameters. It would appear that for this work Mathiesen used the same material as was employed by Gilg and Schuster (1919) who made a similar examination of the seeds.

The findings of both Mathiesen and Gilg & Schuster (1919) are set out in Table 2, though it is not always clear from their reports in which part of the seeds the colours were found to develop.

Wagenaar (1932) published a modification of the sulphuric acid test. He used the concentrated acid diluted with one-third of its volume of glycerol and reported that the characteristic colour developed more slowly and remained more localised than when the glycerol was omitted. Wagenaar also reported that the colour first appeared in the cells of the endosperm and that the procambial strands were always stained red.

Smelt (1933) made a further examination of the seeds of a few species of Strophanthus but observed the colour reactions given with a large number of chemical reagents. In all fourteen reagents were examined, of which four were recommended as suitable for the present purpose.

The technique employed by Smelt consisted of /

of extracting the crushed seed with 70% alcohol at 60°C for five minutes. This extract was then cooled, filtered, and the filtrate evaporated to dryness. Finally the residue so obtained was then defatted by washing twice with a few mils. of light petroleum (b.pt. 50° to 60°) and again dried. The test was applied to the residue as described under the various reagents which are detailed below. In a few cases Smelt also applied the tests to thick sections of the dry seeds and reported that the colours were the same, though less pronounced, than those given when the above technique was employed.

Chemical Tests recommended by Smelt (1933)

1. Sulphuric Acid Test - mix 1 mgm. (approx.) of residue with 1 drop of 75% v/v sulphuric acid and allow to stand.

According to Smelt neither concentrated nor 65% v/v sulphuric acid give such definite colours as the strength recommended.

2. Phenol and Hydrochloric Acid Test - warm 1 mgm. (approx.) of the residue to a temperature of 50° to 60° with 5 mils. of concentrated hydrochloric acid containing 1% w/v of phenol. Allow to stand.

3. Furfuraldehyde and Sulphuric Acid Test - mix 1 mgm. (approx.) of the residue with 0.1 mil. of 1% w/v solution of furfuraldehyde in 95% alcohol and 0.5 mil. 75% v/v sulphuric /

sulphuric acid. Allow to stand.

4. Resorcinol and Hydrochloric Acid Test - heat 1 mgm. (approx.) of the residue to a temperature of about 60° with 5 mils. of concentrated hydrochloric acid containing 0.1% w/v of resorcinol.

The results of Smelt's tests are set out in Table 3.

Owing to the fact that Smelt's report refers to the colours given by the dried and defatted alcoholic extract of the seed whereas Mathiesen's applies to the freshly cut surface of the dry seed, it is almost impossible to draw a fair comparison between the results observed by these two workers. It is obvious, however, that in Mathiesen's report a greater variety of distinct colours are mentioned and furthermore, when a transverse section of the seed is employed it is possible to differentiate between the colour produced in the endosperm and that seen in the cotyledons.

In order to study the merits and demerits of these various techniques, a number of experiments were performed using seeds of species of which a plentiful supply was at hand.

In the first place sections were cut and examined as described by Mathiesen. This method was found to be only moderately satisfactory because, owing to the brittle nature of the material, it was extremely /

extremely difficult to obtain whole transverse sections of sufficient thinness to observe the localisation of the various colours. Furthermore, the development of colour was often irregular and sometimes so slow that even after 30 minutes' observation the colour had not reached its final shade. It was thought that this slow development might be occasioned by the presence of fixed oil in the section preventing the penetration of aqueous reagents. Accordingly, a number of sections were defatted by immersion in light petroleum and then subjected to the action of the reagents. No appreciable improvement in the colour development was observed. The question of temperature was next considered and it was found that only a slight elevation in temperature was necessary to ensure rapid and uniform development. In order to maintain the temperature at a known level in all cases and at the same time permit of continuous observation of the specimen it was found necessary to employ an electrically heated and thermostatically controlled microscope stage in a manner which will be described later.

Some examination of Smelt's procedure was then made, and it was found that, although the colours were in nearly every case quite distinct, they were inferior to those obtained from the transverse section of the seed, and the method suffered from the great disadvantage that any difference either in shade or actual colour between the endosperm and the cotyledons was not shown.

Wagenaar's modification of the sulphuric acid test was also tried out, but it was not found to possess /

possess any appreciable advantage over the test as performed without the glycerol. It was also noticed that only in a few cases were the procambial strands stained red and not in all cases as claimed by Wagenaar.

As a result of these preliminary experiments the following procedure was devised, and it proved to be a rapid and reliable method of observing the colour sequence to be seen in each case.

Seeds of the species to be examined were slightly softened by exposure to a moist atmosphere at a temperature of 50°C for a period ranging from 10 to 30 minutes according to the nature of the material. Hand sections were then cut and each treated separately on a microscope slide with one of the reagents detailed below. The preparation was immediately placed on an electrically-heated microscope stage maintained at a temperature of 40°C and continuously observed by strong reflected artificial daylight at a magnification of 40 diameters. It was found in this way that in every case the colour sequence passed through all its phases and reached its final form within a period of five minutes.

The tests applied in each case were as follows:-

Test No. 1. Sulphuric Acid Test - two drops of 75% v/v sulphuric acid were applied to the transverse section which was then examined as above.

Test /

Test No. 2. Phenol and Hydrochloric Acid Test - two to three drops of a 1% solution of phenol in concentrated hydrochloric acid were applied to the section and examined.

Test No. 3. Furfuraldehyde and Sulphuric Acid Test - two drops of a 1% w/v solution of furfuraldehyde in 95% alcohol were applied to the section and the mixture allowed to stand until most of the alcohol had evaporated. Two drops of 75% v/v sulphuric acid were then added and the mount examined.

Test No. 4. Resorcinol and Hydrochloric Acid Test - two to three drops of a 0.1% w/v solution of resorcinol in concentrated hydrochloric acid were applied to the section which was then examined as before.

Colour /

Colour Sequences Observed with the Above Reagents.

Strophanthus Kombé Oliver (specimen S 41)

	Endosperm	Cotyledons
Test No. 1.		
Immediate Colour	pale green	Nil
Colour in 30 secs.	strong green	very pale green
" " 60 "	brownish-green	pale bluish-green
" " 2 mins.	dark brownish-green	bright bluish-green
" " 5 "	brownish-violet	strong bluish-green
Test No. 2.		
Immediate Colour	Nil	Nil
Colour in 30 secs.	pale pink	very pale pink
" " 60 "	pale brownish-pink	pale pink
" " 2 mins.	brownish-pink	pink
" " 5 mins.	no change	no change
Test No. 3.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale blue	yellowish-green
" " 60 "	strong blue	green
" " 2 mins.	bluish-black	dark green
" " 5 "	dark bluish-black	very dark green
Test No. 4.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale yellow	very pale pink
" " 60 "	pale orange	pale salmon pink
" " 2 mins.	orange	salmon pink
" " 5 "	no change	no change

Strophanthus Courmontii Sacleux (specimen S 12)

	Endosperm	Cotyledons
Test No. 1.		
Immediate colour	nil	nil
Colour in 30 secs.	orange red	numerous pale pink spots
" " 60 "	dark orange	uniform pale pink
" " 2 mins.	reddish-violet	pink
" " 5 "	strong violet	pinkish-violet
Test No. 2.		
Immediate Colour	nil	nil
Colour in 30 secs.	clear bright violet	pale violet
" " 60 "	as previous but a slight increase in depth of colour	
" " 2 mins.	no change	no change
" " 5 "	no change	no change
Test No. 3.		
Immediate Colour	light orange	light orange
Colour in 30 secs.	orange	orange
" " 60 "	dark orange	dark orange
" " 2 mins.	dull brownish-orange	dull brownish-orange
" " 5 "	dark brown	dark brown
Test No. 4.		
Immediate Colour	nil	nil
Colour in 30 secs.	pink	pale pink
" " 60 "	strong bright rose	strong pink
" " 2 mins.	dark rose	pale rose
" " 5 "	violet-brown	dark purplish-red

Strophanthus sarmentosus P.DC. (specimen S 44)

	Endosperm	Cotyledons
Test No. 1.		
Immediate Colour	nil	very pale pink
Colour in 30 secs.	bright orange	pink
" " 60 "	bright dark orange	strong pink
" " 2 mins.	brownish-orange	orange
" " 5 "	brown	dark orange
Test No. 2.		
Immediate Colour	nil	nil
Colour in 30 secs.	bright greenish-blue	pale greenish-blue
" " 60 "	dark green	strong violet
" " 2 mins.	little significant change but colours slightly darker in both cases	
" " 5 "	no change	no change
Test No. 3.		
Immediate Colour	pale bright yellow	pale bright yellow
Colour in 30 secs.	no change	no change
" " 60 "	light orange	light orange
" " 2 mins.	orange	pink
" " 5 "	brownish-orange	almost colour-less
Test No. 4.		
Immediate Colour	nil	nil
Colour in 30 secs.	bright green	violet pink
" " 60 "	dark green	strong violet-pink
" " 2 mins.	brownish-green	violet
" " 5 "	light brownish-violet	dark violet

Strophanthus sarmentosus P.DC. (specimen S 53)

	Endosperm	Cotyledons
Test No. 1.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale orange	pale orange
" " 60 "	orange	reddish-orange
" " 2 mins.	reddish-orange	reddish-orange
" " 5 "	brown	strong orange with a brownish tinge
Test No. 2.		
Immediate Colour	nil	nil
Colour in 30 secs.	purplish-pink	pale purplish-pink
" " 60 "	darker purplish-pink	purplish-pink
" " 2 mins.	bright purple	bright purple
" " 5 mins.	very dark purple	strong purple
Test No. 3.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale yellow	pale yellow
" " 60 "	pale orange	yellow
" " 2 mins.	orange	orange
" " 5 "	dark brownish-orange	pale brownish-orange
Test No. 4.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale violet-pink	pale violet-pink
" " 60 "	strong violet-pink	strong violet-pink
" " 2 mins.	reddish-purple	reddish-purple
" " 5 "	dark purple	dark purple

Strophanthus sarmentosus var. major Dewevre (specimen S 45)

	Endosperm	Cotyledons
Test No. 1.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale orange	pale orange
" " 60 "	bright orange	pale orange
" " 2 mins.	strong bright orange	orange
" " 5 "	brownish-orange	pale pinkish-orange
Test No. 2.		
Immediate Colour	nil	nil
Colour in 30 secs.	very pale pink	very pale pink
" " 60 "	bright violet-pink	pale violet-pink
" " 2 mins.	strong violet	violet
" " 5 "	deep purple	purple
Test No. 3.		
Immediate Colour	yellow	yellow
Colour in 30 secs.	bright orange	bright orange
" " 60 "	dark orange	orange
" " 2 mins.	reddish-orange	orange
" " 5 "	dark reddish-orange	pale orange
Test No. 4.		
Immediate Colour	nil	nil
Colour in 30 secs.	nil	nil
" " 60 "	nil	pale pink
" " 2 mins.	pale violet	pink
" " 5 "	no change	no change

Strophanthus Emini Aschers (specimen S 48)

	Endosperm	Cotyledons
Test No. 1.		
Immediate Colour	nil	nil
Colour in 30 secs.	bright pink	very pale pink
" " 60 "	strong purplish-red	strong bright pink
" " 2 mins.	dark purple	purplish-red
" " 5 "	purplish-black	dark reddish-purple
Test No. 2.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale greenish-blue	nil
" " 60 "	slate-grey	pale pink
" " 2 mins.	no change	violet-pink
" " 5 "	no change	bright purple
Test No. 3.		
Immediate Colour	bright yellow	bright-yellow
Colour in 30 secs.	bright orange	bright orange
" " 60 "	bright blue	purple
" " 2 mins.	bluish-black	indigo-blue
" " 5 "	both endosperm and cotyledons too dark to discern any actual colour	
Test No. 4.		
Immediate Colour	nil	nil
Colour in 30 secs.	slate-grey	nil
" " 60 "	no change	pale pink in region adjacent to endosperm
" " 2 mins.	brownish-grey	violet
" " 5 "	dark brown	dark purple

Strophanthus hispidus P.DC. (specimen S 60)

	Endosperm	Cotyledons
Test No. 1.		
Immediate Colour	pale green	pale green
Colour in 30 secs.	no change	emerald green but showing bright red spots
" " 60 "	olive green	no change in colours but red areas rather greater in extent
" " 2 mins.	brownish-red	red now predominates; green confined to epidermal region
" " 5 "	dark brownish-red	red but one shows purple area in region of procambial strand and the other a green area. In both cots. the epidermis is dark green
Test No. 2.		
Immediate Colour	nil	nil
Colour in 30 secs.	greyish-green	very pale pink
" " 60 "	greyish-blue-green	pale violet
" " 2 mins.	no change	strong violet
" " 5 "	no change in actual colours but intensity much diminished	
Test No. 3.		
Immediate Colour	yellow	yellow
Colour in 30 secs.	dark orange	bright yellow
" " 60 "	orange-brown	dark yellow
" " 2 mins.	brown but innermost layer dark green	brownish-orange
" " 5 "	dark brown but dark green in innermost layer	one purplish-brown other brownish-orange

Strophanthus hispidus P.DC. (specimen S 60) (contd.)

	Endosperm	Cotyledons
Test No. 4.		
Immediate colour	Nil	Nil
Colour in 30 secs.	pale bright blue	pale pink
" " 60 "	slate blue	no change
" " 2 mins.	dark slate blue	pale violet
" " 5 "	no change	no change

Specimen S 31 of Strophanthus hispidus, which was collected in 1906, was tested as above and found, in spite of its age, to give almost identical colour reactions. Thisis not in agreement with Mathiesen (1927-28) who reported that old samples gave only a yellowish colour.

Strophanthus Nicholsoni Holmes (specimen S 16)

	Endosperm	Cotyledons
Test No. 1.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale bright pink	pale bright pink
" " 60 "	bright rose	bright rose
" " 2 mins.	dark rose	purplish-rose
" " 5 "	no change	no change
Test No. 2.		
Immediate Colour	nil	nil
Colour in 30 secs.	violet-grey	nil
" " 60 "	strong violet	pale violet
" " 2 mins.	purple	violet
" " 5 "	dark purple	purple
Test No. 3.		
Immediate Colour	orange	orange
Colour in 30 secs.	dark orange	dark orange
" " 60 "	brownish-orange	brownish-orange
" " 2 mins.	dark brownish-orange	brownish-orange but with a purplish tinge
" " 5 "	very dark brownish-orange	dark purplish-orange
Test No. 4.		
Immediate Colour	nil	nil
Colour in 30 secs.	olive-green	nil
" " 60 "	rose tinged with green	bright pink
" " 2 mins.	dark purple	strong violet
" " 5 "	no significant change	no significant change

Strophanthus gratus (Wall & Hook) Franchet (specimen S 61)

	Endosperm	Cotyledons
Test No. 1.		
Immediate Colour	nil	nil
Colour in 30 secs.	grey	very pale pink
" " 60 "	reddish-orange	deep pink
" " 2 mins.	dark reddish-orange	orange
" " 5 "	dull dark red	strong dark orange
Test No. 2.		
Immediate Colour	nil	nil
Colour in 30 secs.	grey	pale bright pink
" " 60 "	greyish-pink	strong violet-pink
" " 2 mins.	pinkish-grey	bright purple
" " 5 "	dark grey and pink mottled	dark purple
Test No. 3.		
Immediate Colour	nil	nil
Colour in 30 secs.	lemon yellow	lemon yellow
" " 60 "	dark yellow	orange
" " 2 mins.	almost black	mostly almost black but bright orange in region of procambial strands
" " 5 "	no change	no change
Test No. 4.		
Immediate Colour	nil	nil
Colour in 30 secs.	grey	very pale pink
" " 60 "	pinkish-grey	pink
" " 2 mins.	brownish-grey	bright purple
" " 5 "	reddish-brown	strong dark purple

Strophanthus mirabilis Gilg (specimen S 10)

	Endosperm	Cotyledons
Test No. 1.		
Immediate Colour	nil	nil
Colour in 30 secs.	violet	pale violet
" " 60 "	purple	pale purple but procambial strands red
" " 2 mins.	very dark purple	strong purple
" " 5 "	purplish-black	very dark purple: red no longer evident
Test No. 2.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale grey	nil
" " 60 "	greyish-pink	very pale pink
" " 2 mins.	dark grey	violet
" " 5 "	very dark grey	purple
Test No. 3.		
Immediate Colour	orange	orange
Colour in 30 secs.	dark purple	bright purple
" " 60 "	purplish-black	dark purple
" " 2 mins.	black	very dark purple
" " 5 "	no change	no change
Test No. 4.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale orange	very pale pink
" " 60 "	greyish-orange	pink
" " 2 mins.	grey	bright pink
" " 5 "	no change	no change

Strophanthus petersianus Klotzsch (specimen S 13)

	Endosperm	Cotyledons
Test No. 1.		
Immediate Colour	nil	nil
Colour in 30 secs.	greyish-pink	pale pink
" " 60 "	reddish-brown	reddish-orange
" " 2 mins.	dark reddish-brown	dark reddish-orange
" " 5 "	no significant change	no significant change
Test No. 2.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale grey	nil
" " 60 "	greyish-violet	pale violet
" " 2 mins.	strong bright purple	strong bright purple
" " 5 "	dark purple	dark livid purple
Test No. 3.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale yellow	orange
" " 60 "	bright yellow	strong orange
" " 2 mins.	orange	dark orange
" " 5 "	no change	no change
Test No. 4.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale grey	nil
" " 60 "	pinkish-grey	pink
" " 2 mins.	greyish-violet	pale violet
" " 5 "	dark reddish-purple	bright purple

Strophanthus amboensis Engl. & Pax (specimen S 14)

	Endosperm	Cotyledons
Test No. 1.		
Immediate Colour	nil	nil
Colour in 30 secs.	dull orange	dull violet
" " 60 "	reddish-brown	purple
" " 2 mins.	almost black	dull brownish-purple
" " 5 "	black	dark dull brownish-purple
Test No. 2.		
Immediate Colour	nil	nil
Colour in 30 secs.	grey	pale grey
" " 60 "	strong emerald-green	bluish-green
" " 2 mins.	dark green	strong greenish-blue
" " 5 "	very dark green	dark greenish-blue
Test No. 3.		
Immediate Colour	nil	nil
Colour in 30 secs.	bright yellow	bright yellow
" " 60 "	dark yellow	purplish
" " 2 mins.	dull brownish-orange	dull purple
" " 5 "	dark brown	dull dirty purple
Test No. 4.		
Immediate Colour	nil	nil
Colour in 30 secs.	bluish-grey	nil
" " 60 "	strong purple	purple with bright blue areas
" " 2 mins.	dark purple	dark bluish-purple
" " 5 "	almost black	very dark purple

All /

Strophanthus amboensis Engl. & Pax (specimen S 14) contd.

All the above tests were also applied to Strophanthus ambœnsis (specimen S 46). In every case the colours were almost identical and only two minor differences were observed; in Test 1 the endosperm of S 46 did not turn quite so dark as that of S 14 and in Test No. 3 the cotyledons of S 46 remained of a strong, relatively bright purple and never appeared of the dull dirty hue as seen in S 14.

Strophanthus /

Strophanthus Barteri Franchet (specimen S 15)

	Endosperm	Cotyledons
Test No. 1.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale grey	pale violet
" " 60 "	reddish-orange	bright violet
" " 2 mins.	deep bright orange	no change
" " 5 "	no change	no change
Test No. 2.		
Immediate Colour	nil	nil
Colour in 30 secs.	grey	pale pink
" " 60 "	violet-pink	pale violet
" " 2 mins.	strong reddish-purple	bright purple
" " 5 "	no change	no change
Test No. 3.		
Immediate Colour	nil	nil
Colour in 30 secs.	lemon yellow	lemon yellow
" " 60 "	orange	orange
" " 2 mins.	strong orange	strong orange
" " 5 "	strong dark reddish-orange	strong dark reddish-orange
Test No. 4.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale grey	nil
" " 60 "	light purple	pale violet
" " 2 mins.	strong bright purple	violet
" " 5 "	very dark purple	deep vivid purple

Strophanthus Arnoldianus Wildem. & Th. Dur. (specimen S 47)

	Endosperm	Cotyledons
Test No. 1.		
Immediate Colour	pale green	pale green
Colour in 30 secs.	green	bluish-green
" " 60 "	brownish-green	green
" " 2 mins.	reddish-brown	emerald green (procambial strands bright red)
" " 5 "	almost black	dull brownish-green (procambial strands dull red)
Test No. 2.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale grey	nil
" " 60 "	grey	nil
" " 2 mins.	greyish-pink	pale pink
" " 5 "	dark greyish-pink	dull pink
Test No. 3.		
Immediate Colour	pale yellowish-green	pale yellowish-green
Colour in 30 secs.	brownish-green	dull orange
" " 60 "	dark brownish-green	reddish-purple
" " 2 mins.	dark brownish-purple	purple
" " 5 "	almost black	dark purple
Test No. 4.		
Immediate Colour	pale grey	pale grey
Colour in 30 secs.	pale greenish-grey	very pale pink
" " 60 "	pale bluish-green	pale violet
" " 2 mins.	bluish-green	pale violet
" " 5 "	no change	no change

Strophanthus Boivini Baill. (specimen S 49)

	Endosperm	Cotyledons
Test No. 1.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale green	pale pink
" " 60 "	greenish-orange	no change
" " 2 mins.	orange	no change
" " 5 "	no change	no change
Test No. 2.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale blue	very pale yellow
" " 60 "	violet	very pale orange
" " 2 mins.	dark violet	pale reddish-violet
" " 5 "	purple	purple
Test No. 3.		
Immediate Colour	orange	orange
Colour in 30 secs.	bright orange	bright orange
" " 60 "	brownish-orange	brownish-orange
" " 2 mins.	dark brownish orange	dark brownish-orange
" " 5 "	black	no change
Test No. 4.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale green	pale pink
" " 60 "	greenish-grey	pale bright pink
" " 2 mins.	greenish-brown	violet
" " 5 "	dark greenish-brown	deep violet

Strophanthus Gossweilerii Hess (specimen S 50)

	Endosperm	Cotyledons
Test No. 1.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale greyish-pink	very pale pink
" " 60 "	bright orange-red	pink
" " 2 mins.	dark reddish-orange	pale orange
" " 5 "	strong dark reddish-orange	reddish-orange
Test No. 2.		
Immediate Colour	nil	nil
Colour in 30 secs.	grey	nil
" " 60 "	greyish-pink	pale pink
" " 2 mins.	greyish-violet	violet
" " 5 "	dark greyish-purple	purple
Test No. 3.		
Immediate Colour	nil	nil
Colour in 30 secs.	yellow	yellow
" " 60 "	very dark yellow	strong yellow
" " 2 mins.	yellowish-brown	dark yellow
" " 5 "	dark orange-brown	yellowish-brown
Test No. 4.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale grey	nil
" " 60 "	violet-grey	pale grey
" " 2 mins.	purple	violet
" " 5 "	purplish-brown	strong violet

Strophanthus divaricatus Wall (specimen S 51)

	Endosperm	Cotyledons
Test No. 1.		
Immediate Colour	nil	nil
Colour in 30 secs.	bright pinkish-violet	bright pinkish-violet
" " 60 "	violet-brown	violet-brown
" " 2 mins.	dark brownish-purple	light brownish-purple
" " 5 "	purplish-black	purplish-black
Test No. 2.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale grey	nil
" " 60 "	pinkish-grey	pinkish-grey
" " 2 mins.	violet-grey	violet-grey
" " 5 "	purplish-grey	purplish-grey
Test No. 3.		
Immediate Colour	yellow	yellow
Colour in 30 secs.	bright yellowish-orange	bright yellowish-orange
" " 60 "	brownish-orange	brownish-orange
" " 2 mins.	light earthy-brown (fading)	light earthy-brown (fading)
" " 5 "	dirty violet-brown	dirty violet-brown
Test No. 4.		
Immediate Colour	nil	nil
Colour in 30 secs.	bluish-grey	nil
" " 60 "	violet-grey	violet
" " 2 mins.	reddish-purple	pale purple
" " 5 "	dark reddish-purple	purple

Strophanthus intermedius Pax (specimen S 52)

	Endosperm	Cotyledons
Test No. 1.		
Immediate Colour	nil	nil
Colour in 30 secs.	nil	pale yellow
" " 60 "	pink	pale orange
" " 2 mins.	bright orange	dull orange
" " 5 "	strong orange	dull dirty orange
Test No. 2.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale blue	nil
" " 60 "	purple	pale bluish-green but central region colourless
" " 2 mins.	dark purple	bright blue but central region colourless
" " 5 "	as above but fading slightly	dark blue except central region which is pale blue
Test No. 3.		
Immediate Colour	yellow	yellow
Colour in 30 secs.	bright orange	bright orange
" " 60 "	strong bright orange	strong bright orange
" " 2 mins.	dark orange	brownish-orange
" " 5 "	no change	no change
Test No. 4.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale grey	nil
" " 60 "	pinkish-grey	pale bluish-green
" " 2 mins.	bright rose	bright bluish-green
" " 5 "	dark rose	no change

Strophanthus Tholloni Franchet (specimen S 54)

	Endosperm	Cotyledons
Test No. 1.		
Immediate Colour	nil	nil
Colour in 30 secs.	very pale orange	very pale orange
" " 60 "	bright reddish-orange	bright reddish-orange
" " 2 mins.	very strong bright reddish-orange	very strong bright reddish-orange
" " 5 "	dark orange-red	dark orange-red
Test No. 2.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale violet	pale violet
" " 60 "	strong violet	no change
" " 2 mins.	dark purple	pale bright purple
" " 5 "	purplish-black	strong bright purple
Test No. 3.		
Immediate Colour	nil	nil
Colour in 30 secs.	bright orange	bright orange
" " 60 "	bright reddish-orange	bright reddish-orange
" " 2 mins.	strong bright reddish-orange	strong bright reddish-orange
" " 5 "	no change	no change
Test No. 4.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale pink	pale pink
" " 60 "	bright pink	bright pink
" " 2 mins.	bright rose	bright rose
" " 5 "	strong dark rose	strong dark rose

Strophanthus Wightianus Wall (specimen S 55)

	Endosperm	Cotyledons
Test No. 1.		
Immediate Colour	nil	nil
Colour in 30 secs.	nil	very pale pink
" " 60 "	pale orange-pink	pale bright pink
" " 2 mins.	orange	bright pink
" " 5 "	strong orange	dull dark pink
Test No. 2.		
Immediate Colour	nil	nil
Colour in 30 secs.	greyish-pink	nil
" " 60 "	strong greyish-violet	pale pink
" " 2 mins.	dark purple	pale violet
" " 5 "	purplish-black	bright violet
Test No. 3.		
Immediate Colour	nil	nil
Colour in 30 secs.	bright orange	lemon yellow
" " 60 "	dark reddish-orange	brownish-yellow
" " 2 mins.	brownish-orange	no change
" " 5 "	dark brownish-orange	dull yellowish-brown
Test No. 4.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale green	pale pink
" " 60 "	pale greenish-orange	pale bright pink
" " 2 mins.	greenish-orange	bright rose
" " 5 "	purplish-brown	dark rose

Strophanthus congoensis Franchet (specimen S 57)

	Endosperm	Cotyledons
Test No. 1.		
Immediate Colour	nil	nil
Colour in 30 secs.	yellow	epidermis pink where the two cotyledons are in contact with one another
" " 60 "	dull orange	dirty violet
" " 2 mins.	dull dark orange	dirty violet-brown
" " 5 "	dirty brown	no change
Test No. 2.		
Immediate Colour	nil	nil
Colour in 30 secs.	greenish-grey	nil
" " 60 "	dull dark green	nil
" " 2 mins.	dark purple	pale blue
" " 5 "	purplish-black	bright purplish-blue
Test No. 3.		
Immediate Colour	nil	nil
Colour in 30 secs.	bright orange	bright yellow
" " 60 "	strong dull orange	brownish-yellow
" " 2 mins.	dull brownish-orange	yellowish-brown
" " 5 "	dull dark brownish-orange	almost black
Test No. 4.		
Immediate Colour	nil	nil
Colour in 30 secs.	pale grey	nil
" " 60 "	bluish-grey	nil
" " 2 mins.	purplish-grey	violet in regions adjoining endosperm
" " 5 "	purplish-black	no change

When the results of these chemical tests are compared with the test concerning the limited number of species reported on by Gilg and Schuster (1919) and Mathiesen (1927-28), it is seen that while, in many cases, there is general agreement in the colours shown in the early stages of the tests, the colours reported by these workers do not represent the full range which has been demonstrated here. Furthermore, it is clear that it is only by elevating the temperature at which the observations are made and by standardising the conditions, that these biochemical reactions can be made to proceed to completion and thus serve a valuable diagnostic purpose.

This difficulty of incomplete colour development is well seen in the sulphuric acid test (the only one employed by the workers referred to above) especially in regard to the seeds of the species Kombe, Emini, gratus, amboensis, and Arnoldianus.

A marked disagreement is noted between the results shown here and those of the literature in regard to the behaviour of sarmentosus, neither of the authenticated specimens examined here showing violet at any stage in the colour sequence as had been reported by Gilg and Schuster.

TABLE 2. /

TABLE 2.

COLOUR REACTIONS WITH SULPHURIC ACID ON DRY SEED SECTIONS.

Species	Gilg & Schuster 1919	Mathiesen 1927-28
Strophanthus Kombe Oliver	yellow → light green → emerald green → russian green. In embryo violet → dark blue-green → violet.	sequence observed as given but epidermis of cotyledons of a lighter and purer green than the mesophyll
Strophanthus Courmontii Sacleux	bright yellow → yellow → light orange → orange → red orange → reddish orange → violet.	Cot. mesophyll yellow and epidermis light violet. After a few minutes whole cotyledon a striking blue-violet. Endm. light orange - red orange and finally pale clear rose.
Strophanthus sarmentosus P.DC.	yellow → orange → pale rose red; inner endosperm and epidermis of cot. pale light green; reddish to bright violet.	yellow → light orange → pale rose red → reddish → pale violet.
Strophanthus Emini Aschers.	light yellow → orange → light rose → bright rose → violet.	In endm. colours run quickly through this sequence but in cots. more slowly through yellow → green yellow → pale blue violet.
Strophanthus hispidus P.DC.	light yellow → yellow green → emerald green → russian green. This appears to be the main reaction and the following variations were seen in the specimens examined. (a) endosperm and cot. green but latter red specks throughout. (b) as above but with edge of cot. green and the centre orange red. (c) cot. green but with a reddish band within the epidermis. (d) one cot. green and half of the other red. (e) one cot. red, the other green. (f) as above but endosperm adjoining red cot. was also red. (g) both cots. red; one half /	variations observed as quoted by Gilg and Schuster.

TABLE 2 (contd.)

COLOUR REACTIONS WITH SULPHURIC ACID ON DRY SEED SECTIONS.

Species	Gilg & Schuster 1919	Mathiesen 1927-28
Strophanthus hispidus P.DC. (contd.)	half of endosperm red, the other green → blue green → dark blue green → violet.	
Strophanthus Nicholsoni Holmes	light yellow → yellow → light rose → bright eosin red → violet.	yellow shades not distinct. Bluish-red colour appears first in endosperm which changes gradually to violet. Cots. give a pale rose.
Strophanthus gratus Wall & Hook	pale weak rose → bright rose → violet rose.	confirmed.
Strophanthus amboensis Engl. & Pax	bright yellow → orange - red orange → violet.	confirmed in main features.
Strophanthus Barteri Franch.	bright yellow → orange yellow → orange → red orange → red → violet.	sequence observed as given but endosperm later changed to blue and finally bluish-green.
Strophanthus Arnoldianus Wildem. & Th. Dur.	bright yellow → bright green → emerald green → russian green. In embryo colour finally changed to violet.	reliable observation not possible owing to unsuitable material.
Strophanthus Tholloni Franch.	pale bright yellow → pale light rose → rose.	sequence observed as given but endosperm takes on the colours more rapidly and more strongly than the embryo.

TABLE 3. /

TABLE 3.

COLOUR REACTIONS REPORTED BY SMELT (1933)

(CARRIED OUT ON POWDERED EXTRACTS)

Species	Sulphuric Acid	Phenol and Hydrochloric Acid	Furfuraldehyde and Sulphuric Acid	Resorcinol and Hydrochloric Acid
Strophanthus Kombe	Dark green	red-brown tinge	greenish-grey in five minutes. Indigo-blue in fifteen minutes.	red-orange
Strophanthus Courmontii	Brown. Green at edges in ten minutes.	brown tinge	brown	brown tinge
Strophanthus sarmentosus	pale pink in five minutes	almost colourless	pale pink	pale red-orange
Strophanthus Emini	brown; violet in five minutes	violet	deep violet	purple
Strophanthus hispidus	brownish-red	brown tinge	purplish-grey	red-orange
Strophanthus Nicholsoni	brown. Violet in ten minutes	violet	violet (paler than Emini)	purple (paler than Emini)
Strophanthus gratus	pale orange-pink	almost colourless	pale red-brown	pale red-orange

SUGGESTED SCHEMA FOR THE IDENTIFICATION OF SPECIES OF STROPHANTHUS SEED COMBINING RESULTS FROM MORPHOLOGY, ANATOMY, AND BIOCHEMICAL TESTS.

(This is a summation of those features only which are pertinent in a systematic examination of seeds believed to fall within the group examined in these studies.)

A consideration of the morphological and histological characters of the seeds of those species of Strophanthus which have been studied, shows immediately that this is a very natural genus and that the differences which exist between the seeds of the various species are seldom more than very minor. In a few species it is possible to identify the seeds without the slightest difficulty but in the majority of cases this can only be accomplished with difficulty and frequently it becomes necessary to employ chemical tests for corroboration. Only the seeds of Strophanthus Barteri and those of Strophanthus Nicholsoni are sufficiently outstanding in their macroscopical characters to enable identification to be made by this means with any degree of certainty.

When the histology of the various species of seed is considered, it is immediately obvious that the various species may be divided into two groups according as well-defined crystals of calcium oxalate are present in any tissues of the seed or completely absent. On this basis the division is as follows:-

GROUP /

GROUP I. Species containing well-defined crystals of calcium oxalate.	GROUP II. Species containing no well-defined crystals of calcium oxalate.
Strophanthus Kombé	Strophanthus Emini
" Courmontii	" Nicholsoni
" sarmentosus	" gratus
" sarmentosus var. major	" mirabilis
" hispidus	" ambœensis
" petersianus	" Barteri
" Arnoldianus	" Gossweilerii
" Boivini	" divaricatus
	" intermedius
	" Tholloni
	" Wightianus
	" congoensis

GROUP I - The calcium oxalate crystals which occur in the seeds comprising this group may be present in one or more of the three distinct regions which each seed exhibits, viz. spermoderm, endosperm, and cotyledons. As the following Table shows, well-formed crystals are almost always confined to one of these regions. In the exceptional case, (Strophanthus sarmentosus), calcium oxalate crystals occur in both the /

the spermoderm and the cotyledons.

Species of Strophanthus seed	Crystals of Calcium Oxalate		
	Spermoderm	Endosperm	Cotyledons
Kombe	Not numerous - mostly small clusters but occasional prisms present.	Absent.	Absent.
Courmontii	Numberous - mostly single prisms up to 20 microns in size - also twin-prisms, clusters, and conglomerates.	Minute 2 - 3 microns.	Absent.
sarmentosus	Numerous irregular clusters of rhombohedral crystals.	Absent.	Numerous clusters and occasional single prisms.
sarmentosus var. major	Absent.	Minute 2 - 3 microns	Numerous clusters or conglomerates up to 25 microns.
hispidus	Absent.	Occasional aggregates.	Absent.
petersianus	A few ill-defined aggregates.	Absent.	Absent.
Arnoldianus	A few single prisms or conglomerates up to 25 microns.	Minute 2 - 3 microns.	Absent.
Boivini	Absent.	Absent.	Numerous well-defined clusters 10 to 15 microns.

The /

The seeds of Strophanthus Boivini and Strophanthus sarmentosus var. major may therefore be separated from the other members of this group as the only two species which contain well-defined crystals of calcium oxalate in the cotyledons but no crystals in the spermoderm. They are sufficiently dissimilar from one another both in their macroscopical and in certain of their microscopical features to enable them to be separated from one another. Strophanthus sarmentosus var. major is a much longer seed than that of Strophanthus Boivini, attaining a length of 19 mms. as against 10 mms. in the case of the latter. In addition many of the hairs on Strophanthus sarmentosus var. major attain a length of 1000 microns whereas those on Boivini do not exceed 350 microns. Confirmation may also be obtained by chemical tests. In this case the Resorcinol and Hydrochloric Acid Test shows the most distinct differentiation, sarmentosus var. major yielding a pale violet in the endosperm and a pink in the cotyledons while Boivini gives a pale green passing through various shades to dark greenish-brown in the endosperm and a pink which passes to deep violet in the cotyledons.

The seed of Strophanthus hispidus is characterised by not possessing any crystals of calcium oxalate in either the spermoderm or the cotyledons, but it does show occasional aggregates in the endosperm. Confirmation of identification may be obtained by means of the Sulphuric Acid Test in which the red and green colouration of the cotyledons at an intermediate stage is very characteristic.

The /

The five remaining species in Group I all possess calcium oxalate crystals in the spermoderm. These crystals vary both in form and frequency from one species to another and the differences are probably sufficient to enable identification to be made. It is thought, however, that when allowance is made for the variation liable to occur within a species, this method is not sufficiently reliable in all cases and that confirmation should be obtained by means of chemical tests.

As the Table given earlier shows, the seeds of Strophanthus Courmontii and Strophanthus sarmentosus are the only two possessing an abundance of crystals in the spermoderm and they may therefore be separated from Kombé, petersianus and Arnoldianus.

The seeds of Courmontii and sarmentosus differ from one another in several respects and their separation, one from the other, presents no difficulty. In Courmontii no crystals occur in the cotyledons and the crystals which occur in the spermoderm are mostly in the form of single prisms though twin-prisms, clusters, and conglomerates are also seen in small numbers. In the case of sarmentosus numerous cluster crystals occur in the cotyledons and the spermoderm crystals are almost all in the form of irregular clusters of rhombohedral crystals. These two species are also readily distinguished by making a microscopical examination of surface preparations of the spermoderm. In sarmentosus the middle lamella is very strongly lignified and stands out sharply, in a stained preparation, from the remainder of the anticlinal wall. /

wall. The epidermal hairs attain a length of 700 microns. In Courmontii the anticlinal walls of the epidermal cells are uniformly lignified and the greatest length seen in the epidermal hairs is 500 microns. Further confirmation may also be obtained by the respective behaviour of these two seeds towards chemical reagents. Strophanthus Courmontii yields a violet colour in both the endosperm and the cotyledons when the Sulphuric Acid Test is applied, whereas sarmentosus, even when due allowance is made for the difference in the reactions between the two samples of this species examined, gives an orange or brownish-orange when treated in this way.

As Table I shows, the seeds of the three remaining species in Group I are very much alike in their main features and only minor macroscopical and microscopical differences exist on which to base a means of identification. How far these various differences can be depended upon it is impossible to say without a knowledge of the variation liable to occur within each species, but the following points of difference appear to be of consequence:-

(a) Kombé presents a greenish tinge which is sometimes seen in Arnoldianus but not in petersianus.

(b) The base of Kombé seed is winged but no wing is seen in either Arnoldianus or petersianus.

(c) The hair covering in Kombé is almost always intact and the hairs are arranged in longitudinal rows. In Arnoldianus the hair-covering is also usually intact but there is no suggestion of an arrangement in rows /

rows and furthermore the hairs appear to be much shorter than in Kombé. In petersianus the hairs are readily detached and consequently bare areas of testa are often seen.

(d) petersianus is the least flattened seed of the three and this is well shown by the ovate outline of the transverse section of the seed.

(e) Measurement of the hairs shows that in the case of Arnoldianus the maximum is 350 microns whereas in both Kombé and petersianus the hairs frequently attain 700 microns in length.

(f) In Arnoldianus the sub-epidermal layer shows a very much wider variation in thickness as seen in transverse section than either Kombé or petersianus. In the first mentioned species it attains 60 microns as against a maximum of 15 microns in the cases of the latter two. This increase in thickness is due to abnormally large cell-cavities and not to an increase in the number of cells present in the layer.

(g) Arnoldianus possesses numerous minute crystals about 2 microns in size, in the endosperm. These are not seen in either Kombé or petersianus.

- Differentiation of the seeds of these three species may readily be made by means of chemical tests but it is noticeable that while petersianus stands out very distinctly, the seeds of Kombé and Arnoldianus show a considerable degree of similarity with one /

one another.

The Sulphuric Acid Test separates petersianus immediately. Both the endosperm and cotyledons first assume a pinkish colour which passes to a reddish-orange or reddish-brown. With Arnoldianus and Kombe green or bluish green is the outstanding colour produced in this test.

The Resorcinol and Hydrochloric Acid Test is the only one which shows a clear distinction between Arnoldianus and Kombe. The former shows pale grey passing to bluish-green in the endosperm and pale grey passing to violet in the cotyledons, while the latter shows pale yellow passing to orange in the endosperm and pink to salmon-pink in the cotyledons.

GROUP II - In this group there are no well-defined crystals of calcium oxalate to enable a preliminary separation to be made. The seeds of two of the species concerned, viz. Strophanthus Nicholsoni and Strophanthus Barteri are sufficiently characteristic in their macroscopical features to enable them to be separated from the other members of the group and from one another. The former exhibits a very woolly appearance owing to a dense covering of long, yellowish-white, tangled epidermal hairs. These hairs may attain 2500 microns in length and the hair-wall is always lignified. Strophanthus Barteri is very different in appearance. The seed is of a dull reddish-brown colour, slightly rough to furry externally but not noticeably hairy to the naked eye. Microscopic examination does, however, reveal the presence of a uniform /

uniform covering of relatively short hairs measuring up to 150 microns in length and possessing thin walls which are usually non-lignified but sometimes show a lignified rib on the side of the shaft adjacent to the epidermis of the seed. A clear distinction between the seed of Strophanthus Nicholsoni and that of Strophanthus Barteri is also shown when either the Sulphuric Acid Test or the Resorcinol and Hydrochloric Test is applied. With the former test Nicholsoni yields in both the endosperm and cotyledons pale bright pink passing to a rose, whereas Barteri gives a pale grey passing to deep bright orange in the endosperm and a pale violet passing to a bright violet in the cotyledons. In the Resorcinol and Hydrochloric Acid Test the distinction between Nicholsoni and Barteri is very clear in the early phases of the colour development but less so in the later stages when the colours are very similar to one another. In Nicholsoni the endosperm first assumes a very distinct olive-green which passes through a rose tinged with green to dark purple, while the cotyledons pass from bright pink to strong violet. In Barteri the endosperm passes from pale grey through various shades of purple to a very dark purple, while the cotyledons first develop a pale violet which passes finally to a deep vivid purple.

Three other species in this Group which stand out sharply from the other members, though not from one another, are gratus, divaricatus, and Wightianus. Superficially the seeds of these species of Strophanthus bear a very close resemblance to one another and to the naked eye they appear glabrous and woody. The only /

only obvious macroscopical difference is that Wightianus possesses a small but not always conspicuous basal wing. This is not a sufficiently distinct or reliable feature on which to base the identification of the seed of this species.

In their microscopical characters the seeds of gratus, divaricatus, and Wightianus also present some considerable degree of similarity but sufficient differences exist to enable a separation to be made. The microscopical distinctions between divaricatus and Wightianus are, however, so slight that it is thought desirable to confirm this separation by chemical tests.

Microscopical examination shows that none of these three seeds is actually glabrous; all bear hairs. In divaricatus and Wightianus the hairs, although very characteristic, are so much alike as to make separation one from the other by this means almost impossible, but in gratus they are markedly different. In the seed of this species only a small number of epidermal hairs occur; they are unicellular, very thin-walled, and some 70 to 90 microns in length. The shaft tapers only slightly towards the apex of the hair. In both divaricatus and Wightianus the hairs are rudimentary and take the form of bluntly-conical protuberances 25 to 40 microns in length. In both cases the cell-wall of the hair is non-lignified, but whereas in divaricatus it is smooth, in Wightianus it is slightly warty. The only other microscopical /

microscopical distinction between the seeds of these two species is seen on examination of surface preparations of the spermoderm. The outline of the epidermal cells in divaricatus is seen to show a very much wider variation in shape than is seen in Wightianus and in addition to the axially elongated cells which are typical of the latter species, and which are indeed typical of the seeds of all the species of Strophanthus examined, except those of Strophanthus Tholloni, which are not being considered at the moment and which possess other unusual features, divaricatus shows many epidermal cells which are nearly isodiametric and some which are transversely elongated.

Further evidence of distinction between divaricatus and Wightianus is afforded by the various chemical tests tabulated. All four Tests show clear differences in the colour sequences but the most distinct is found to be the Resorcinol and Hydrochloric Acid Test. When this is applied, the endosperm of divaricatus assumes a bluish-grey which passes through violet and reddish-violet to a dark reddish-purple, while cotyledons pass through a somewhat similar sequence though the reddish tinge is seldom evident. In the case of Wightianus, however, the endosperm first assumes a pale green which passes through greenish-orange to purplish-brown, while the cotyledons pass from pale pink to dark rose.

Of the remaining six species in Group II the seeds of Strophanthus Tholloni and Strophanthus mirabilis are the only two possessing a distinct basal wing. This is very much more conspicuous in Tholloni than /

than in mirabilis. Numerous differences exist between the seeds of these two species and there is never the slightest difficulty in distinguishing between them. Tholloni is a very long, narrow seed, generally of a dull brownish-green colour, and some of the specimens in the material available exceed 20 mms. in length. It is also seen that the awn is sessile, the plume commencing immediately above the apex of the seed. It is not suggested that this last feature is peculiar to Tholloni because in many of the species of Strophanthus examined the material available did not permit of this feature of the seed being reported on owing to the removal of the awns prior to dispatch. It can be said, however, that in all cases where the awn is available, the plume is supported on a naked pedicel of varying length. The seed of mirabilis, in comparison with Tholloni, is shorter, less conspicuously lanceolate, and covered with yellowish-brown silky hairs.

Clear microscopical differences also exist between the seeds of Tholloni and mirabilis. Surface preparations of the spermoderm show that the epidermis of the former is characterised by consisting of cells with conspicuously sinuous, anticlinal walls and these cells are variously orientated towards one another, whereas in mirabilis these cells have straight walls and they all lie parallel to one another. When transverse sections of the two seeds are compared, the thickening on the anticlinal walls of the epidermal cells is seen to be square-shaped in Tholloni and /

and broadly spindle-shaped in mirabilis. Any of the chemical tests may also be used to distinguish between the seeds of the two species under consideration but of the four tabulated, the Furfuraldehyde and Sulphuric Acid Test is seen to be the most distinctive in this particular case. When this test is applied, the endosperm of Tholloni passes from bright orange to bright reddish-orange, while the cotyledons pass through a similar sequence. In the case of mirabilis both the endosperm and the cotyledons pass from orange through shades of purple to purplish-black.

The five remaining species, viz. Emini, amboensis, Gossweilerii, intermedius, and congoensis, present only such minor macroscopical and microscopical differences that when due allowance is made for the variation liable to occur within a species, some other means is essential for confirmation of identification. This is provided by the colour reactions. The following macroscopical points are, however, worthy of note:-

(a) Emini has a thicker and more woolly coat of hairs than any of the others in this sub-group, and many of these hairs attain 1000 microns in length. The raphe is conspicuous and spathulate at the chalazal end.

(b) congoensis, like Emini, is a dull brownish seed but the hairs are more securely attached than in the case of the latter, and it presents a furry rather than a shaggy appearance. All specimens of congoensis examined showed the minute undulations on the raphe which occur at right angles to the surface of /

of the testa.

(c) amboensis, Gossweilerii, and intermedius resemble one another so closely that it is almost impossible to distinguish one from another with any degree of certainty.

The seeds of all five species in this sub-group are readily distinguished from one another by the colour reactions produced when the various chemical tests are applied. The clearest distinction is provided by the Phenol and Hydrochloric Acid Test as seen in the following comparison though even here intermedius and congoensis are sufficiently alike in their reactions to make it desirable to confirm the identification by means of an additional test. The Resorcinol and Hydrochloric Acid Test serves this latter purpose well.

PHENOL /

PHENOL AND HYDROCHLORIC ACID TEST.

	Endosperm	Cotyledons
Strophanthus Emini	greenish-blue → slate-grey	pink → violet-pink → purple
Strophanthus amboensis	grey → green → dark green	grey → greenish-blue
Strophanthus Gossweilerii	grey → greyish-pink → purple	pink → violet purple
Strophanthus intermedius	pale blue → purple → dark purple → fading	bluish-green → bright blue → fading
Strophanthus congoensis	greenish-grey → green → purple → purplish-blue	pale blue → bright deep blue

A clear distinction between intermedius and congoensis is seen when the Resorcinol and Hydrochloric Acid Test is applied.

	Endosperm	Cotyledons
Strophanthus intermedius	pale grey → pinkish-grey → bright rose → dark rose	pale bluish-green → bright bluish-green
Strophanthus congoensis	pale grey → bluish-grey → purplish-grey → purplish-black	violet in region adjoining endosperm

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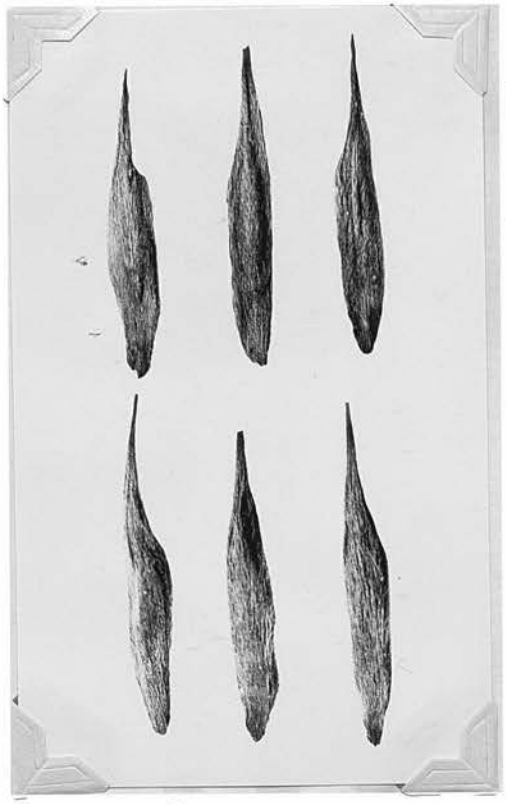
ILLUSTRATIONS.

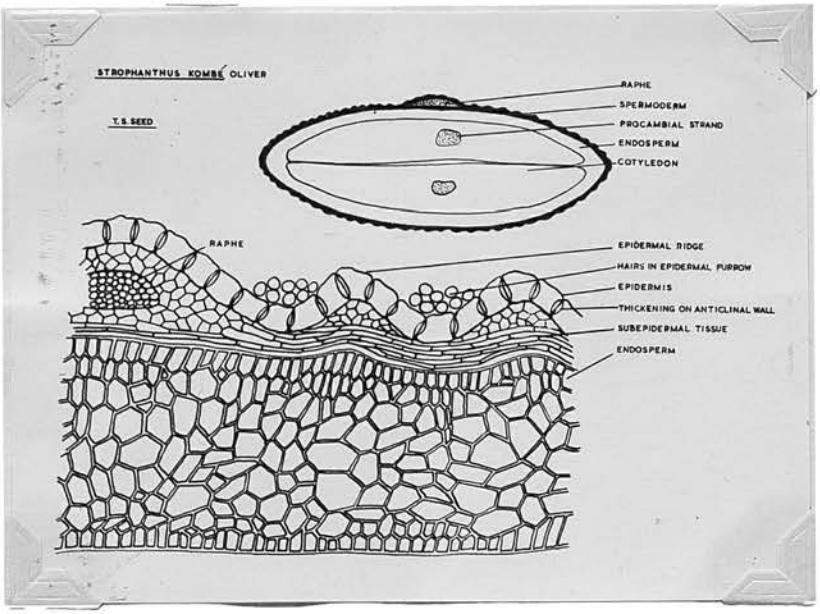


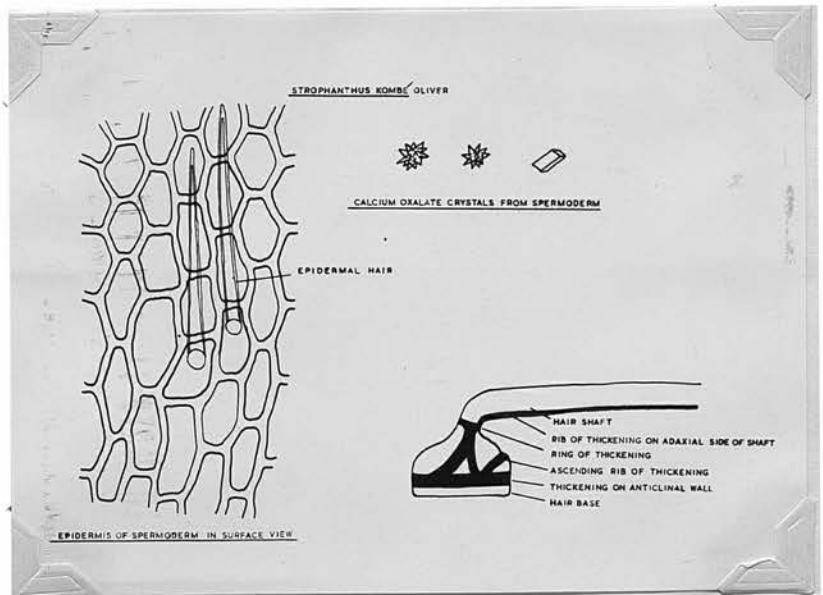
Strophanthus Kombé
Oliver

Ventral surface

Dorsal surface

Seed x2



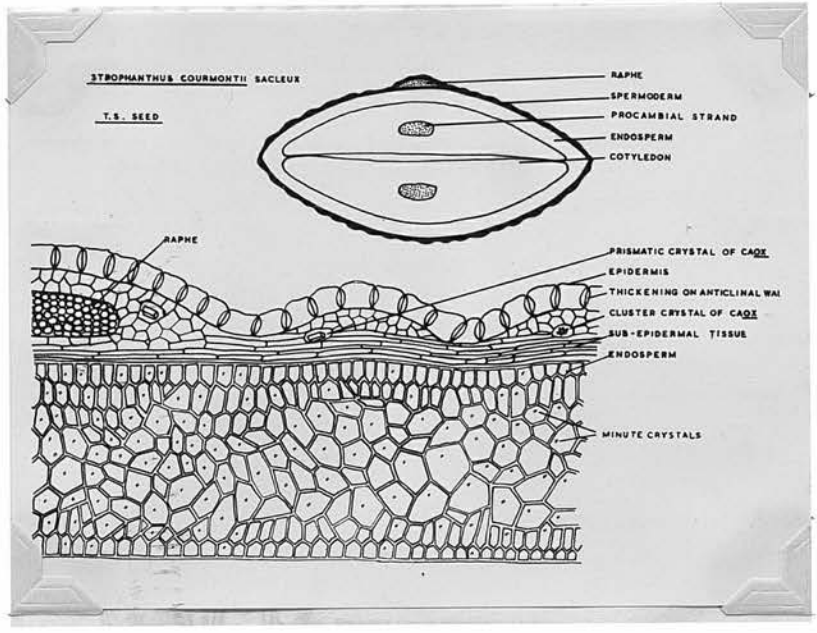


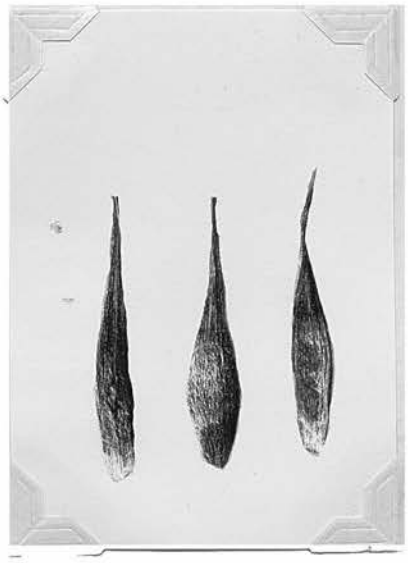
Strophanthus Courmontii Sacleux

Ventral surface

Dorsal surface

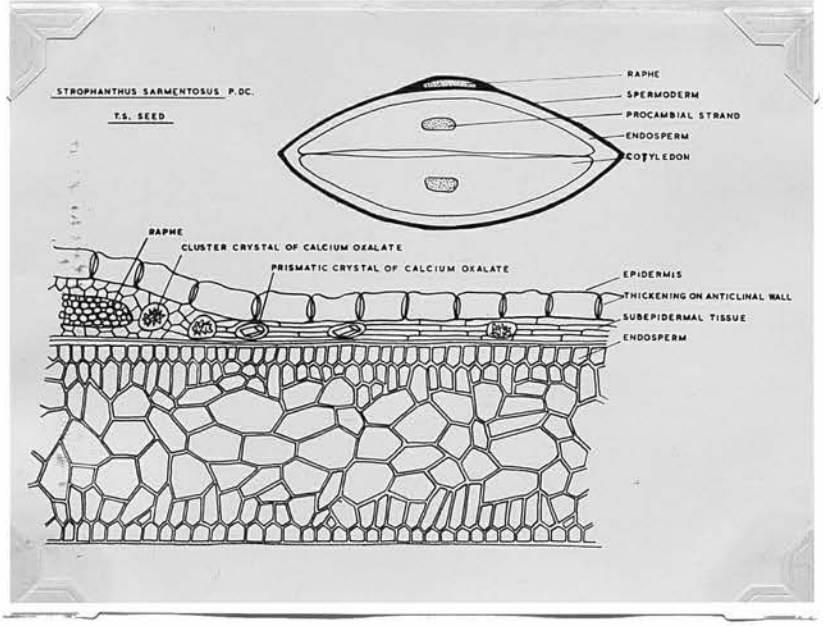
Seed x2

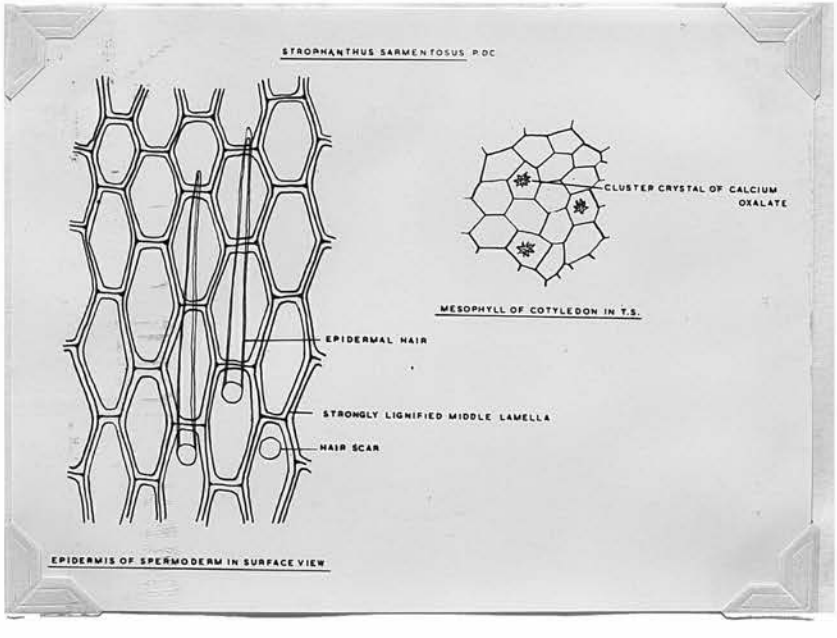




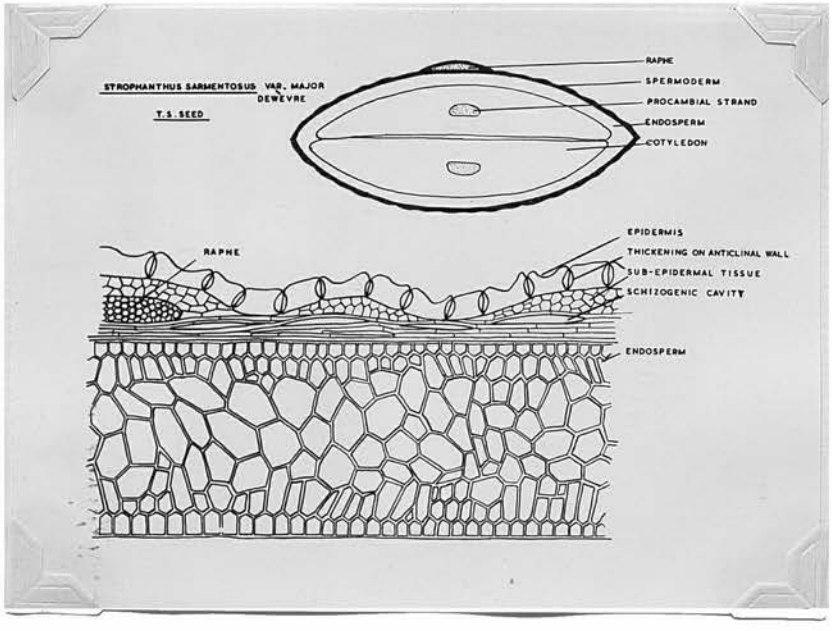
Strophanthus sarmentosus P. DC.

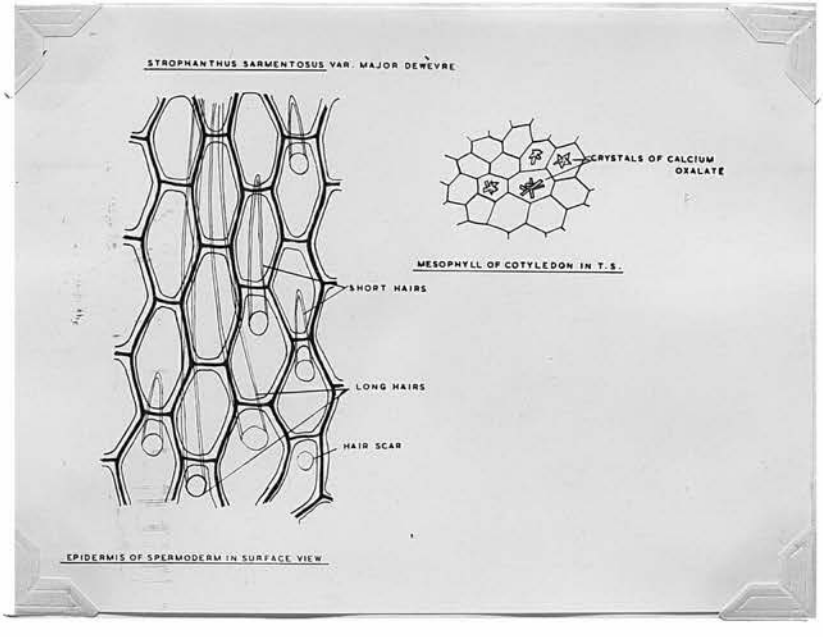
Seed x2



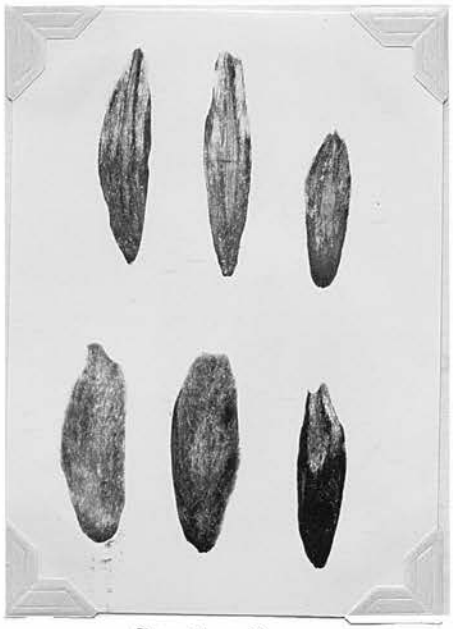


Strophanthus sarmentosus var. major Dewevre





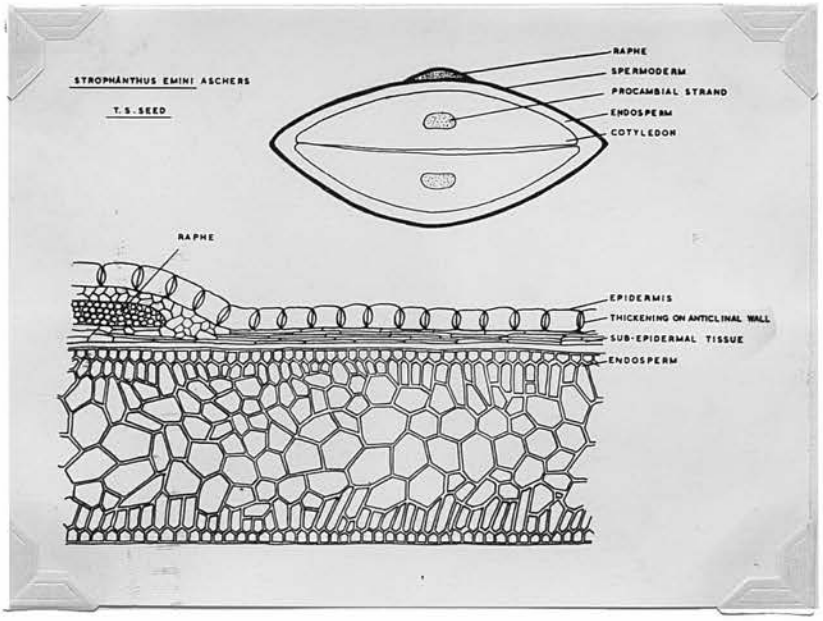
Strophanthus Emini Aschers



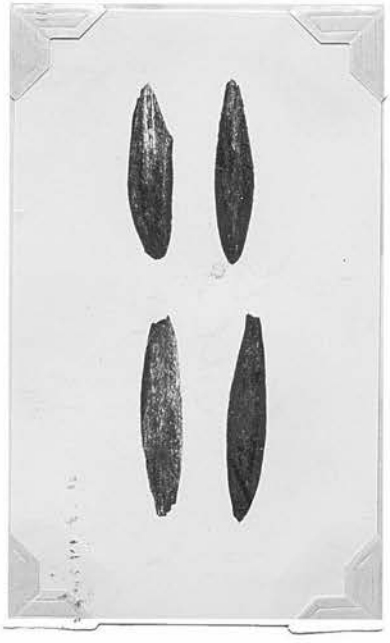
Ventral surface

Dorsal surface

Seed x2



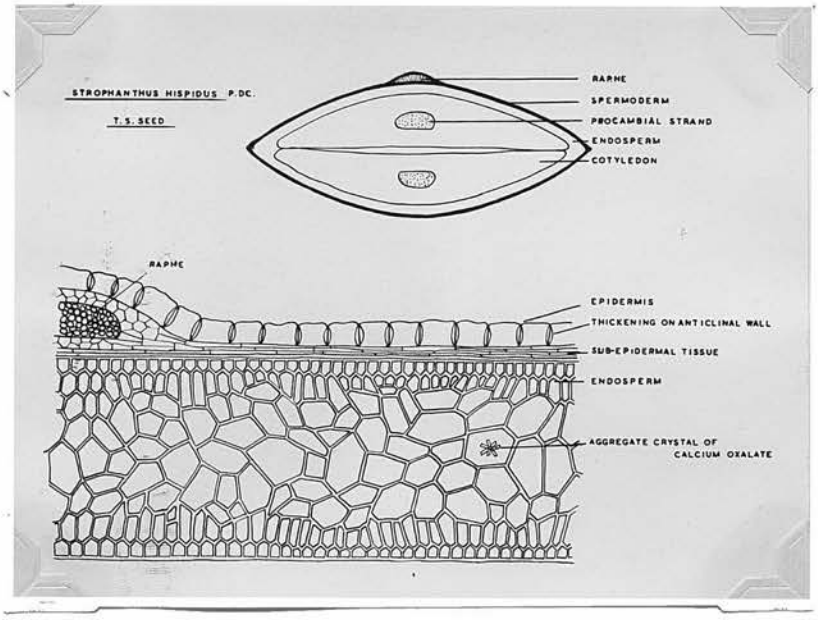
Strophanthus hispidus P. DC.



Ventral surface

Dorsal surface

Seed x 2

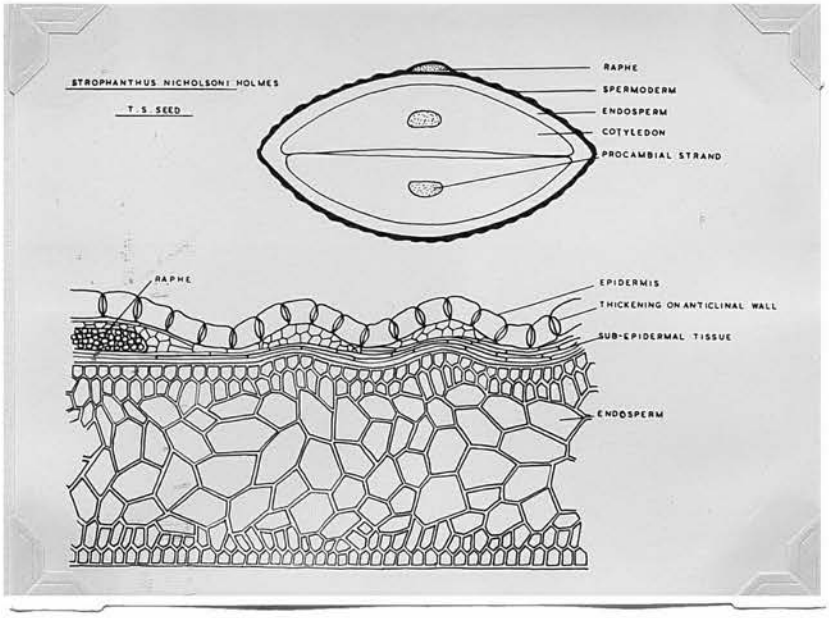


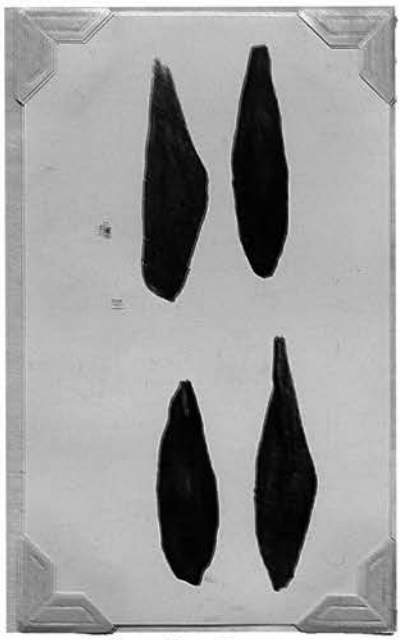
Strophanthus Nicholsoni Holmes

Ventral surface

Dorsal surface

Seed x2



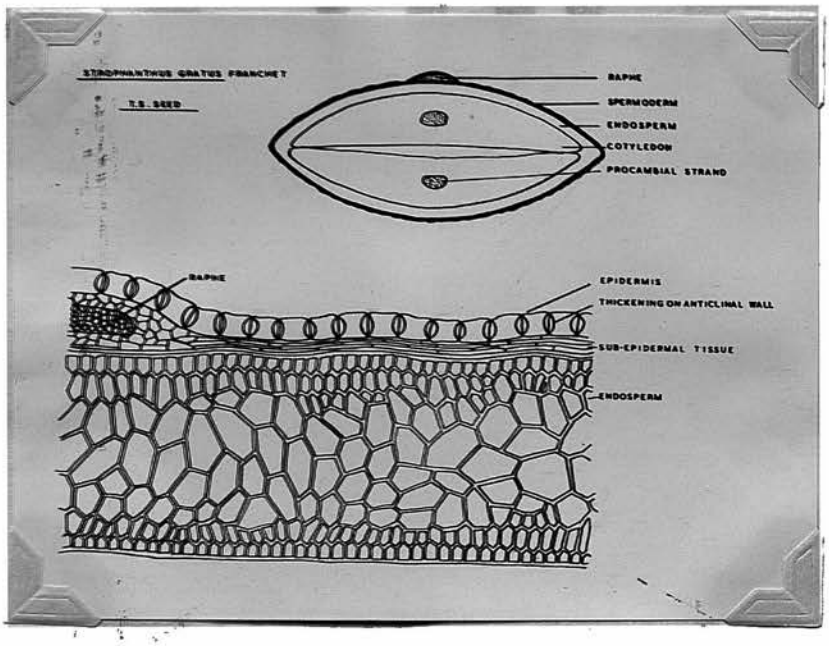


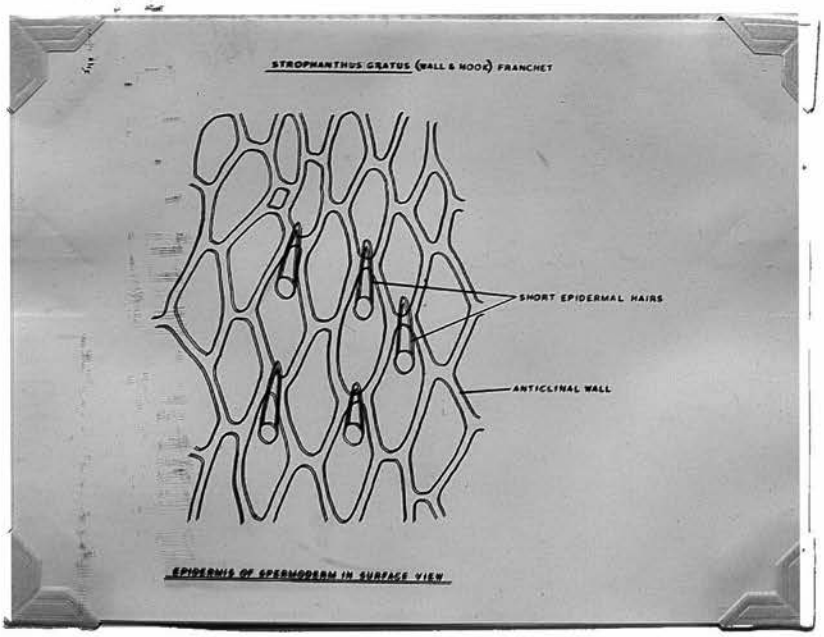
Seed x2

Strophanthus gratus
Franchet

Dorsal surface

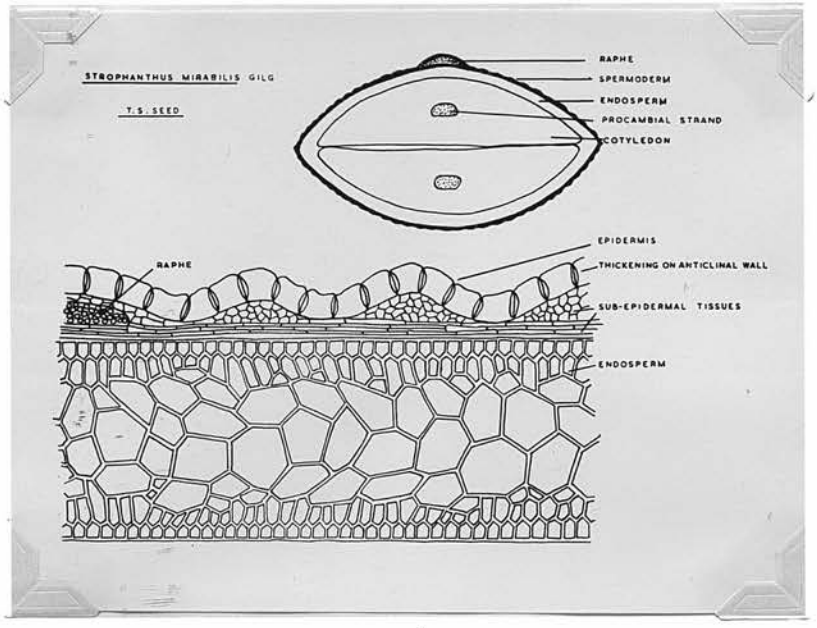
Ventral surface



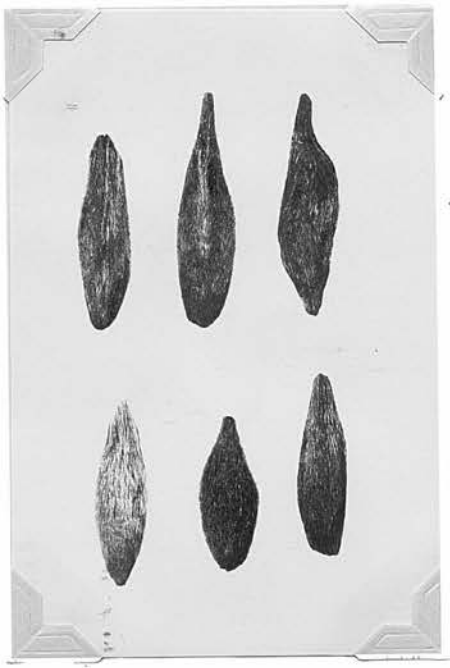


Strophanthus mirabilis Gilg

Seed x2



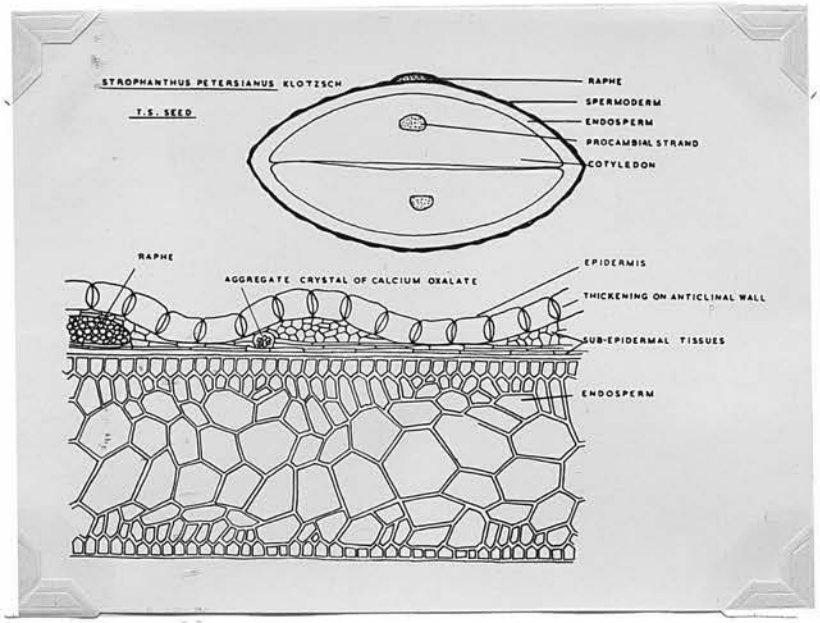
Strophanthus petersianus Klotzsch



Ventral surface

Dorsal surface

Seed x2

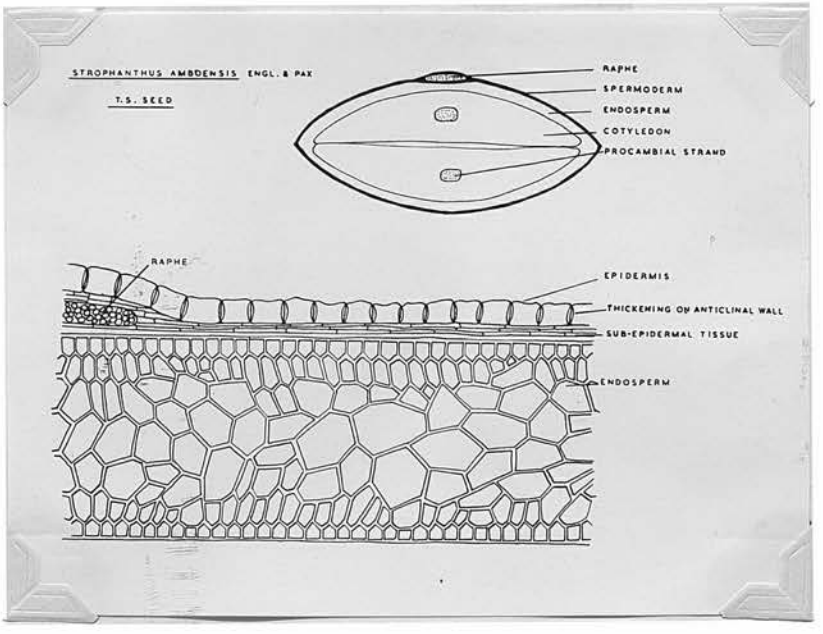


Strophanthus amboensis Engl. & Pax

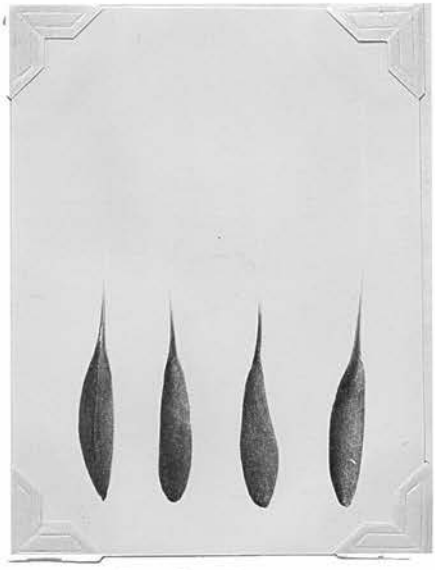
Ventral surface

Dorsal surface

Seed x2



Strophanthus Barteri Franchet



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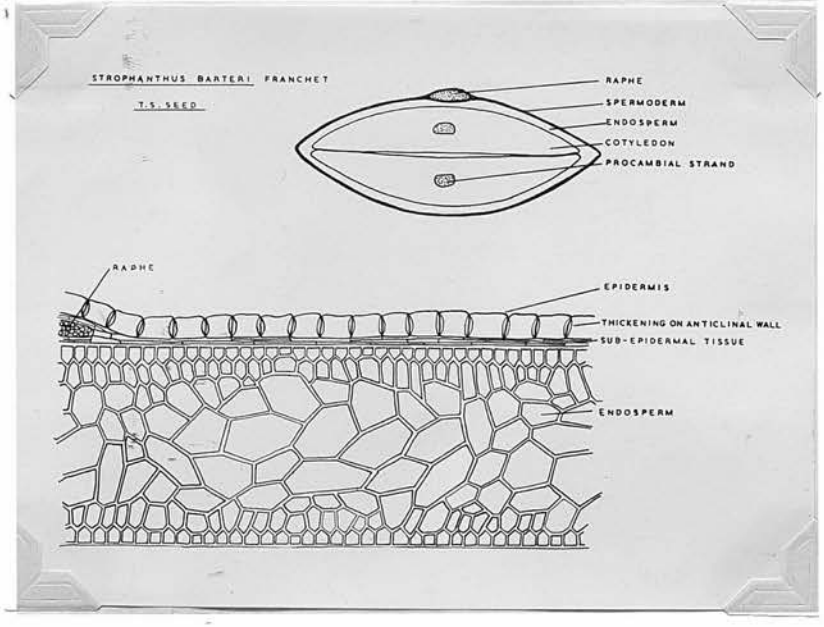
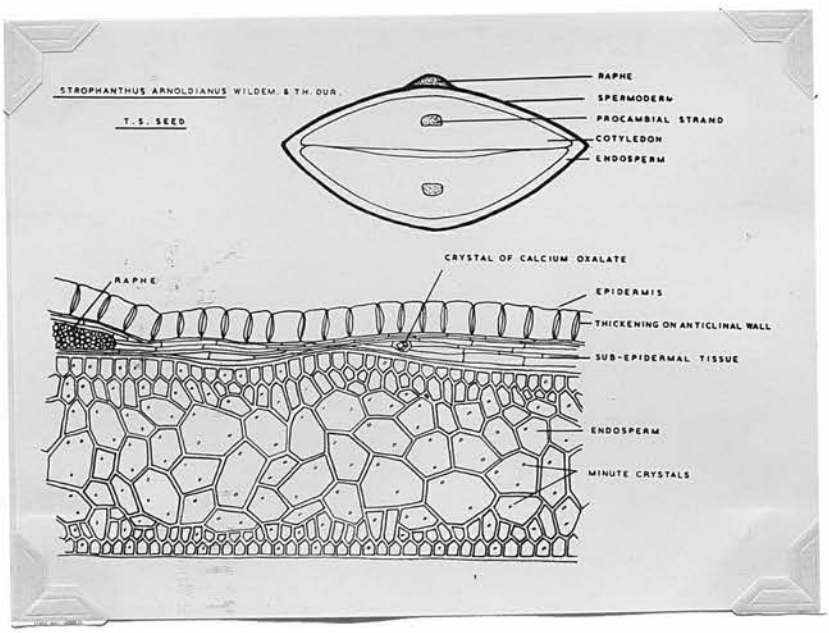


Strophanthus Arnoldianus Wildem. & Th. Dur.

Seed x2

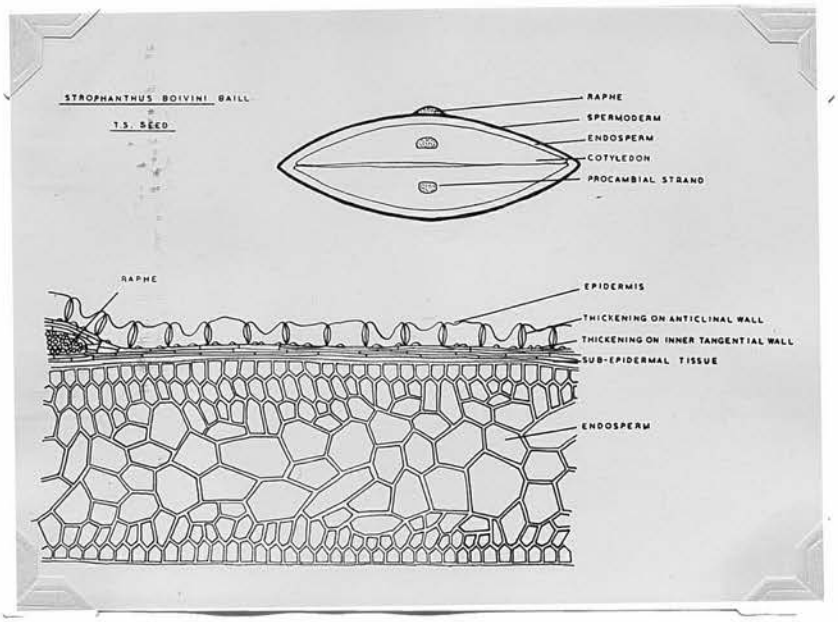


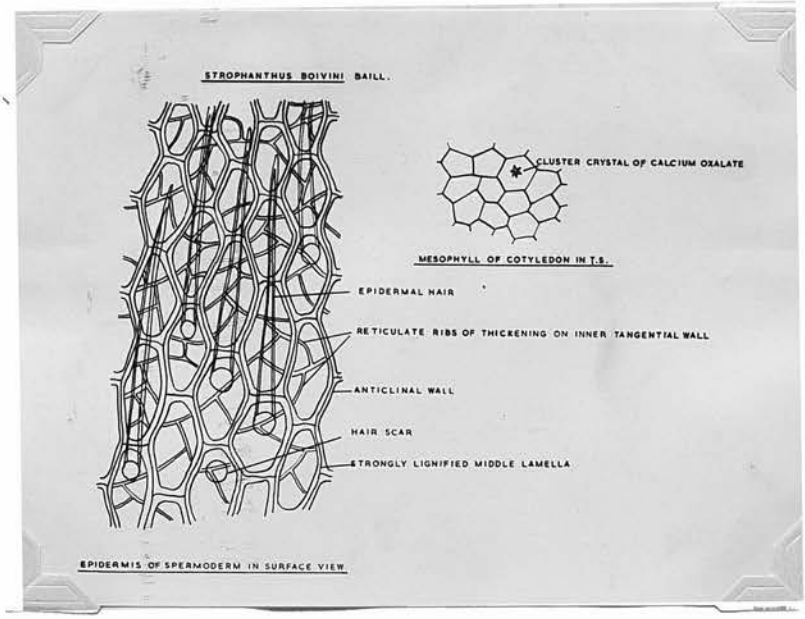
Strophanthus Boivini
Baill.

Ventral surface

Dorsal surface

Seed x2



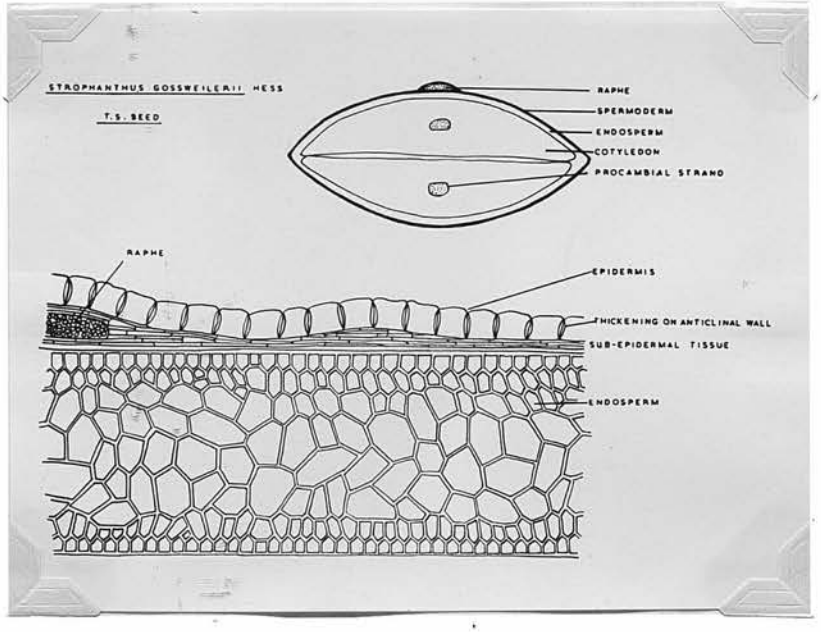


Strophanthus Gossweillerii Hess

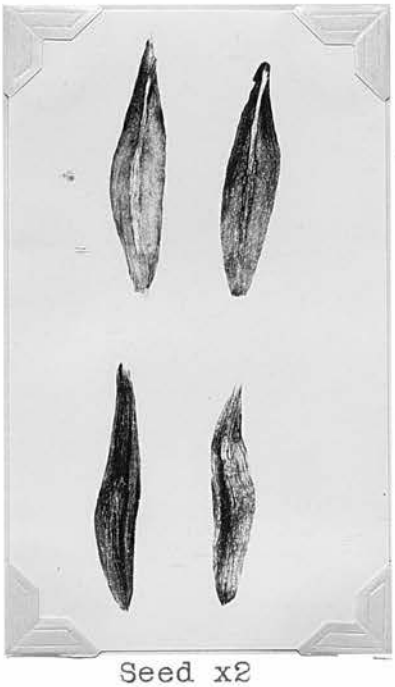
Ventral surface

Dorsal surface

Seed x2



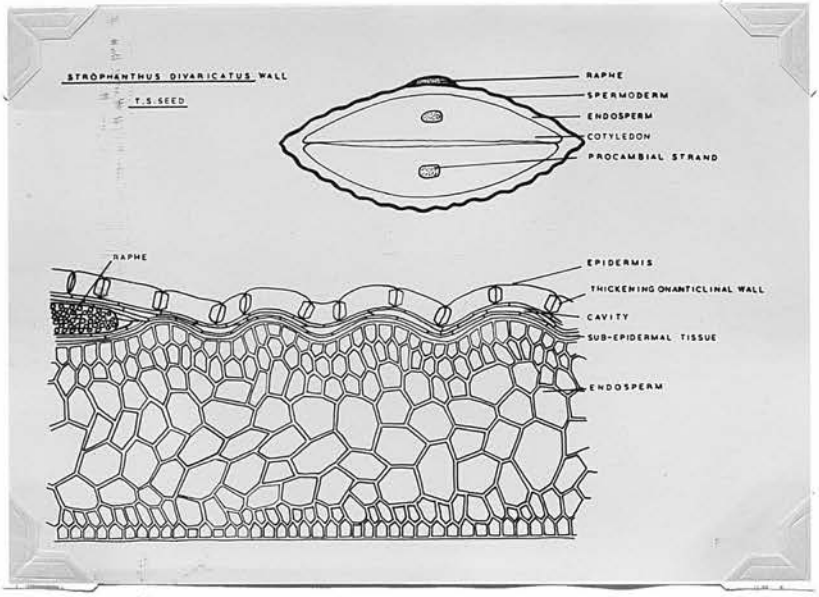
Strophanthus divaricatus Wall

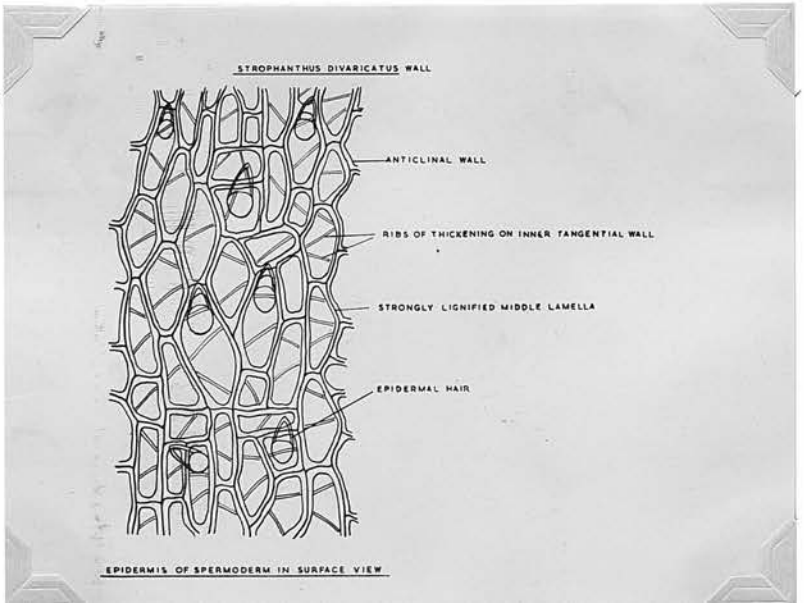


Ventral surface

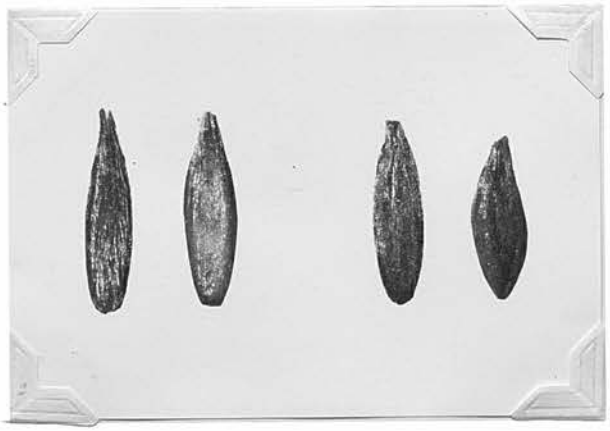
Dorsal surface

Seed x2

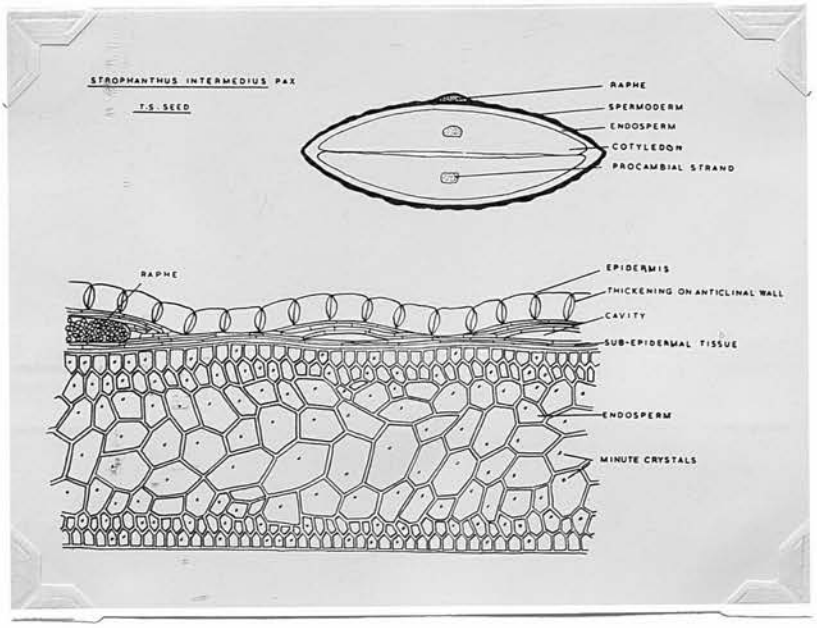




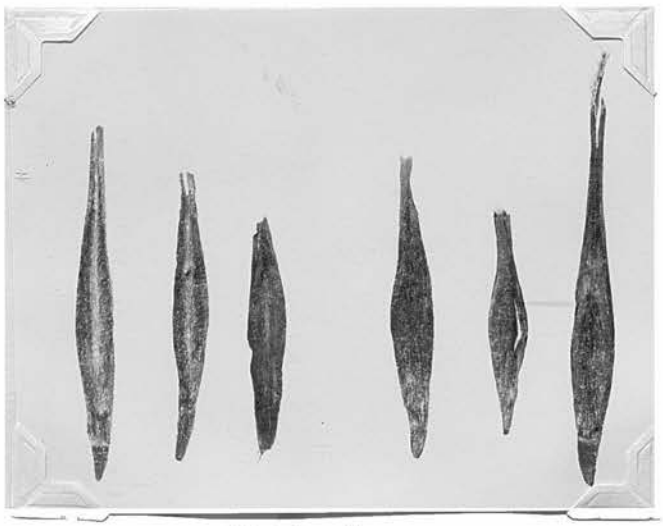
Strophanthus intermedius Pax



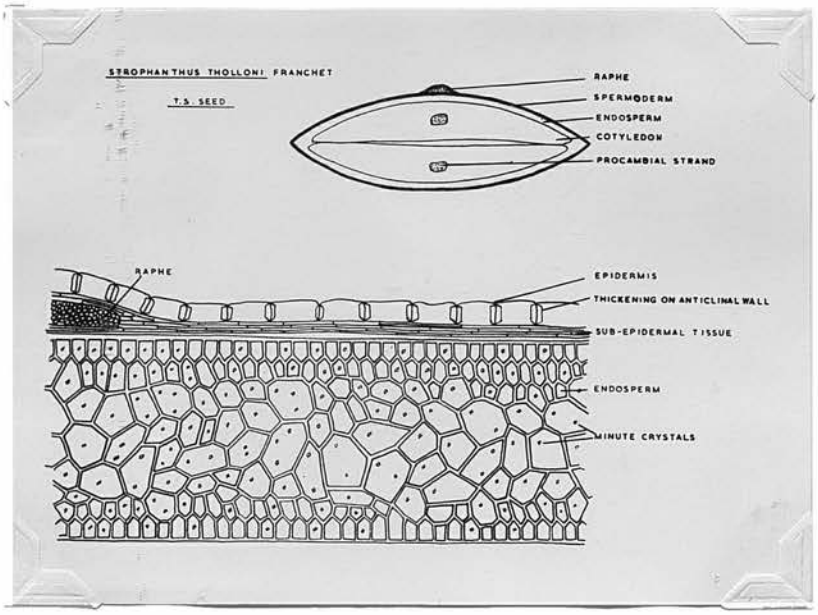
Seed x2

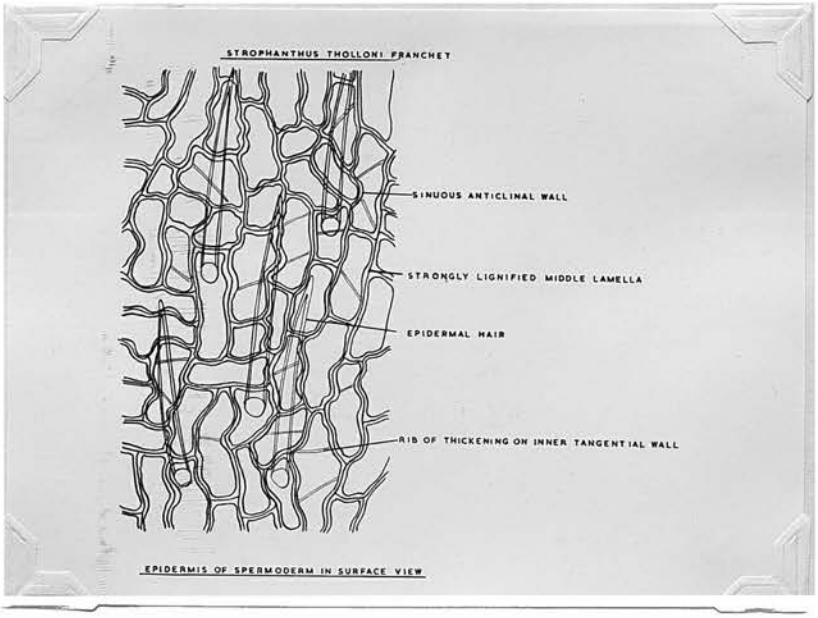


Strophanthus Tholloni Franchet

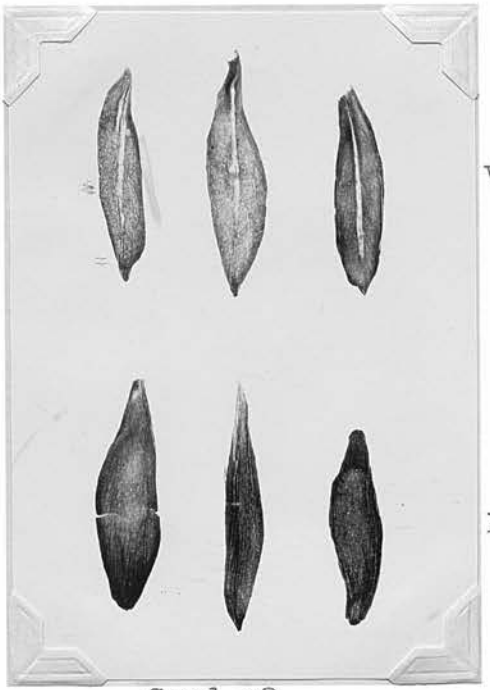


Seed x2





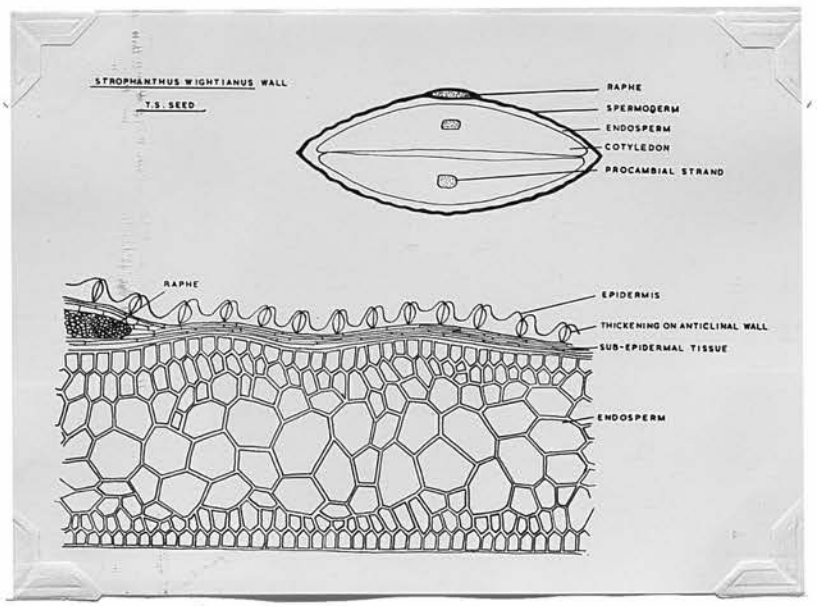
Strophanthus Wightianus Wall

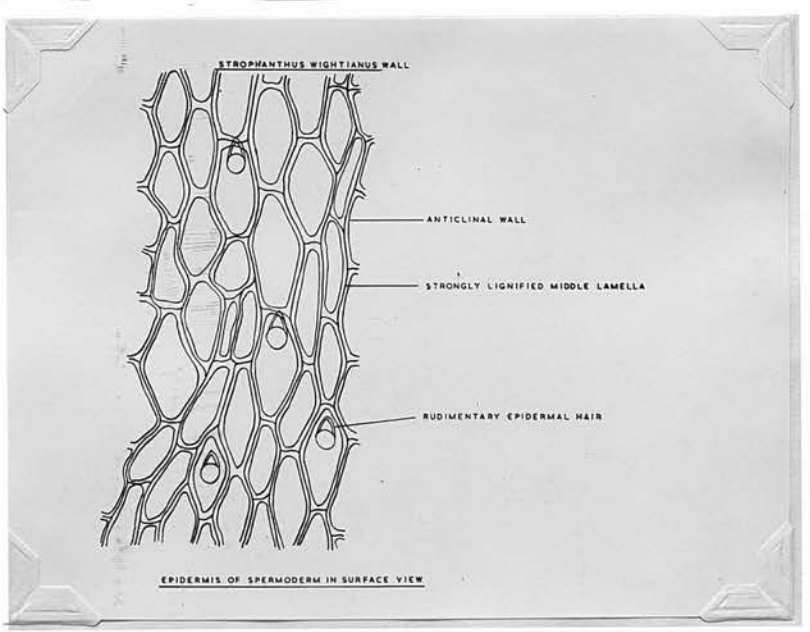


Ventral surface

Dorsal surface

Seed x2





Strophanthus congoensis Franchet

Ventral surface

Dorsal surface

Seed x2