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Harada, Morishige
Kyushu University

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バージョン：

Anatomical Characteristics of the Seed-Integument observed on 10 Species of *Eucalyptus*

Morishige HARADA

I. Introduction

The 10 species seeds of *Eucalyptus* were forwarded to me for the first time in 1954 by Mr. RODGER, Director of the Forestry and Timber Bureau in Canberra, Australia. These are the seeds of *E. botryoides, E. fastigata, E. ficifolia, E. gigantea, E. globulus, E. pauciflora, E. pilulalis, E. robusta, E. rostrata* and *E. tereticornis*. I have studied in order to find the ground of classification being based upon the construction of integument in seeds of *Eucalyptus* and the mutual relation between the degree of sclerenchym of cell-membrane in the outer-integument and resisting character to the cold of young plants germinated from those seeds.

I express my hearty thanks to Mr. K. KOKETSU who has served me to get these seeds of *Eucalyptus*, during his stay at Canberra in 1954, and to Mr. G. J. RODGER who forwarded to me useful seeds of these *Eucalyptus* species for my investigation in 1954 and to Mr. M. R. JACOBS, Master of Australian Forest School, who forwarded to me the useful literature "The Natural Occurrence of the *Eucalyptus*" which is connected with my investigation in 1955.

II. Methods of Experiment

Though these seeds are generally small grains, I have divided them into three classifications: larger grain, mean grain and smaller grain from their size for convenience of my investigation. The seeds of *E. ficifolia* and *E. globulus* belong to 'larger grain,' those of *E. fastigata, E. gigantea, E. pauciflora, E. pilularis* to 'mean grain,' those of *E. botryoides, E. robusta, E. rostrata* and *E. tercticornis* to 'smaller grain'.

I used phloroglucinol and hydrochloric acid to test lignification, acetic acid and hydrochloric acid to test crystal of calcium-oxalate, Sudan III to test oil, ferric chloride solution and potassium dichmate solution to test tannin, jodjod-potassium solution, nitric acid, caustic potash solution as reagent for colour-reaction of integument of seed, eosin, safranin, congored and methylene-blue to test the degree of the seeds dyed with colouring matters. I observed on the hand-sections of all materials to test the structure of seed-integument.

III. Results of Experiment

The seeds of *E. ficifolia* and *E. globulus* belonging to larger grain are remarkably characterized by the outer shape, so we can easily distinguish them with the naked eye from those of the other species (Refer to Plate I. Fig. 1(a), 2(a) (b)). Among the seeds of *E. fastigata*, *E. gigantea*, *E. pauciflora* and *E. pilularis* belonging to mean grain, those of *E. fastigata* and *E. gigantea* bear somewhat resemblance in shape and size to each other (Refer to Plate I. Fig. 3(a) (b), 4(a) (b)), and those of *E. pauciflora* and *E. pilularis* are also observed to have similarity to each other in some degree in shape and size (Refer to Plate I. Fig. 5(a) (b), 6(a) (b)). Among the seeds of *E. botryoides*, *E. robusta*, *E. rostrata* and *E. tereticornis* belonging to smaller grain, those of *E. botryoides* and *E. tereticornis* (Refer to Plate I. Fig. 7(a) (b), 8(a) (b)), and those of *E. robusta* and *E. rostrata* are also observed to be similar in some degree in shape and size to each other (Refer to Plate I. Fig. 9(a) (b), 10(a) (b)).

From the results of the experiment about the seeds of 10 species of *Eucalyptus*, the outer integument is observed to have more characteristics than the inner one. Inner-integument in the seeds of *E. fastigata*, *E. gigantea*, *E. pauciflora* and *E. pilularis* is relatively thick, and consists of many flat parenchymatous cells pressed (Refer to Plate I. Fig. 3(c), 4(c), 5(c), 6(c)), but such thin inner-integument as the seeds of *E. botryoides*, *E. ficifolia*, *E. globulus*, *E. robusta*, *E. rostrata* and *E. tereticornis* consist of one row of smaller parenchymatous cells, and they are some ellipse or some square in shape at the cross section (Refer to Plate I. Fig. 1(b), 2(c), 7(c), 8(c), 9(c), 10(c)).

The seeds of *E. fastigata* and *E. globulus* contain many dark brown substances in inner-integument, but other species contain many brown substances, and therefore it is difficult to find the cells of inner-integument at the cross section of seeds of 10 species. The naked eye-colour of the seeds of *E. fastigata* (nak. col. dark brown: out.-integ. white), *E. ficifolia* (nak. col. brown: out.-integ. pale yellow), *E. globulus* (nak. col. black, out.-integ. dark gray), *E. gigantea* (nak. col. brown: out.-integ. white), *E. pauciflora* (nak. col. black purple: out.-integ. pale yellow) *E. pilularis* (nak. col. brown: out.-integ. pale yellow) and

E. robusta (nak. col. brown: out.-integ. pale yellow) among 10 species of *Eucalyptus* seems to be caused more from the colour of the inner-integument containing many coloured substances in the cells than from that of the outer-integument.

The contained substances in the integument of 10 species of *Eucalyptus* are crystals of calcium oxalate, oil and tannin, and I have observed that they are more contained in the inner-integument than in the outer one. Though all species contain crystals of calcium oxalate in their integument, the species containing them in outer-integument are only *E. ficifolia* and *E. globulus*. We find oil in inner-integument of 10 species of *Eucalyptus*, but the species containing the one in outer-integument are *E. ficifolia*, *E. botryoides*, *E. robusta*, *E. rostrata* and *E. tereticornis*. Seed-integument of each species contains tannin, whose amount is larger in inner-integument than in outer-one. Each cell in integument relatively contains more tannin in cell-lumen than in cell-membrane. Such cells consisting of remarkable sclerenchymatous cell-membrane as those in outer-integument of *E. fastigata*, *E. gigantea*, *E. pauciflora* and *E. pilularis* contain relatively little tannin resulting from the narrowness of the cell-lumen.

The colour-reaction by reagent of nitric acid, caustic potash solution and jodjodpotassium solution is only remarkably recognized at the lignified membrane of the outer integument-cells of *E. fastigata*, *E. gigantea*, *E. pauciflora*, *E. pilularis* and *E. rostrata*. These outer-integument cells become yellow, yellow-brown or brown colour by nitric acid or caustic potash solution and deep brown colour by jodjodpotassium. Though integument cells of each species are not dyed with eosin and congored, they are dyed well with the colouring matters of safranin and methylenblue, the former dyeing it red and the latter blue.

The outer-integument has more characteristics than the inner-one and the seeds of these 10 species are divided into 4 sections from the characteristics seen in structure of the outer-integument cells as follows:

(I) Outer-integument cells consisting of remarkably sclerenchymatous cell-membrane
E. fastigata, *E. gigantea*, *E. pauciflora*, *E. pilularis*

(II) Outer-integument cells consisting of somewhat sclerenchymatous cell-membrane
E. rostrata

(III) Outer-integument cells consisting of the decomposed cell-membrane
E. botryoides, *E. globulus*, *E. robusta*, *E. tereticornis*

(IV) Outer-integument cells consisting of thin cell-membrane
E. ficifolia

Tbe characteristics in cells of 4 sections above mentioned are as follows:

(I) Outer-integument cells consisting of remarkably sclerenchymatous cell-membrane

The outer-integument belonging to this section is lignified. The narrow belt which is found to be stiff portion at the periphery of each of the sides constructing these seeds and the one at the periphery of its navel consist of larger sclerenchymatous cells than the other portion of that side (Refer to Plate I. Fig. 5(a). Plate II. Fig. 5(a)(b)).

(a) *E. fastigata*

The thickness of seed-integument is av. 90 μ and that of the outer-integument av. 72 μ. The sclerenchymatous cells of the outer-integument arrange in a row and are rectangles for a radial direction, being av. 72 μ in length and av. 21 μ in breadth. Lumen of each cell forms a narrow line at the cross section of seed-integument (Refer to Plate I. Fig. 3(c)). Cell-lumen contains black or brown substances. Outer-integument at each side of the seed has large, long sclerenchymatous cells and large roundish polygonal ones in some degree at the horizontal section (Refer to Plate II. Fig. 3(a) (b)).

(b) *E. gigantea*

The thickness of seed-integument is av. 78 μ and that of the outer-integument av. 58 μ. The sclerenchymatous cells in the outer integument arrange in a row and their shape resembles that of *E. fastigata* at the cross section (Refer to Plate I. Fig. 4(c)). The sclerenchymatous cells are of two kinds made up roundish ones and somewhat squerish, polygonal ones at the horizontal section (Refer to Plate II. Fig. 4(a) (b)). This point makes *E. gigantea* different from *E. fastigata.*

(c) *E. pauciflora*

The thickness of seed-integument is av. 28 μ and that of the outer-integument av. 14 μ. The sclerenchymatous cells of the outer-integument arrange in a row at the cross section, and are relatively of smaller rectangles than those of *E. fastigata* and *E. gigantea.* Those of *E. pauciflora* are av. 24 μ in length and 15 μ in breadth at the cross section of the seed-integument (Refer to Plate I. Fig. 5(c)). Cell-lumen contains pale yellow substance. *E. pauciflora* has only one kind of somewhat irregular shaped roundish polygonal sclerenchymatous cells with relatively wide cell-lumen at the horizontal section of the outer-integument of seeds (Refer to Plate II. Fig. 5(a) (b)).

(d) *E. pilularis*

The thickness of seed-integument is av. 89 μ, and that of the outer-integument av. 56 μ. The sclerenchymatous cells of the outer-integument are almost polygonal at the cross section of seed-integument, and their size is remarkably large in comparison with those of *E. pauciflora* (Refer to Plate I. Fig. 6 (c)). Cell-lumen contains pale yellow substances. Outer-integument consists of larger and longer cells having remarkably sclerenchymatous cell-membrane at the horizontal section of the outer-integument (Refer to Plate II. Fig. (6)). The narrow stiff portion at the periphery of each side of this seed is made remarkably larger sclerenchymatous cells, which are long for the radial direction, their cell-lumen being narrow, containing brown substances, and the largest one among them amounting to 70 μ in length. 21 μ in breadth.

(II) Outer-integument cells consisting of somewhat sclerenchymatous cell-membrane.

Only *E. rostrata* belongs to this section. The thickness of seed-integument is av. 14 μ and that of the outer-integument av. 7 μ. The outer-integument cells arrange in a row, each cell is semicircle at the cross section of seed-integument. Its cell-membrane is somewhat sclerenchymatous and lignified. It is only this species that we find thus difference in structure from those among 10 speces of *Eucalyptus* (Refer to Plate I. Fig. 10(c)). Cell-lumen is wide and pale yellow in colour.

Outer-integument consists of longer cells at the horizontal section, each of which has many pits in membrane. The special cells arranging in a row at the periphery of each side is more sclerenchymatous at the outerside than at the inner side (Refer to Plate II. Fig. 10 (a) (b)). This state of sclerenchym is remarkably different in comparison with that at the periphery of *E. fastigata*, *E. gigantea*, *E. pauciflora* and *E. pilularis*.

(III) Outer-integument cells consisting of the decomposed cell-membrane

The seeds of 4 species of *E. botryoides*, *E. globulus*, *E. robusta* and *E. tereticornis* belong to this section. Appearances of seeds of *E. botryoides*, *E. globulus* and *E. tereticornis* are black, but those of *E. robusta* brown. The riped seeds above mentioned, species have many small trichomes grown on their surface, and there feel rough, differing from the other seeds of *Eucalyptus* species.

(a) *E. botryoides*, *E. globulus* and *E. tereticornis*

These 3 species are not fixed the thickness of outer-integument and shape of their cells owing to the decomposition occurring to cells of outer-integument.

When we observe the seeds of these species with the microscope we find black stripes in net-work on the surface of the seeds of *E. globulus* and *E. tereticornis*, and the size of each division of the net-work is larger in the former than in the latter. Black stripes of *E. botryoides* from imperfect, irregular net-work.

These 3 species have parenchymatous tissue consisting of small cells in an enclosure surrounded by stripes on their seed surface. The cell-lumen of *E. botryoides* is brown in colour, *E. globulus* dark brown, *E. tereticornis* yellow brown, but the colour of the cell-membrane of 3 species is black (Refer to Plate II. Fig. 2, 7(a) (b) and 8(c)).

We find distinctly the decomposed state of cells in outer-integument at the cross section, and in the cells remaining unbrocken lignification is not recognizable, and it is traceable that some parts of the remaining cells look as if they had been dissolved. Though the remaining cells of *E. globulus* and *E. botryoides* are relatively large in size, those of *E. tereticornis* are smaller than those above mentioned (Refer to Plate I. Fig. 2(c), 7(c) and 8(c)). Cells of inner-integument arrange in a row at inner side of remaining cells. Judging from above mentioned, it is evident that the parenchymatous cells surrounded by stripes on the surface of seeds are inner-integument cells which have been brought out up to the seed surface caused by the decomposition of outer-integument cells.

(b) *E. robusta*

The brown stripes of *E. robusta* also form net-work, at the horizontal section of seed, and its distribution and shape fully resemble those of *E. globulus* and *E. tereticornis*. The parenchymatous cells surrounded by stripes are smaller and brown, and cells-membrane is pale brown in colour (Refer to Plate II. Fig. 9(a) (b)). The rests of destroyed cells of outer-integument are distinctly discernable at the cross section of seed. The rests do not present lignification, but they look as if they had been dissolved. The size of remaining cells is much smaller than those of *E. globulus* and *E. botryoides* (Refer to Plate I. Fig. 9 (c)).

I found yellow ones amongst black seeds of *E. tereticornis*, and outer-integument of the seeds consists of yellow sclerenchymatous cells whose lignification is recognizable though not in those of black seed. Inner-integument of yellow seed consists of smaller parenchymatous cells, and contains many crystals of calcium oxalate (Refer to Plate II. Fig. 8 (a) (b)).

As seeds of *Cucumis sativus* ripen their epidermis get soluble, and disappear from the surface after they had become viscosity-substance. Epidermis of the seed of *Lagenaria vulgaris* consists of the palisade cells which are kept while the seed is green, but in accordance with its ripeness, its palisade cells become mucilaginous and finally disappear, and only their sclerenchymatous cell-membranes remain looking like hair. In case of full ripe seeds of *Benicasa cerifera*, only the longitudinal sclerenchymatous parts of the palisade cells in their epidermis remain in hair-like appearrance at places along the edge of the palisade cells.

Judging from above mentioned, I should like to conclude as follows: According to the ripeness of the seed of *E. tereticornis*, it changes from yellow to black in colour, the outer-integument of the seed gradually goes through chemical metamorphosis within this period until it gets dissolved and lost except one part retained at the periphery of the sclerenchymatous cell. When we observe the surface of the seeds, its remaining cells represent, trichome and the parenchymatous cells surrounded by stripes at horizontal section of seed are inner-integument cells. Though I could not find any young seeds such as those of *E. tereticornis* among the forwarded seeds of *E. botryoides*, *E. globulus* and *E. robusta*, I suppose that the development process of outer-integument with net-work is probably similar to that of *E. tereticornis.*

(IV) Outer-integument cells consisting of parenchymatous cell-membrane

The seed of *E. ficifolia* belongs to this section. The thickness of seed-integument is av. 74 μ, and that of the outer-integument av. 42 μ. The outer-integument of seed consists of many parenchymatous cells at the horizontal section of the integument while we observe at the cross section the parenchymatous cells arranged in 2–3 rows in outer-integument. Cell-lumen is colourless or brown, cell-membrane pale yellow in colour. The outer-integument consisting of such parenchymatous cell is only this species among 10 ones. (Refer to Plate I. Fig. 1(b) and Plate II. Fig. 1).

IV. Consideration

According to "The National Occurrence of the *Eucalyptus*," altitude of satisfactory growth of *E. fastigata* is 606 m–1273 m, *E. gigantea* 909 m–1363 m, *E. pauciflora* 606 m–1667 m in main-land of Australia, altitude of typical growth of *E. pilularis* is from just above sea level to 303 m in southern limits to 606 m in northern N.S.W.

Judging from above described the 3 species grow at upper alt. and stand cold, excepting *E. pilularis* among belonging to (I) section of my classification, owing to the construction of the integument previously mentioned. The other 6 species of *Eucalyptus* belonging to (I)–(IV) section of integument classification grow mainly below 500 m in altitude and their resisting-ability to the cold seems to be inferior to that of 3 species of (I) section. Altitude of 10 species typical growing and maximum and minimum temperature of winter in Australia are as follows:

Table I.

Name of *E.*	Sec. of Seed	Alt. of typical growth		Mt. corresponding to uper Alt. of A. in Kyushu, Japan	
		Lower	Upper		
E. fastigata	(I)	606 m	1273 m	Mt. Hikosan	1200 m
E. gigantea		909 m	1363 m	Mt. Yufu	1554 m
E. pauciflora		606 m	1667 m	Mt. Kirishima	1700 m
E. pilularis		Above s. l.	303 m	Mt. Wakasugi	678 m
E. rostrata	(II)	30 m Flinder —	228 m (606) m	Mt. Ranges Sasaguri	65–300 m
E. botryoides	(III)	Above s. l.	151 m		
E. globulus		Above s. l.	303 m		
E. robusta		Above s. l.	65 m		
E. tereticornis		Above s. l.	364 m		
E. ficifolia	(IV)	Above s. l.	151 m		

Table II.

Name of *E.*	Sec. of Seed	Winter Temperature		Alt. (m)	Place
		min. (C)	max. (C)		
E. fastigata	(I)	− 2.0°	8.3°	1194	*Gurnang*
E. gigantea		0.5°	4.0°	1324	Mt. Buffalo
E. pauciflora		− 1.0°	4.0°	1324	〃
E. pilularis		9.0°	20.5°	45	Brisbane
E. rostrata	(II)	4.0°	11.8°	42	Hamilton
E. botryoides	(III)	9.5°	15.0°	77	Jervis Bay
E. globulus		4.0°	11.5°	5	*Hythe*
E. robusta		9.5°	20.3°	42	Brisbane
E. tereticornis		6.0°	21.0°	94	Gympie
E. ficifolia	(IV)	8.0°	16.0°	12	Albany

The forest nursery at the Experimental Forest Office of Kyushu University at Sasaguri-Town, Kasuya Gun, Fukuoka Prefecture in Japan is situated at 50 m above sea level, and Lat. 33°37′ N., Long. 130°34′ E., the results of the latest meteorogical observation for temperature, forest and snow in winter-period are as follows:

Table III.

	Place	Alt.	Decem. (1954)		Jan. (1955)		Feb. (1955)	
			min. (°C)	max. (°C)	min. (°C)	max. (°C)	min. (°C)	max. (°C)
Temperature:	Sasaguri-Town	50 m	−2.3	21.0	−3.2	13.0	−2.0	16.9
	Fukuoka-City	2.5 m	−2	21.5	−2.8	14.3	−1.9	17.9

	Place	Alt.	Frost in days among 3 months	Days in Frost period
Frost:	Sasaguri-Town	50 m	23	181
	Fukuoka-City	2.5 m	21	162
Snow:	5 times in three months, but very light			

Addition: Av. min. temperature for 10 years is 1.2° C in February

Judging from above mentioned tables, though *Eucalyptus* species (*E. fastigata, E. gigantea, E. pauciflora*) grow at upper mountain in Australia, min. temperature at there resembles that of the mountain country, altitude 300 m at Sasaguri district, Fukuoka Prefecture in Japan. I suppose naturally that the other 7 species growing at lower country below 500 m in Australia will be damaged from cold in winter at lower country in Japan.

According to the results of investigation from December, 1954 to February, 1955, on the damage caused from the cold to the seedlings and young trees of *Eucalyptus* at the forest nursery of the Kasuya Experimental Office, *E. gigantea* had no damage at all, the cold damage percentage of *E. ficifolia* was 70 %, *E. fastigata* 0.9 %, *E. globulus* 21 %, *E. pauciflora* 0.24 %, *E. pilularis* 71.8 %, *E. botryoides* 68 %, *E. robusta* 44 %, *E. rostrata* 33.3 % and *E. tereticornis* 84.2 %. The degree of the damage done to them in most cases was the witheredness only seen on the part of leaves and sprouts of the seedlings and young plants of *Eucalyptus*.

On the 26th, November, 1954, I planted young plants of *E. pauciflora* 181 in number and *E. fastigata* 34 and the other 7 species of *Eucalyptus* at Arahira in Kasuya Experimental Forest, situated at 4 km from the Kasuya Office, and its alt. is 300 m above sea, av. min. temperature per 3 months above described was − 3° C. The young plants of *E. pauciflora* and *E. fastigata* mostly has no cold damage there, but the other species were as much damaged by snow and frost as they were at the Forest Nursery.

On the 22nd, November, 1954, I planted the youngs of *E. globulus* 131 in number, *E. pilularis* 92, *E. robusta* 9, *E. rostrata* 92 and *E. tereticornis* 58 at Takatsuji in the Kasuya Experimental Forest, situated at 2 km from the Kasuya Office, alt. 85 m above sea level, min. temperature per 3 months was -2° C. The cold damage percentage of *Eucalyptus* in that period at Takatsuji was counted *E. globulus* 35.8 %, *E. pilularis* 53.2 %, *E. robusta* 77.7 %, *E. rostrata* 63 %, *E. tereticornis* 91.3 %. The degree of the damage was mostly only part of sprouts and leaves of the younger plants of *Eucalyptus*. Judging from above mentioned experiment, *E. gigantea*, *E. fastigata* and *E. pauciflora* have strong resisting character to cold, but the other 7 species are weak to cold in Japan as they are in Australia.

Judging from above described results, the other 3 species excepting *E. pilularis* among (I) section of seed with outer-integument consisting of remarkably sclerenchymatous cell have very resisting character to the cold within my this experiment, but each species belonging to (II)-(IV) [The section of seed with outer-integument consisting of less sclerenchymatous cells (II). The section of the decomposed cells (III). The section of the parenchymatous cells (IV)] reduces its resisting power to the cold in the order given above, in other words, the first section the strongest, the second less, and third and the forth the least. I suppose that the thickness of integument, especialy the degree of being sclerenchymatous of cell-membrane in the outer-integument and the state of its tissue have mutual relation to the resisting character to the cold of the young plants germinated from those seeds.

In other words, it indicate that from the physiological necessity the species of *Eucalyptus* growing at moderately upper country with cold temperature scatter their seeds on the cold area and so these seeds consists of thick integument for that purpose, especially for protecting the embryo with sclerenchymatous cell-membrane. The species of *Eucalyptus* whose seeds consist of thin inner-integument, especially the outer-one being less sclerenchymatous such as *E. rostrata*, grows at mean altitude with mean temperature, while, *Eucalyptus* plants whose seeds consist of thin integument, especially those with outer-integument consisting of decomposed cells or those with the parenchymatous cells grow at moderately at warm lower area. Thus species of *Eucalyptus* are physiologically provided with such characteristics about as to enable themselves adapted to their environment. If I could find similar results about seeds of many other species of *Eucalyptus* than 10 species I tried, I should think very interesting and those experimental results would have the applied value about the natural occurrence and artificial plantation of *Eucalyptus*.

V. Summary

1) Seeds of 10 species of Eucalyptus contain mostly crystals of oxalate of lime, oil and tannin in seed-integument and we find them more in the inner-integument than the outer one.

2) The sclerenchymatous cells in outer-integument are lignified, and colour reaction by reagent is recognized, namely these become vellow, yellow brown or brown in colour by nitric acid or caustic potash solution and deep brown in colour by jodjodpotassium.

3) Though integument-cells of 10 species of *Eucalyptus* are not dyed by eosin and congored, they are dyed well by colouring materials of safranin and methylenblue, the former dying them red and the latter blue.

4) Seeds of *E. ficifolia* and *E. globulus* are relatively large grains among those of 10 species of *Eucalyptus* and each of the two entirely is different from the other in shape and outwardly colour, the former consisting of parenchymatous cells in outer-integument, latter of decomposed cells, and the cells left undecomposed represent tiny trichome on the surface of seed.

5) The seeds of *E. fastigata* and *E. gigantea* have mutual resemblance in size and shape, outer-integument of each species consisting of two kinds of sclerenchymatous cells, the former is of larger longer cells and of larger roundish polygonal ones at the horizontal section, but the latter of rather roundish polygonal cells and rather squarish polygonal ones.

6) Seeds of *E. pauciflora* and *E. pilularis* are like each other in size and shape, the former consisting of somewhat irregular polygonal sclerenchymatous cells with relatively wide cell-lumen at the horizontal section, but the latter of larger cells with remarkably sclerenchymatous cell-membrane.

7) The seeds of *E. robusta* and *E. rostrata* resemble each other in shape, but the former has brown stripes of net-work on the surface of seed, with the decomposed state of cells in outer-integument distinctly discernible at the cross section, but the outer-integument of *E. rostrata* consists of long larger and rather sclerenchymatous cells, each cell having membrane with many pits in it at the horizontal section, and each cells being semicircle and arranged in a row at the cross section of outer-integument.

8) The seeds of *E. botryoides* and *E. tereticornis* resemble each other in shape, and each has black stripes on the surface of seed representing net-work sound and regular in the latter and far less sound and regular in

the former, the cells left undecomposed are found at the cross section of the seeds of each species, but those of *E. botryoides* are larger in shape than those of *E. tereticornis*, and the decomposed cells seem to be dissolved.

9) I think that the structure of seed-integument of the 10 species is closely related to the resisting character to the cold of the young plants germinated from these seeds.

Anatomical Literature of Seed

1. Alves, A.: Züchtung und Samenbau von Klee und Gräsern in Dänemark und Schweden. Arbeiten der Deutschen Landwirtschafts-Gesellschaft, Ht. 208, 1912.
2. Bachmann, E.: Die Entwicklungsgeschichte und der Bau der Samenschale der *Scrophularineen.* Inaugl. Dissertation, Leipzig, 1880.
3. Bernatzky, I.: Anatomische Bestimmung des Samens. von *Cuscuta trifolii* und *C. suaveolens.* Landw. Vers-St. 88: I, II, 1916.
4. Collins, E. J.: The structure of the integumentary system of the barley grain in relation to localized water absorption and semipermeability. Ann. Bot., 32: 381–414, 1918.
5. Grimbach, P.: Vergleichende Anatomie verschiedenartiger Früchte und Samen bei derselben Spezies. Inaugl. Dissertation, Münster, 1913.
6. v. Höhnel, F.: Morphologische Untersuchungen über die Samenschalen der *Cucurbitaceen* und einiger verwandter Familien. Sitzb. d. K. Akad. Wiss. I. Abt. 73: 1-41, 1876.
7. Kamensky, K. W.: Anatomische Struktur der Samen von einigen *Cuscutaarten* und deren systematischer Wert. Angew. Bot. Zeitsch. f. Erforschung der Nutzpflanzen, 10: 5, 387–409, 1928.
8. Kamensky, K. W.: Morphologische-anatomische Unterscheidungsmerkmale der Unkrautsamen aus den Familien *Liliaceae* und *Iridaceae.* Bull. of Appl. Bot Gene and Plant-Breeding, 25: 4, 59–108, 1931
9. Kolle, F.: Untersuchungen über den Bau der Samenschale an Hilum und Chalaza bei einigen officinellen Pflanzen. Inaugl. Dissertation, Bern, 1918.
10. Kondo, M.: Der anatomische Bau einiger auslandischer Hulsenfruchte, die jetzt viel in den Handel kommen. Zeitsch. f. Untersuchung der Nahrungs und Genussmittel, sowie Gebrauchsgegenstande, 25: 1–56, 1913.
11. Kondo, M.: Anatomische Untersuchungen über japanische Coniferen-Samen und Verwandte. Landw. Vers.-St., 81: 443-468, 1913.
12. Krauss, L.: Entwicklungsgeschichte der Früchte von *Hordeum, Triticum, Bromus* und *Poa* mit besonderer Berücksichtigung ihrer Samenschalen. Jahrb. f. Wiss. Bot., 77: 733-808, 1933.
13. Kujala, V.: Untersuchungen über den Bau und die Keimfähigkeit von Kiefern-und Fichtensamen. Helsinki, 1927.

14. LAKON, G.: Beiträge zur forstlichen Samenkunde. Zur Anatomie und Keimung reiniger Koniferensamen.
Naturw. Zeitschr. f. Forst-und Landwirtschaft, Jahrg. 10: 401–410, 1912.
15. LONDE, G.: Über die Entwicklungsgeschichte und den Bau einiger Samenschalen.
Inaug. Dissertation, 1874.
16. MERZ, M.: Untersuchungen über Anatomie und Samentwicklung der *Utricularien* und *Pinguicula*.
Inaugl. Dissertation, Bern. 1897.
17. NETOLITZKY, F.: Anatomie der Angiospermen-Samen.
Berlin, 1926.
18. NIETHAMMER, A.: Beitzversuche und anatomisch-chemische Studien mit den Samen des Wirsingkohles.
Zeitchr. f. Pflanzenkarankheiten und Pflanzenschutz. 41: 149–167, 1931.
19. PAMMEL, L. H.: Anatomical characters of the seeds of *Leguminosae*, chiefly genera of Gray's manual.
Transactions of the Academy of Science, St. Louis, 9: 6, 91–263 with Tables and Plates, 1899.
20. PRITZEL, E.: Der systematische Wert der Samen-anatomie, insbesondere des Endosperms bei den Parietales.
Inaugl. Dissertation, Berlin, 1897.
21. REEVES, R. G. and VALLE, C. C.: Anatomy and microchemistry of the cotton seed.
Bot. Gaz., 93: 259–277, 1932.
22. RITTER, G.: Die systematische Verwertbarkeit des anatomischen Baues von Früchten- und Samen.
Beihefte z. Bot. Centralbl., 26: 1, 132–156, 1909.
23. VON RÜMKER, K.: Dar Saatbau und die Saatbauvereine.
Berlin, 1922.
24. 沢田利農夫：本邦産主要林木種子の鑑別法（針葉樹の部）.
朝鮮総督府林業試験場報告，第8号，昭和3年.
25. SCHÄCKEL, A.: Zur Kentnis des Baues und der Inhaltverhältnisse der Hülsen und Samenschalen der *Leguminosen*.
Inaugl. Dissertation, Göttingen, 1919.
26. SETTEGUST, H.: Die landwirtschaftlichen Sämerein und der Samenbau.
Leipzig, 1892.
27. 渋谷常紀. 稲の種皮の組織学的研究（予報）.
日本作物学会記事，第1巻，第2号，15–16，昭和3年.
28. VOIGT, A.: Über den Bau und die Entwicklung des Samens und des Samenmantels von *Myristica fragrans*.
Inaug. Diss., Göttingen, 1885.
29. WINTON, A. L.: The anatomy of certain oil seeds with especial reference to the microscopic examination of cattle foods.
Rpt. Conn, Agr. Exp. Stat, 1903, Part II. Food products, 175–198.
30. WINTON, A. L.: Anatomie des Hanfsamens.
Zeitschr. f. Unters. d. Nahrungs u. Genussmittel, 7: 385–388, 1904.
31. 近藤万太郎：日本農林種子学（後編）.
昭和9年.
32. NOBBE. F.: Handbuch der Samenkunde. 1876.

Explanation of Plate I

Outer shape of 10 species of *Eucalyptus* and cells in integument of ripe seed at the cross section

Fig. 1(a).	Outer shape of seed of *E. ficifolia*	× 25
Fig. 1(b).	Cells in integument of *E. ficifolia*	× 270
Fig. 2(a).	Outer shape of seed of *E. globulus*	× 25
Fig. 2(b).	Outer shape of seed of *E. globulus*	× 12
Fig. 2(c).	Cells in integument of *E. globulus*	× 270
Fig. 3(a).	Outer shape of seed of *E. fastigata*	× 25
Fig. 3(b).	Outer shape of seed of *E. fastigata*	× 12
Fig. 3(c).	Cells in integument of *E. fastigata*	× 270
Fig. 4(a).	Outer shape of seed of *E. gigantea*	× 25
Fig. 4(b).	Outer shape of seed of *E. gigantea*	× 12
Fig. 4(c).	Cells in integument of *E. gigantea*	× 270
Fig. 5(a).	Outer shape of seed of *E. pauciflora*	× 25
Fig. 5(b).	Outer shape of seed of *E. pauciflora*	× 12
Fig. 5(c).	Cells in integument of *E. pauciflora*	× 270
Fig. 6(a).	Outer shape of seed of *E. pilularis*	× 25
Fig. 6(b).	Outer shape of seed of *E. pilularis*	× 12
Fig. 6(c).	Cells in integument of *E. pilularis*	× 270
Fig. 7(a).	Outer shape of seed of *E. botryoides*	× 25
Fig. 7(b).	Outer shape of seed of *E. botryoides*	× 12
Fig. 7(c).	Cells in integument of *E. botryoides*	× 270
Fig. 8(a).	Outer shape of seed of *E. tereticornis*	× 25
Fig. 8(b).	Outer shape of seed of *E. tereticornis*	× 12
Fig. 8(c).	Cells in integument of *E. tereticornis*	× 270
Fig. 9(a).	Outer shape of seed of *E. robusta*	× 25
Fig. 9(b).	Outer shape of seed of *E. robusta*	× 12
Fig. 9(c).	Cells in integument of *E. robusta*	× 270
Fig. 10(a).	Outer shape of seed of *E. rostrata*	× 12
Fig. 10(b).	Outer shape of seed of *E. rostrata*	× 25
Fig. 10(c).	Cells in integument of *E. rostrata*	× 270

am ……abdomen
co ……concavity at the point
ce………concavity at the rear
itc ……inner-integument cell
ln………Lumen of cell
na ……navel
or………rest of outer-integument cell
otc ……outer-integument cell
pc ……sclerenchymatous portion at periphery of the side
po ……sclerenchymatous portion situated at periphery of ovel
ps ……sclerenchymatous portion at the point of seed
re………rear sd……side
su ……sture
wi ……wing

PLATE I. Fig. 1-10

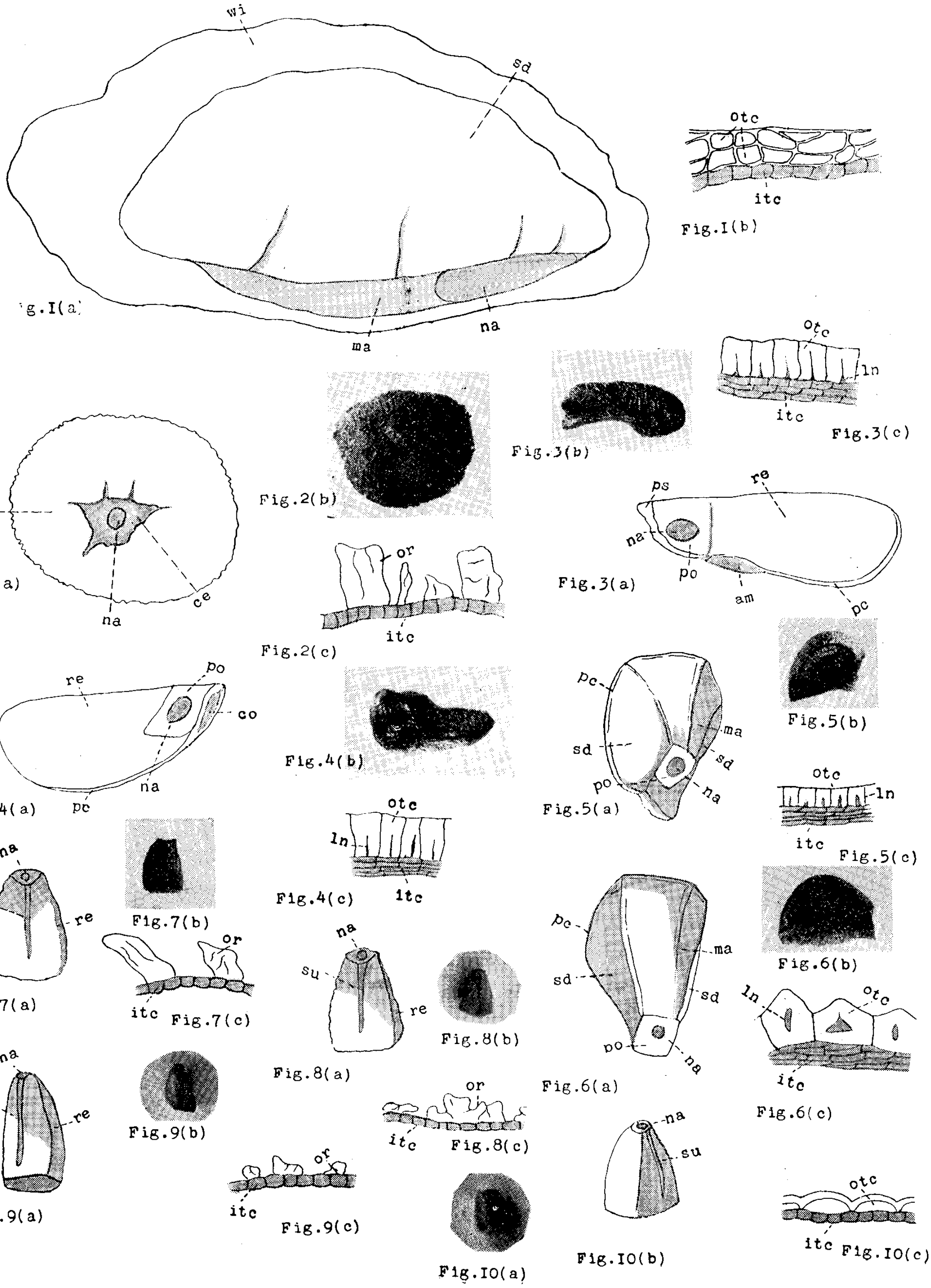


PLATE II. Fig. 1–10

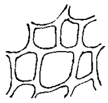


Fig.I

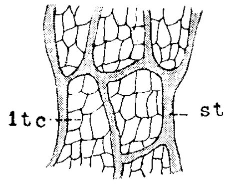


Fig.2

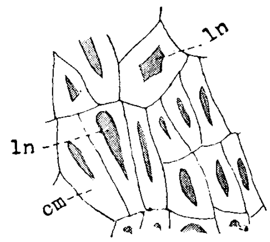


Fig.3(a)

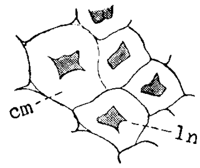


Fig.3(b)

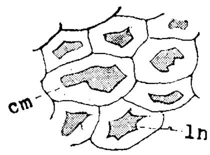


Fig.4(a)

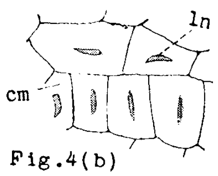
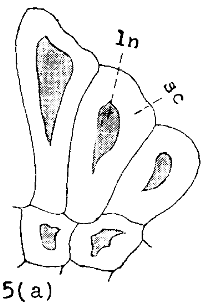


Fig.4(b)



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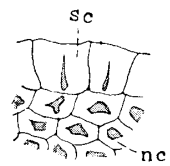


Fig.5(b)

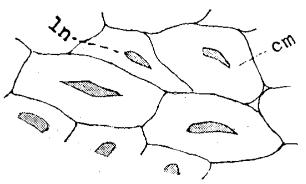


Fig.6

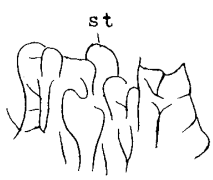


Fig.7(a)

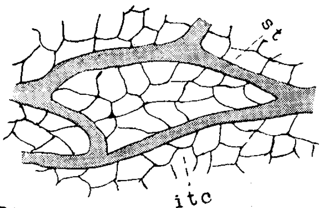
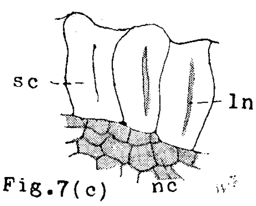


Fig.7(b)



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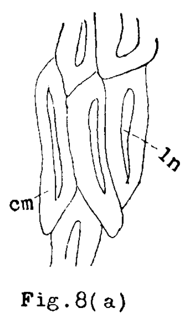
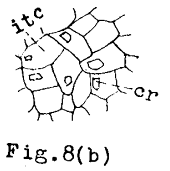


Fig.8(a)



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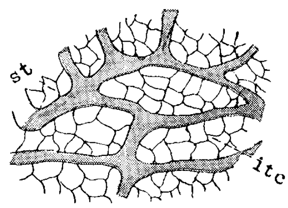

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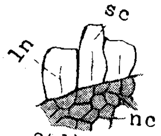

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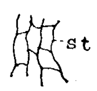

Fig.9(a)

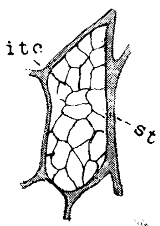

Fig.9(b)

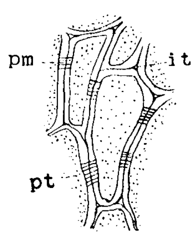

Fig.IO(a)

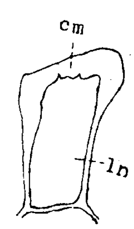

Fig.IO(b)

Explanation of Plate II

Cells in outer-integument of ripe seed of 10 species
of *Eucalyptus* at the horizontal section

Fig. 1. Cells in outer-integument of *E. ficifolia* × 270
Fig. 2. Black spripes distributing on the surface of seed and inner-integument cells of *E. globulus* × 270
Fig. 3(a) (b). Outer-integument cells consisting of the seed of *E. fastigata* × 360
Fig. 4(a) (b). Outer-integument cells consisting of the seed of *E. gigantea* × 360
Fig. 5(a). Cells in sclerenchymatous portion at periphery of each side and cells at inner portion of its side of *E. pauciflora* × 360
Fig. 5(b). Cells in the sclerenchymatous portion at periphery of the navel and cells at the inner portion of the navel of *E. pauciflora* × 360
Fig. 6. Outer-integument cells consisting of the seed of *E. pilularis* × 360
Fig. 7(a). Black spripes distributing on the surface of seed of *E. botryoides* × 60
Fig. 7(b). Black spripes distributing on the surface of ripe seed and inner-integument cells of *E. botryoides* × 360
Fig. 7(c). Cells in the sclerenchymatous portion at periphery of navell of seed and cells at the inner portion of the navel of *E. botryoides* × 360
Fig. 8(a) (b). Outer-integument cells and inner-integument cells consisting of the yellow seed of *E. tereticornis* × 270
Fig. 8(c). Black spripes distributing on the surface of the ripe seed and inner-integument cell of *E. tereticornis* × 270
Fig. 8(d). Cells in the sclerenchymatous portion at the periphery of navel and cells at the inner portion of the navel of *E. tereticornis* × 270
Fig. 9(a). Brown spripes distributing on the surface of ripe seed of *E. robusta* × 60
Fig. 9(b). Blown spripes distributing on the surface of seed and inner-integument cells of *E. robusta* × 270
Fig. 10(a). Outer-integument cells consisting of seed of *E. rostrata* × 360
Fig. 10(b). Especial cells in the sclerenchymatous portion at periphery of each side of *E. rostrata* × 270

cm ……cell-membrane
cr………crystal
it ………intercellular spaces
itc ……inner-integument cell
ln………lumen of cell
nc ……cells in navel
or………rests of outer-integument cell
po………sclerenchymatous portion situated at periphery of ovel
pm ……pits membrane
pt………pit
sc………cells of sclerenchymatous portion
st………stripe

Résumé

(El Español)

He estudiado sobre la estructura de las integumentes de la semillas de las diez especies de *Eucalyptus*, las cuales son *E. botryoides*, *E. fastigata*, *E. ficifolia*, *E. gigantea*, *E. globulus*, *E. pauciflora*, *E. pilularis*, *E. robusta*, *E. rostrata* y *E. tereticornis*. Escribo el sumario siguiente:

Las semillas de las diez especies de *Eucalyptus* contenen crystals de calcio-oxlicoacido, óleo y tanino, los cuales están muchos en integumento interior que integumento exterior. La celda esclesótica del integumento externo tiene el estado lenoso, la cual se tinta a castaño intenso por la solución de jodjodpotasa, los integumentos de todas diez especies se tintan rojos por safranin y azules por methyllazul.

Puedo clasificar las cuatro secoiónes sobre la estructura de integumento externo de las diez especies:

1) El integumento externo consiste de las celda muy esclesóticas
   E. fastigata, *E. gigantea*, *E. pauciflora*, *E. pilularis*
2) El integumento externo consiste de las celdas algún esclesoticas
   E. rostrata
3) El integumento externo consiste de las celdas destructivos
   E. botryoides, *E. globulus*, *E. robusta*, *E. tereticornis*
4) El integumento externo consiste de las celdas blandas
   E. ficifolia

Puedo clasificar las dos secciónes sobre la estructura de integumento interior de las diez especies de *Eucalyptus*:

1) El integumento interior es espeso relativamente y consiste de las blandas celdas, las cuales arreglan irregularmente.
   E. fastigata, *E. gigantea*, *E. pauciflora*, *E. pilularis*
2) El integumento interior es delgado relativamente y consiste de las blandas celdas, las cuales arreglan en una fila.
   E. botryoides, *E. ficifolia*, *E. globulus*, *E. robusta*, *E. rostrata*, *E. tereticornis*

Las plantas de *Eucalyptus* que ocurren encima de la altura superiora fría relativamente en Australia, son *E. fastigata* (altura speriora: 1194 m, tempera-

tura de mínimo en julio: $-2°$ C), *E. gigantea* (alt. sup. 1324 m, temp. min 0.5° C), *E. pauciflora* (alt. sup. 1324 m, temp. min. $-1°$ C) en las diez especies, las semillas consisten de las celdas muy esclesóticas al integumento externo y el integumento interior es espeso relativamente.

Las plantas de *Eucalyptus* que ocurren encima de la colina o la costa abrigada en Austrlia son *E. botryoides* (altura superior: 77 m, temperatura de minimo en julio: 9°.5 C), *E. ficifolia* (alt. sup. 12 m, temp. min. 8° C), *E. globulus* (alt. sup. 5 m, temp. min. 4° C), *E. robusta* (alt. sup. 42 m, temp. min. 9°.5 C) y *E. tereticornis* (alt. sup. 94 m, temp. min. 6° C) en las diez especies, las otras semillas consisten de las celdas destructos o las celdas blandas al integumento externo y el integumento interior es delgado, excepto la semilla de *E. pilularis*, la cual tiene las celdas muy esclesóticas (alt. sup. 45 m, temp. min. 9° C).

Las plantas de *Eucalyptus* que ocurre encima de la altura mediano desde altura del nivel de mar en Australia, es solo *E. rostrata* (altura superior: 42 m, temperatura de minimo en julio: 4° C) en las diez especies, la semilla consiste de las celdas algún esclesóticas al integumento externo y el integumento interior es delgado.

Suponeo que la mutualidad esté en la estructura de las semillas de *Eucalyptus* plantas y la ocurrencia natural de *Eucalyptus* plantas en la limite de mi experimento, pero la semilla de *E. pilularis* esté la excepción.