BOTANICAL GAZETTE

THE
BOTANICAL GAZETTE

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JOHN MERLE COULTER AND CHARLES REID BARNES,

WITH OTHER MEMBERS OF THE BOTANICAL STAFF
OF THE UNIVERSITY OF CHICAGO

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P. 10, line 10 from above, p. 11, lines 17 and 21 from above, for Brainard read Brainerd.

P. 14, line 13 from below, for nearly read rarely.

P. 132, line 9 from above, for Schuman read Schumann.

P. 203, footnote 4, line 5, for Mazijck read Mazyck.

P. 225, line 1, for **Cratægus Texana** read CRATAEGUS TEXANA.

P. 274, footnote 1, line 1, for plant read vegetable.

P. 328, line 16 from above, for G. read Galphimia.

P. 328, line 9 from below, for S. read Solanum.

P. 329, line 6 from above, for Aecidium read aecidium.

P. 333, line 5 from above, for V. read Viguiera.

P. 343, footnote 3, line 2, for 1888 read 1898.

P. 356, line 8, *dele* American.

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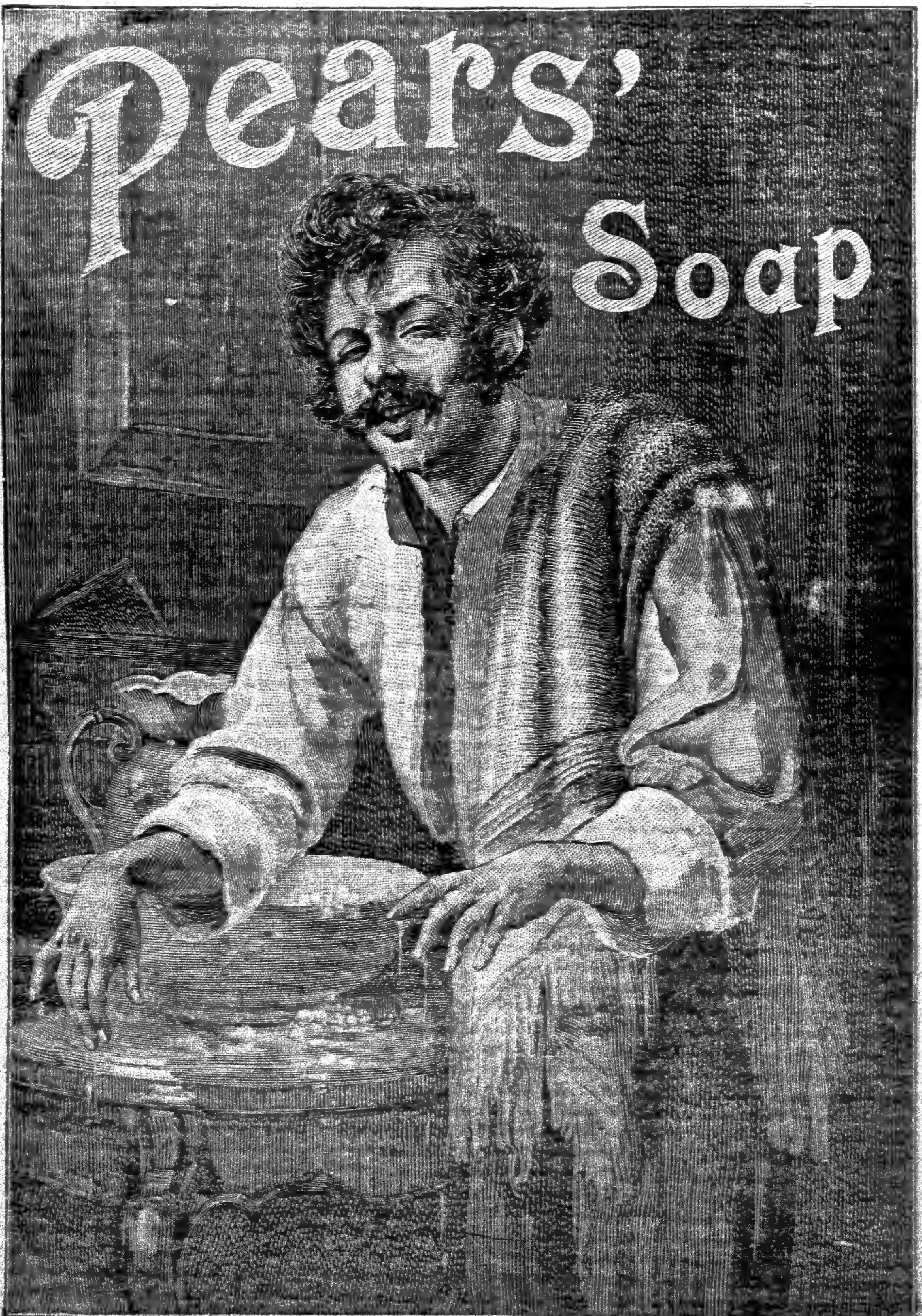
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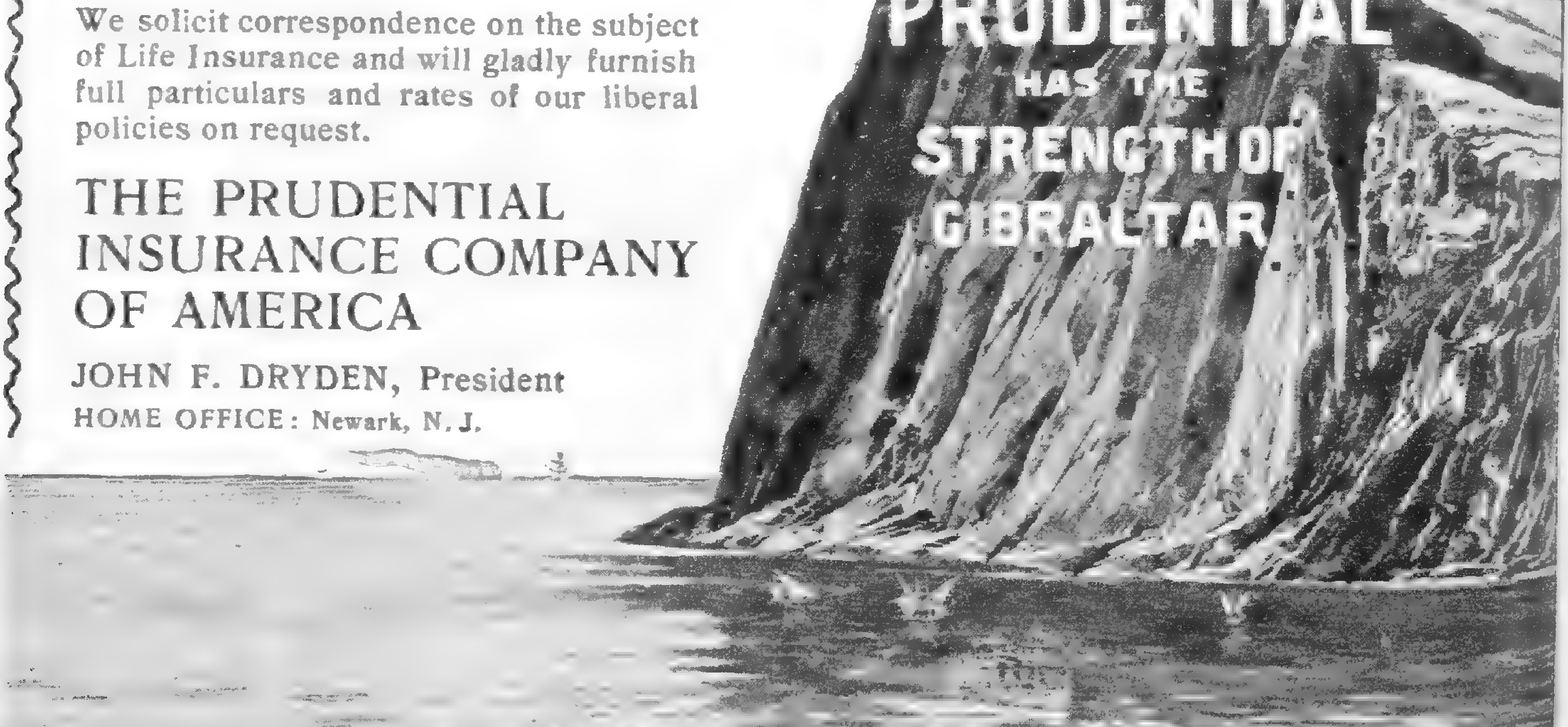
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NEW OR LITTLE KNOWN NORTH AMERICAN TREES. II.

CHARLES S. SARGENT.

Gleditsia Texana, n. sp.—Unarmed. Leaves puberulous, or tomentose toward the base of the slender rachis, ultimately becoming nearly glabrous, 12 to 22-foliolate; leaflets oblong-ovate, often somewhat falcate, rounded or acute, and apiculate at the apex, obliquely rounded at the base, obscurely crenulate-serrate, short-petiolulate, thick and firm, dark green and lustrous on the upper surface, pale on the lower surface, ½ to 1 in. long. Staminate flowers orange-yellow, in slender racemes 3 to 4 in. long; calyx-lobes ovate, acute, villous, rather shorter than the petals; stamens exserted. Pistillate flowers unknown. Legume straight, compressed, without pulp, rounded or short-pointed at the apex, abruptly rounded at the broad base, thin-walled, dark chestnut-brown, puberulous, only slighly thickened on the margins, many-seeded, 4 to 5 in. long and 1 in. wide. Seeds oval, compressed, dark chestnut-brown and lustrous, nearly ½ in. long.

A tree 100 to 120 feet in height, with a trunk rarely more than 2½ feet in diameter covered with pale smooth bark, and upright slightly spreading branches. Flowers at the end of April. Fruit ripens and falls late in the autumn.

High rather dry bottom-lands of the Brazos river near Brazoria, Texas, in dense woods composed principally of *Gleditsia triacanthos*, *Platanus occidentalis*, and *Populus deltoidea.*

First made known from legumes picked up from the ground several years ago by Mr. N. S. Plank, and later by collections made by Mr. B. F. Bush in 1899 and 1900.

Gleditsia Texana is an interesting addition to the North American silva. From *Gleditsia triacanthos*, which it resembles in foliage and in the staminate flowers, it is distinguished by its spineless branches and smoother pale bark. From all other species of the genus it differs in the legume. This resembles those of the many-seeded species, of which *Gleditsia triacanthos* is the type, in its general form and color, and in its numerous seeds. It differs from them in its much smaller size, thin compressed walls with thinner margins, and in the absence of the sweet pulp which surrounds their thicker lighter-colored seeds. It differs in form from the compressed pulpless legume of *Gleditsia aquatica*, and in its more numerous seeds. Like the legume of that species, the legume is frequently seedless.

Known only in a single grove in a comparatively small number of individuals, and sharing something of the character of each of the other American species which both grow near it, the hypothesis of a natural hybrid between those species might be considered, were it not for the fact that the fruit of *Gleditsia triacanthos* is nearly half-grown in this region before the flowers of *Gleditsia Texana* open, while the flowers of *Gleditsia aquatica* do not open until ten or twelve days after those of *Gleditsia Texana* have fallen.

Crataegus Engelmanni, n. sp.—Leaves broadly obovate or rarely elliptical, rounded and often short-pointed at the apex, gradually narrowed below into short glandular pilose petioles, coarsely glandular-serrate with incurved teeth usually only above the middle and generally only at the apex, coriaceous, dark green, lustrous and roughened on the upper surface with short rigid pale hairs, pale on the lower surface, pilose above and below on the slender midribs and on the thin obscure primary veins and veinlets, 1 to 1½ in. long and ½ to 1 in. broad; stipules linear-lanceolate, light red, ⅓ in. long, caducous. Flowers ¾ in. in diameter, in 8 to 12-flowered wide slender-branched cymes thickly coated with long pale hairs; bracts linear-lanceolate, tomentose or villous, often ½ in. long; calyx tomentose, villous or nearly glabrous, the lobes narrow, acuminate, entire, glabrous on the outer surface and usually more or less pubescent on the inner surface, reflexed after anthesis, often deciduous before the ripening of the fruit; stamens ten; filaments slender;

anthers small, rose-color; styles two or three. Fruit globose, about ⅓ in. in diameter, bright orange-red with a yellow cheek and thin dry green flesh; tube of the calyx prominent, the cavity broad in proportion to the size of the fruit, shallow; nutlets two or three, thick, prominently ribbed on the back with high rounded ridges, ¼ in. long.

A tree from 15 to 20 feet in height with a trunk 5 to 6 inches in diameter covered with dark brown scaly bark, wide-spreading usually horizontal branches forming a low flat-topped or a rounded head, and slightly zigzag branchlets marked with large scattered white lenticels, at first clothed with pale hairs, becoming nearly glabrous and reddish-brown during the first season and lighter-colored and gray, or gray tinged with red during their second year, and armed with remote slender straight or slightly curved chestnut-brown spines 1½ to 2½ in. long. Flowers from the end of April (Augusta, Ga.) to the end of May (Missouri). Fruit ripens early in November.

Dry hillsides and slopes, often on limestone; less frequently along the low margins of meadows and roadsides. Kimmswick, Missouri, *Dr. George Engelmann*, May 1860; Pacific, Missouri, *George W. Letterman*, 1881; southern Missouri, *B. F. Bush* (nos. 86 and 19), 1898, 1899; West Nashville, Tennessee, *T. G. Harbison*, May 1899; Tuscaloosa, Alabama, *T. G. Harbison*, May 1899; Gunterville, Alabama, *T. G. Harbison*, June 1899; Rome, Georgia, *C. Boynton*, May 4, 1899; Birmingham, Alabama, *C. Boynton*, January and July 1899; Washington Road near Augusta, *A. Cuthbert* and *C. S. Sargent*, April 1900.

Well distinguished from *Crataegus Crus-galli*, with which for many years it has been confounded, by its smaller thinner leaves roughened above by rigid hairs and pilose on the lower surface, more prominent primary veins and villous or tomentose branchlets and cymes, *Crataegus Crus-galli* in all its forms, as I now understand it, being perfectly glabrous, with veins which, except in the case of leaves on the most vigorous shoots, are usually almost entirely within the parenchyma; by its smaller brighter red and yellow fruit; and by its less numerous and more slender spines.

Crataegus Canbyi, n. sp.—Glabrous. Leaves oblong-oval to ovate or rarely obovate, pointed or occasionally rounded at the apex, cuneate and entire at the base, coarsely and doubly serrate above the middle with glandular incurved teeth, often more or less deeply lobed on vigorous leading shoots with broad acute lobes, coriaceous, dark green and lustrous above, pale and dull below, 2 to 2½ in. long and 1 to 1½ in. wide, or on leading shoots often 3 to 4 in. long and 2 in. broad, the thick midribs and four or five pairs of remote primary veins raised and conspicuous on the lower surface and impressed on the upper surface; petioles stout, grooved and glandular on the upper side with scattered dark red persistent glands, more or less winged above by the decurrent base of the leaf-blades, red below the middle, ½ to ¾ in. long; stipules oblong-obovate to linear-lanceolate, glandular-serrate, ½ in. long. Flowers ⅝ in. in diameter, in loose many-flowered long-branched compound cymes; calyx-lobes narrow, acuminate, serrate with slender teeth tipped with small red glands, nearly entire, reflexed and closely appressed on the fruit, often deciduous before maturity; stamens ten or rarely twelve or thirteen; filaments slender, elongated; anthers small, rose-color; styles three to five. Fruits oblong to subglobose, full and rounded at the ends, depressed at the insertion of the stalks, flesh red, thick, juicy, and succulent, ½ to ⅝ in. long, drooping on the slender elongated peduncles, lustrous dark crimson, punctate with occasional large pale dots; calyx cavity deep and narrow; nutlets three to five, ¼ in. long, light chestnut-brown, prominently ridged on the back with broad rounded ridges.

A bushy much-branched tree 20 to 25 feet in height with a short stout trunk often a foot in diameter covered with dark brown scaly bark; branches stout, erect, wide-spreading, at first dark green and marked with numerous pale raised lenticels, slightly zigzag, soon becoming light orange-brown and lustrous, gray during their second year, and armed with few stout chestnut brown spines varying from ¾ to 1½ in. in length. Flowers the middle of May; the fruit ripens early in October and falls in early winter.

Hedges and thickets near Wilmington, Delaware; Pennsylvania, meadows of Tohickon Creek, Quakertown, *C. D. Fretz*, 1899 and 1900; Tinicum island, Delaware county, *B. H. Smith*, 1900.

To be distinguished from the related *Crataegus Crus-galli* by its oblong usually pointed leaves with veins raised and prominent on the lower surface, by its short infrequent spines, by the habitual appearance of the flowers ten days before those of that species open in the same region, and by the red juicy flesh of the fruit. First noticed in October 1898, by Mr. W. N. Canby of Wilmington, Delaware, who permits the association of his name with this handsome tree.

Crataegus Peoriensis, n. sp.—Leaves obovate, short-pointed or occasionally rounded and sometimes slightly irregularly lobed at the broad apex, gradually narrowed below, sharply and often doubly glandular-serrate usually only above the middle, glabrous with the exception of a few scattered pale hairs near the base of the upper surface of the midribs, thick and firm, with four or five pairs of thin primary veins raised and conspicuous below, deeply impressed above and running very obliquely from the slender midrib to the end of the leaf, dark green and very lustrous on the upper surface, pale on the lower surface, bright bronze color as they unfold, ½ to 2 in. long, ¾ to 1 in. wide, and on vigorous leading shoots frequently a third larger and occasionally laterally lobed; petioles broad, deeply grooved, more or less winged and slightly glandular above the middle, and covered early in the season with short white scattered hairs; stipules glandular, linear-lanceolate, or on vigorous shoots lunate and ½ to 1 in. long. Flowers cup-shaped, ½ in. in diameter when fully expanded, in broad loose slender-stemmed many-flowered corymbs, their bracts and bractlets linear, conspicuously glandular, caducous; calyx glabrous, the cup deep and narrow; calyx-lobes narrow, acuminate, entire or irregularly glandular-serrate with minute stalked dark red glands, pubescent below the middle on the upper surface, spreading nearly at right angles to the cup when the flowers open, persistent on the fruit; stamens ten; filaments elongated, slender; anthers small, rose-color; styles usually two or three. Fruit oblong to obovate, full and rounded at the ends, slightly depressed at the insertion of the peduncle, bright scarlet, ½ to ¾ in. long, with thick nearly white firm flesh; nutlets two, or rarely three, thick, prominently ridged, about ¼ in. long.

A tree 20 or 25 feet in height with a trunk sometimes a foot in diameter covered with dark brown scaly bark, stout spreading branches forming a broad flat-topped head, and slightly zigzag, glabrous branchlets green when they first appear, orange-brown and lustrous during their first season, growing lighter during their second year, and armed with straight or slightly curved very slender dull chestnut-brown spines 2 to 2½ in. long. Flowers from the middle to the end of May. Fruit ripens early in October but when gathered retains its shape and color until December.

In open woods along the moist borders of streams or depressions in the prairie and on hillsides in clay soil. Short and Peoria counties, Illinois, where it was discovered by *Mr. Virginius H. Chase* of Wady Petra, Illinois, September 1897 (nos. 48, 446, 449, 481, 485).

Crataegus pratensis, n. sp.—Leaves obovate-oblong, pointed or rounded at the apex, gradually tapering below and decurrent nearly to the base of the short slender petioles, sharply and often doubly serrate usually only above the middle with teeth tipped with minute dark red caducous glands, more or less deeply divided above into short broad acute lobes, with slender midribs and narrow oblique primary veins deeply impressed on the upper side and raised and prominent below, bright bronze-yellow and coated on both surfaces with short pale hairs when unfolding; at maturity glabrous, thick and firm, dark green and lustrous on the upper surface, pale on the lower surface, ½ to 2 in. long, 1 to 1½ in. broad, and on vigorous shoots often 3 in. long and 2½ in. broad; stipules lunate, stalked, coarsely glandular-serrate, on vigorous shoots often 1 in. in length. Flowers ⅓ in. in diameter, in broad loose thin-branched many-flowered compound pubescent ultimately glabrous cymes; calyx coated on the outer surface with matted white hairs, the cavity deep and narrow; calyx-lobes acute, coarsely glandular-serrate, spreading or more or less reflexed at anthesis, often deciduous from the fruit; stamens ten; filaments slender, elongated; anthers small, rose color; styles two or three. Fruit globose, pendent on the elongated peduncles, bright scarlet, 1/3 in. in diameter, with thin dry yellow flesh; nutlets usually two or three, broad and thick, full and ridged on the back, about 1/4 in. long.

A tree occasionally 20 feet in height, with a trunk 3 to 7 in. in diameter covered with dark brown scaly bark and frequently armed with long slender much-branched ashy gray spines, wide-spreading branches forming a broad round-topped head, slender glabrous branchlets marked with white lenticels, at first green, becoming light chestnut-brown and lustrous during their first summer, and furnished with slender straight or slightly recurved chestnut-brown spines 2 to 2½ in. long. Flowers from the middle to the end of May. Fruit ripens the first of October and falls in November.

Open woods near the banks of small streams in the prairie region of Stark and Peoria counties, Illinois, where it was discovered by *Mr. Virginius H. Chase* in May 1898. Rare and local. Trees which appear to be of the same species were found by *Mr. B. F. Bush* near Swan, Taney county, Missouri, in October 1889; and later by *Professor William Trelease* and myself.

Crataegus submollis, n. sp. (*Crataegus tomentosa* Emerson, Trees Mass. 435. 1846 [not Linnaeus]; ed. 2, 494, *pl.* —. 1875.—*Crataegus coccinea mollis* Brunet, Cat. Vég. Lig. Can. 25. 1867 [in part, not Torrey & Gray]; Watson & Coulter, Gray's Man. ed. 6. 165. 1890 [in part].—*Crataegus subvillosa* Macoun, Cat. Can. Pl. **1**: 147. 1888 [in part, not Torrey].—*Crataegus mollis* Sargent, Silva N. Am. **4**: 99. *pl. 182.* 1892 [in part, not Scheele]; Koehne, Herb. Dendr. 232.—*Crataegus coccinea subvillosa* Lange, Rev. Spec. Gen. Crataegi 31. *fig.* —).—Leaves ovate, acute, cuneate at the base, sharply serrate with gland-tipped teeth, slightly divided above the middle into three or four pairs of acute lobes, membranaceous, pale yellow-green and roughened on the upper surface with short closely appressed rigid hairs, paler and at first coated below with dense hoary tomentum, at maturity puberulous only on the prominent midribs and remote slightly raised veins, 2½ to 4 in. long and 2 to 2½ in. wide; petioles slender, slightly grooved and glandular on the upper side, winged above by the decurrent bases of the leaves, tomentose, often tinged with red below the middle and 1 to 2 in. long; stipules linear-lanceolate or lunate on vigorous shoots, tomentose, glandular-serrate, ½ to ¾ in. long, caducous. Flowers 1 in. in diameter, in broad many-flowered compound tomentose cymes, their bracts and bractlets glandular-serrate with dark glands; calyx tomentose, its cup deep and broad; calyx-lobes acute from a broad base, tomentose, glandular with small stalked persistent red glands, usually wide-spreading at anthesis and persistent, erect and much enlarged on the fruit; stamens ten; filaments slender; anthers small, pale yellow; styles three to five. Fruit pear-shaped with yellow subacid dry flesh, about ¾ in. long, gracefully drooping on the slender elongated puberulous branches of the cymes, bright orange-red, lustrous, marked with occasional pale lenticels, puberulous toward the base; nutlets usually five, rounded and slightly ridged on the back, a third of an inch long. Flowers from the 20th to the end of May. Fruit ripens and falls from the first to the middle of September.

A tree 25 to 30 feet in height with a trunk occasionally a foot in diameter covered with light brown scaly bark, and wide-spreading branches, or often a tall intricately branched shrub, and with branchlets at first green and coated with hoary tomentum, becoming before midsummer dark orange-brown, and during their second year lustrous and pale gray-green to orange-brown, glabrous and very lustrous, slightly zigzag and armed with slender bright chestnut-brown straight or more or less incurved spines 2½ to 3 in. long.

On rich hillsides, along the margins of roads, and sometimes in low moist soil, from the neighborhood of Montreal, *J. G. Jack*, 1899, to Orono and Dover, Maine, *M. L. Fernald*, May 1887, and Aguust 1896; Gerrish island, Maine, *J. G. Jack*, September 1899; and to Jamaica Plain and Milton, Massachusetts.

Confounded by me in the fourth volume of *The Silva of North America*, where it is well figured, with *Crataegus mollis* of Scheele, a common tree from Michigan to Nebraska and Missouri. *Crataegus submollis* differs from that species in its smaller and less deeply lobed cuneate leaves, which are not truncate or cordate even on vigorous leading shoots; in its ten, not twenty, stamens; smaller, less downy fruit on much longer, more slender and drooping peduncles; in its more zigzag orange-colored branchlets, those of *Crataegus mollis* being of a bright chestnut-brown color during the first summer; longer and much more numerous spines; and in its smaller size.

Crataegus dilatata, n. sp.— Leaves ovate from a broad, truncate, cordate, or slightly rounded base, coarsely irregular glandular-serrate, unequally lobed usually with two or three pairs of acute lateral lobes, membranaceous, with slender midribs and four or five pairs of thin primary veins, when the flowers open roughened on the upper surface with short ridged white hairs, light yellow-green, and conspicuously plicate, at maturity dark green, 2 to 2½ in. long, usually as wide as long, and on vigorous leading shoots often 4 to 4½ in. long and usually rather broader than long; petioles slender, terete, glandular, at first more or less villous but soon glabrous, 1 to 1½ in. long, dark red toward the base; stipules linear-lanceolate and on vigorous shoots lunate and foliaceous, glandular with dark red glands, ½ in. long, caducous. Flowers 1 to 1⅛ in. in diameter when expanded, in broad, open, nearly glabrous, villous or tomentose compound cymes, the bracts and bractlets, like the bud-scales, glandular with stalked red glands; calyx villous with soft white deciduous hairs, the cup broad and shallow; calyx-lobes broad, acuminate, coarsely glandular-serrate, much enlarged and spreading on the fruit, and bright red on the upper surface below the middle; stamens 20; filaments slender, elongated; anthers large, rose color; styles usually five, surrounded at the base by small tufts of white hairs. Fruit subglobose with sweet, yellow, thick flesh, ¾ in. in diameter, bright scarlet, punctuate with minute dark spots; nutlets five, comparatively small, prominently ridged on the back, about ¼ in. long.

A tree sometimes 20 feet in height, with a tall straight trunk, wide-spreading branches forming a broad round head, or bushy with numerous spreading stems and slender, glabrous, slightly zigzag branchlets marked with large pale lenticels, at first dark green tinged with red, becoming light chestnut-brown and very lustrous during their first season, dark dull gray in their second year, and armed with stout straight chestnut-brown spines 1 to 2 in. long, or sometimes nearly spineless. Flowers about May 20. Fruit ripens and falls early in September.

Rich hillsides and borders of salt marshes. Revere, Massachusetts, *C. E. Faxon*, May 1884; Somerset, Massachusetts, *Miss L. H. Handy*, May 1899; Ipswich, Massachusetts, *John Robinson*, May 1900; Tiverton, Rhode Island, *C. S. Sargent*, August 1900; Middlebury, Vermont, *Ezra Brainard*, 1900.

It is possible that this is one of the plants cultivated in Europe as *Crataegus coccinea*, but I have not been able to find any trace of it as a garden plant.

CRATAEGUS HOLMESIANA Ashe, Jour. Elisha Mitchell Sci. Soc. **16**^{2}**:** 78. 1900.—Leaves ovate, pointed, rounded, cuneate or on vigorous leading shoots sometimes truncate or cordate at the base, sharply and often irregularly doubly serrate with sharp teeth tipped at first with prominent dark red caducous glands, usually slightly lobed with from three to five pairs of acute lateral lobes, membranaceous, pale yellow-green above, pale and glabrous below, scabrous on the upper surface with short rigid white hairs when the flowers open, at maturity becoming thick, firm, and nearly smooth, 2 to 3 in. long and 2 to 2½ in. wide, with prominent midribs and five or six pairs of stout primary veins deeply impressed above; petioles slender, terete, slightly grooved and glandular on the upper surface with persistent dark glands, and 1 to 1½ in. long; stipules lunate, glandular-serrate, small, caducous. Flowers cup-shaped, ¾ in. in diameter when fully expanded, in loose many-flowered compound glabrous cymes on slender elongated pedicels; calyx narrow, glabrous, tinged with red, its cup broad and shallow; calyx-lobes acute, glandular-serrate or rarely nearly entire, persistent and erect on the fruit; stamens five or occasionally six, seven, or eight; filaments stout, spreading; anthers large, dark purple-red; styles usually three. Fruit pendulous, oblong, crowned with the erect conspicuous calyx-lobes, crimson, lustrous, ½ to ¾ in. long, with thin dry yellow flesh of disagreeable flavor; nutlets prominently ribbed, light chestnut-brown, about ¼ in. long.

A tree occasionally 30 feet in height with a well developed trunk 12 to 15 inches in diameter, covered with pale or nearly white scaly bark, stout upright branches forming an open irregular or more rarely a broad compact head, stout chestnut-brown branchlets and straight usually infrequent spines 1½ to 2 in. long. Flowers from the 5th to the middle of May. Fruit ripens and falls early in September.

From the Province of Quebec, *J. G. Jack*, and Ontario, *D. W. Beadle*, to Maine, Gardner, *Alice M. Richards*, Ellsworth, *Mrs. M. A. Clarke*, North Berwick, *Mrs. John Parlin*, Acworth, *R. Hoffman;* New Hampshire, Holderness, *C. E.* and *W. Faxon*, Haverhill, *E. Faxon*, Troy, *Rand* and *Robinson;* Vermont, Charlotte, *F. H. Horsford*, Ferrisburg and West Addison, *Ezra Brainard*, Bennington, Rutland, North Pownal, and Fairhaven, *W. W. Eggleston*, Rutland, *C. S. Sargent;* Massachusetts, Berlin and West Boylston, *J. G. Jack*, South Lancaster, *C. S. Sargent*, Lanesboro, *C. E. Faxon;* New York, "N. N. Y." in Herb. Gray, without date, Fort Crown Point, *Ezra Brainard*, Rochester, *C. C. Laney;* Rhode Island, Tiverton, *Miss Alice Sargent;* and Pennsylvania, Sellersville, *Dr. C. D. Fretz*.

Crataegus Holmesiana inhabits rich moist hillsides and the borders of streams and swamps, and is always easily recognized by the pale bark of the stem, the distinctly yellow color of the leaves, the small cup-shaped flowers with few stamens, and by the large oblong early fruit. It is very abundant in the upland pastures of Worcester county, Massachusetts, and along the banks of Branch creek at Sellersville, Pennsylvania. It is one of the largest species of New England. I have been unable to discover that this handsome tree, which has probably always been confounded with *Crataegus coccinea*, has ever been an inhabitant of gardens, unless the figure of *Crataegus coccinea*, published in 1835 in the *Botanical Magazine* (*pl. 3434*) was intended to represent this species.

CRATAEGUS COCCINEA Linnaeus.—The name *Crataegus coccinea* was first used by Linnaeus in the first edition of *Species Plantarum* 1: 476. 1753. His description of this species, "*Crataegus* *foliis ovatis repando-angulatis serratis glabris,*" had, however, appeared in 1737 in *Hortus Cliffortianus.* In both works a species of Plukenet (Phyt. Bot. *pl. 46. f. 4*) and a species of Miller (Cat. Pl. Hort. Angl. *pl. 13. f. 1*) were referred by Linnaeus to his *Crataegus coccinea.* Plukenet's plant is preserved in the British Museum. It belongs to the *mollis* group, but the specimen is so meager that I have been unable to identify it. Miller's figure perhaps represents a species of the *mollis* group, but it is certainly not the same plant as the one figured by Plukenet, and I cannot identify it. The only representative of *Crataegus coccinea* in Linnaeus's herbarium, and so labeled by him, is an entirely different plant from either of those represented in Plukenet's or Miller's figures which Linnaeus had referred to his species. Morever, the specimen is not glabrous but villous on the leaves, corymb, and young branches, and the leaves can hardly be described as "*repando-angulatis serratis.*" The Linnaean specimen is not dated, and it is therefore possible that it was not from this specimen but from Plunkenet's or Miller's figure that Linnaeus drew his description of *Crataegus coccinea.* There seems in this case, therefore, but one of two methods to follow in considering this name; either the specimen in Linnaeus's herbarium must be ignored, and the name dropped entirely because it was given to a species founded on two distinct plants, neither of which can be satisfactorily determined; or the specimen in the Linnaean herbarium labeled *Crataegus coccinea* by Linnaeus himself must be accepted as the type of this species. In view of the fact that the name *Crataegus coccinea* is one of the best known of the names which have been applied to American species of the genus, and as the plant labeled *Crataegus coccinea* by Linnaeus is now known to be a common and widely distributed species in the north Atlantic coast region, it is perhaps best to consider the specimen in the Linnaean Herbarium as the type of *Crataegus coccinea,* which can be described as follows:

Crataegus coccinea Linnaeus.—Leaves elliptical or on vigorous shoots mostly semiorbicular, acute or acuminate, divided above the middle into numerous acute coarsely glandular-serrate lobes, cuneate and finely glandular-serrate below the middle and often quite entire toward the base, with slender midribs and remote primary veins arcuate and running to the points of the lobes, at the flowering time membranaceous, coated on the upper surface and along the upper surface of the midribs and veins with short soft white hairs, at maturity thick, coriaceous, dark green and lustrous on the upper surface, paler on the lower surface, glabrous or nearly so, 1½ to 2 in. long and 1 to 1½ in. wide, with slender glandular petioles ¾ to 1 in. long, slightly grooved on the upper surface, often dark red toward the base, and like the young branchlets villous with pale soft hairs; stipules lanceolate to oblanceolate, conspicuously glandular serrate with dark red glands, ½ to ¾ in. long. Flowers ½ to ¾ in. in diameter when fully expanded, in broad many-flowered compound tomentose cymes; bracts and bractlets linear-lanceolate, coarsely glandular-serrate, caducous; calyx tomentose, the lobes lanceolate, glandular-serrate, nearly glabrous or tomentose, persistent, wide-spreading or erect on the fruit, dark red above at the base; stamens ten; anthers yellow; styles three or four. Fruit subglobose, occasionally rather longer than broad, dark crimson, marked with scattered dark dots, about ½ in. in diameter, with thin sweet dry yellow flesh; nutlets three or four, about ¼ in. long, conspicuously ridged on the back with high grooved ridges.

A low bushy tree occasionally 20 feet in height with a short trunk 8 to 10 in. in diameter, or more frequently shrubby and forming wide dense thickets, and with stout more or less zigzag branches bright chestnut-brown and lustrous during their first year, ashy gray during their second season and armed with many stout chestnut-brown straight or curved spines 1 to 1½ in. long. Flowers late in May. Fruit ripens and falls toward the end of October usually after the leaves.

Slopes of hills and the high banks of salt marshes usually in rich well-drained soil, Essex county, Massachusetts, *John Robinson*, 1900; Gerrish island, Maine, *J. G. Jack*, 1899–1900; Brunswick, Maine, *Mrs. Kate Furbish*, May 1899; Newfoundland, *A. C. Waghorne*, 1894.

CRATAEGUS COCCINEA **rotundifolia.**—With *Crataegus coccinea* as described above there often grow in the same thickets plants which differ from it only in the less development of the hairs on the leaves, young branches, and corymbs. Some of these plants are entirely glabrous with the exception of a few short hairs on the upper surface of the young leaves, while others show all degrees of variation in the developement of their villous covering. The synonymy of this form, which cannot be considered more than a variety, is as I understand it as follows:

Crataegus rotundifolia Moench, Bäume Weiss. 29. *pl. 1.* 1785.
Mespilus glandulosa Ehrhart, Beitr. **3**:20. 1788.
Crataegus glandulusa Aiton, Hort. Kew. **2**:168. 1789.
Crataegus horrida Medicus, Gesch. Bot. 1793.
Mespilus rotundifolia Du Roi, Harbk. Baumz, **2**:607. 1795.
Crataegus coccinea Lindley, Bot. Reg. **23**: *pl. 1957.* 1837 (not Linnaeus).
Crataegus coccinea macracantha Sargent, Silva N. Am. **4**:96. 1892, in part, not Lindley.

Crataegus coccinea rotundifolia is one of the commonest New England forms, ranging southward to eastern Pennsylvania, Easton, *T. C. Porter*, 1894, Stroudsburg, *W. M. Canby*, 1900, and Delaware, Fairhurst, *W. M. Canby*, 1900; and westward to the region of the Great Lakes. Its northern and western range, however, is still imperfectly known, as there are evidently some distinct forms of this group which are still confounded with *Crataegus coccinea* and this variety. All the species of the group, which has been curiously overlooked by American botanists, have thick coriaceous dark green and lustrous mature leaves, flowers with ten or nearly twenty stamens and pale yellow anthers, and globose or subglobose scarlet fruit of medium size with three or four nutlets.

Crataegus Jonesae, n. sp. (*Crataegus coccinea macracantha* Rand & Redfield, Fl. Mt. Desert Island 98. 1894, not Dudley).—Leaves elliptical, pointed, cuneate and decurrent at the base, sharply and doubly serrate and usually lobed above the middle with numerous small acute lobes, coriaceous, dark green and lustrous above, pale and puberulous below, especially on the stout midribs and broad remote primary veins, deeply impressed above, 3 to 4 in. long and 2 to 3 in. broad, at first coated above with soft pale caducous hairs and glandular with small dark red deciduous glands on the teeth; petioles stout, more or less broadly winged above, deeply grooved, villous, tinged with red below the middle, frequently twisted at midsummer, thus bringing the lower surface of the leaf-blades to the light, 1½ to 2 in. long; stipules linear-lanceolate, entire or coarsely glandular-serrate, ½ in. long, dark green fading red. Flowers bad-smelling, 1 in. in diameter when fully expanded, in loose lax compound many-flowered long-branched tomentose cymes; calyx tomentose, the cup broad and shallow; calyx-lobes linear-lanceolate, entire, tomentose, elongated, persistent and closely appressed on the fruit; stamens ten; filaments slender, elongated; anthers large, pale rose-color; styles two or usually three. Fruit pendulous in loose clusters, oblong to oblong-obovate, full and rounded at the base, ¾ to 1 in. long, ¾ in. broad, lustrous, bright carmine red, punctate with few dark spots, flesh thick mealy sweet and yellow; nutlets three or rarely two, thick, dark-colored, conspicuously ridged on the back, about seven-sixteenths of an inch long.

A tree occasionally 20 feet in height with a tall trunk a foot in diameter covered with dark brown scaly bark, or in the immediate vicinity of the sea often shrubby with numerous stout spreading stems forming a broad massive bush, and stout wide-spreading or ascending branches zigzag for several years, dark green, tomentose and marked with numerous dark red oblong lenticels when they appear in the spring, becoming dark orange-color and very lustrous in the first season and light gray during their second year, and armed with straight or occasionally curved spines, 2 to 3 inches in length, dark chestnut-brown and lustrous and usually pointed toward the base of the branch. Flowers in early June. Fruit ripens and falls early in October.

Borders of streams, where it grows to its largest size, and the rocky banks of ocean sounds and bays. Now known only in southeastern Maine, where it is distributed from the valley of the Penobscot river to the island of Mt. Desert. Orono, *M. L. Fernald*, May 27, 1887; Somesville, *Rand & Redfield*, June 1889; Somesville, *E. Faxon*, June 1890; *E. L. Rand*, Birch hill, Mt.

Desert island, June 1890, Northeast harbor and Southwest harbor, September 1899; Castine, *C. E. Faxon*, September 1889; Bar harbor, *Miss B. Jones*, June and September 1899.

It is a pleasure to commemorate in this handsome and distinct tree the name of Miss Beatrix Jones, the distinguished landscape-gardener, who first made it possible for me to understand its characters.

Arnold Arboretum,
Jamaica Plain, Mass.

ERIOCAULON DECANGULARE L.; AN ANATOMICAL STUDY.

THEO. HOLM.

(WITH FIVE FIGURES)

IN a paper entitled "Structure de la racine et disposition des radicelles dans les Centrolepidées, Eriocaulées, Joncées, Mayacées, et Xyridées,"[1] Van Tieghem arrives at the conclusion that these orders possess the same peculiarity in regard to the structure of pericambium as do the Gramineæ and Cyperaceæ, and in this they appear to differ from the other orders of monocotyledons. His conclusions in regard to the Gramineæ and Cyperaceæ, however, are mostly based on the observations of Johannes Klinge, which are recorded in his excellent work, "Vergleichend histologische Untersuchung der Gramineen- und Cyperaceen-Wurzeln."[2] It is the structure of the pericambium, Van Tieghem's *péricycle*, which exhibits such marked variation as to seem characteristic of certain orders, at least in some of the species, and the variation consists in its continuity or interruption by the proto-hadrome vessels. Some very instructive tables are contained in Klinge's paper, in which the position of these vessels has been given in relation to the pericambium of a number of species of Gramineæ and Cyperaceæ. From these tables it is seen that in some species all the proto-hadrome vessels are within the pericambium, in others only half of them or only a few, while in still others they are all in direct contact with the endodermis, having thus broken through the pericambium. Van Tieghem describes the same variation in Eriocaulaceæ, etc. Representatives of no less than seven orders of monocotyledons thus exhibit this peculiar structure.

The continuity of the pericambial stratum is considered

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[1] Jour. de Botanique **1** : 305. 1887.

[2] Mém. de l'Acad. Imp. d. sc. d. St. Petersbourg VII. **26** : 12. 1879.

normal, its interruption abnormal. So far, botanists have not ventured to consider these two conditions as anything but specific characters, and if they were really constant they would certainly be of some importance; but my observations have lately shown that they are not to be depended upon as constant in all species. For example, in *Carex hispidula*[3] the pericambium may be interrupted either by all the proto-hadrome vessels or by some of them, while in *C. firma* and *C. supina* this tissue is either continuous or interrupted by the majority of these vessels. These variations were noticed in roots of a single individual, and it is very likely that such irregularities are much more common than is supposed, even in spite of an examination of abundant material. In regard to the Eriocaulaceæ, Van Tieghem describes the root-structure of a few species, and calls special attention to the very regular interruption of the pericambium by all the proto-hadrome vessels in *E. decangulare*, *E. septangulare*, *E. Dregei*, *E. Sellowianum*, and *E. Paraguayense;* while in *E. atratum* and *E. Kunthii* only some of these vessels have broken through the pericambium. Moreover, this author attributes six or eight rays of hadrome to *E. decangulare*, and states that each ray is composed of two vessels, one bordering on endodermis, the other on the central vessel, but separated from it by a layer of conjunctive tissue. Besides Eriocaulon Van Tieghem has described Lachnocaulon,[4] Paepalanthus, and Philodice.

Having observed the irregular disposition of the proto-hadrome in some species of Carex, it seemed well to investigate the matter further, and I have examined the root structure of various other genera, and among them Eriocaulon; and since *E. decangulare* L. exhibits a similar and even more striking variation in its root structure, it was thought worth while to present

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[3] On a collection of Carices from Alaska, with remarks upon the affinities of *Carex circinata* and *C. leiocarpa* C. A. MEY. Am. Jour. Sci. IV. **10**:279. 1900.

[4] Judging from Van Tieghem's description of the root structure in *Lachnocaulon Michauxii* Kth., it appears that his specimens did not belong to this genus, but to Paepalanthus, and evidently *P. flavidulus* Kth. On the other hand, the structure of our North American *Lachnocaulon Michauxii* resembles that which Van Tieghem has ascribed as peculiar to Paepalanthus.

the results. Furthermore, some notes upon the anatomy of the leaf and stem are appended, for it must be remembered that very little has been published heretofore upon the anatomy of Eriocaulon. As stated above, the root structure has been discussed by Van Tieghem, but only in reference to seven species of the genus; and *E. helichrysoides* is the only one which is treated from a general histological point of view by V. A. Poulsen in his anatomical study of the order.[5] Besides these papers there are some few scattered remarks upon the structure of various organs of the genus in the works of DeBary, Russow, and Schwendener. There is thus only one paper in which a general anatomical treatment of the order has been presented, the work by Poulsen cited above. This author, who has studied fifteen species belonging to nine genera, especially Paepalanthus, all from Brazil, deserves credit for having detected several structural peculiarities; and it is a matter for regret that but one species of the large genus Eriocaulon has been examined.

In the present paper some of the anatomical features of *E. decangulare* will be discussed, and attention will be called to such points as do not harmonize with the conclusions of Poulsen and Van Tieghem in reference to this species and others. The material was collected in sphagnum swamps in the vicinity of Washington, D. C. These swamps are wet during the entire season, so that the plants which were studied were not exposed to any drought during the summer months; furthermore, the plants were almost fully exposed to sunlight. Among the plants associated with Eriocaulon may be mentioned: *Fuirena squarrosa, Scleria reticulata, Eleocharis tuberculosa, Rhynchospora alba, R. glomerata, R. cephalantha, Xyris flexuosa, Pogonia ophioglossoides, Drosera rotundifolia, Utricularia subulata, Rhexia Mariana,* and *Asclepias rubra.*

THE ROOT.

The roots of *E. decangulare* studied were all secondary, being developed from the rhizome. Two kinds may be distinguished: some that are quite thick, white, mostly unbranched, and with

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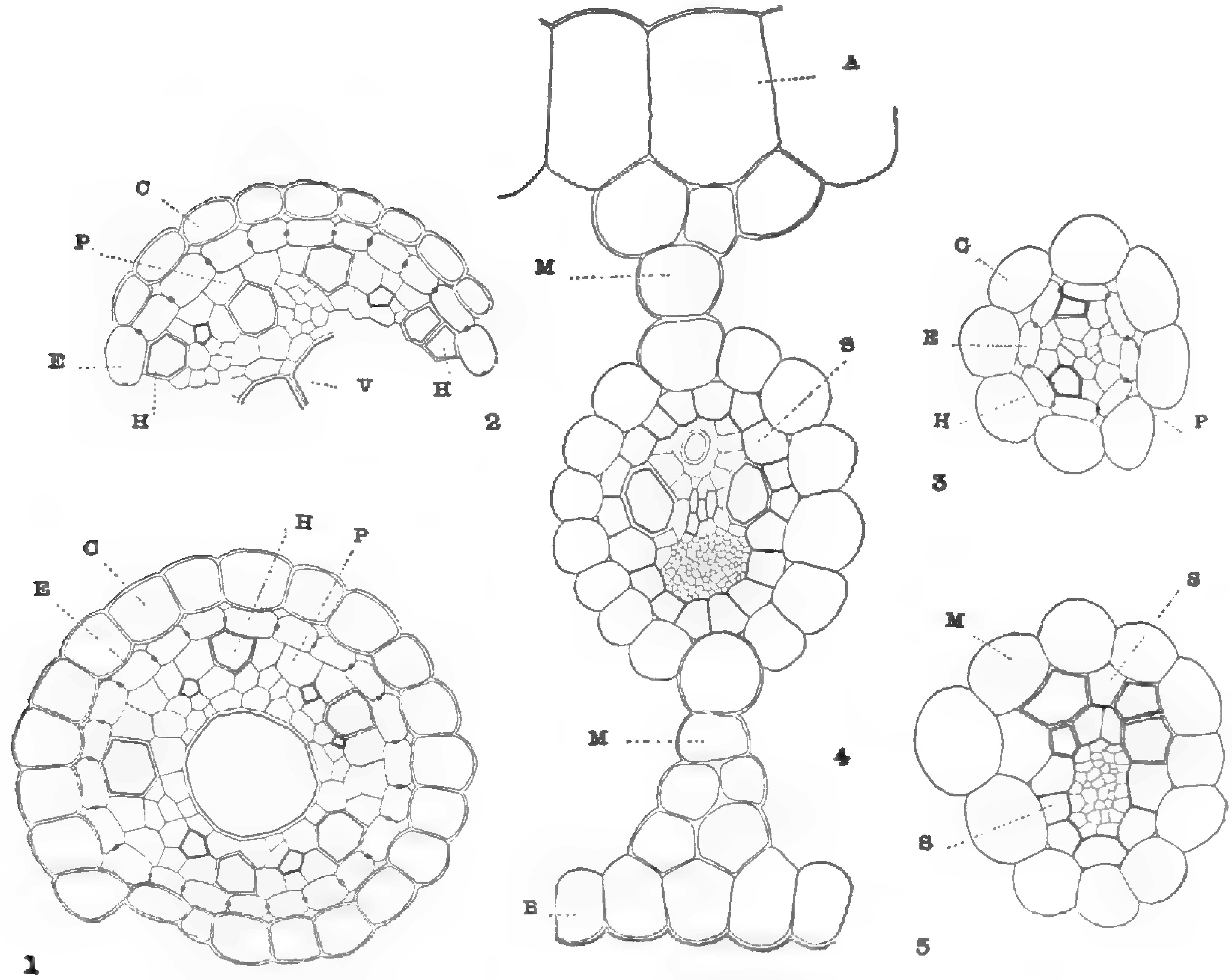
[5] Anatomiske Studier over Eriocaulaceerne. Thesis, Copenhagen. 1888.

few root hairs; and others that are less white, somewhat thinner but decidedly longer, with many lateral rootlets, and amply provided with root hairs. No special arrangement of these two forms was noticed, but the thick ones were perhaps the more abundant. Both forms appeared to have developed in the same year, and I was unable to detect any pronounced difference in their internal structure that might warrant any further distinction than the one observed in their external appearance.

The thick white roots show a very weak structure in general, which seems to imply that they are of short duration, and probably do not last beyond one season. The epidermis is very thin walled, and root hairs are present, but rather scarce. The root hairs observed were all single, not in pairs, as Van Tieghem observed in species of Paepalanthus (Lachnocaulon ?). Poulsen did not find any root hairs at all in *E. helichrysoides*, the specimens of which had perhaps not been lifted with sufficient care. Within the epidermis is a hypodermis of a single stratum, the cells of which are of the same size as those of the epidermis, and are also thin walled. The cortical parenchyma is quite broad, but almost totally collapsed radially, excepting the innermost stratum which borders on the endodermis, and which is often somewhat thick walled in contrast with the other portion of the cortex. There are thus several very wide lacunes in the cortex, and these contain horizontally placed diaphragms composed of star-shaped, thick walled cells, which contain chlorophyll. The lateral roots do not immediately break through the epidermis, but traverse the cortex for some distance downwards before they penetrate the hypodermis and epidermis. A similar course of the lateral roots was observed by Poulsen in *Carpocephalus caulescens* Kth.

The endodermis (*fig. 1, E*) is usually thin walled, and the spots of Caspary are plainly visible. However, in some roots the cell walls of the endodermis are slightly thickened, especially in the basal portion of the root. The pericambium (*figs. 1, 2, P*) is very thin walled, and consists of a single layer, which in no case was observed to be continuous, although a very large number



Theo Holm del.

FIGS. 1–5. ERIOCAULON DECANGULARE L.

FIG. 1. Transverse section of a thick root: *C*, innermost stratum of cortex; *E*, endodermis: *P*, pericambium; *H*, proto-hadrome vessel; the proto-leptome cells are drawn with heavy lines; the drawing shows five proto-hadrome vessels, all bordering on endodermis, and alternating with five groups of leptome; a large vessel occupies the center of the root. × 495.

FIG. 2. Transverse section of a part of a thick root; letters as above; *V*, the two central vessels; one of the proto-hadrome vessels has not broken through the pericambium. × 495.

FIG. 3. Transverse section of a lateral root; letters as above; there are only two proto-hadrome vessels, both of which border on endodermis. × 495.

FIG. 4. Transverse section through a large mestome bundle from the leaf; *A*, epidermis of upper face; *B*, same of lower surface; *M*, the collenchymatic tissue, which surrounds the mestome bundle completely and extends to the epidermis on both faces of the leaf; *S*, the inner sheath, which forms a closed ring around the leptome and hadrome; in the hadrome is a lacune with a ring vessel. × 320.

FIG. 5. Transverse section of a smaller mestome bundle from the leaf; letters as above; the inner sheath (*S*) is interrupted by the vessels. × 495.

of sections were examined. To examine the position of the proto-hadrome in relation to the pericambium, not only were a number of sections taken from roots of various individuals, but also several roots of the same specimen in their entire length from apex to base. The latter method appears to give the most satisfactory results, and is sufficient to demonstrate that neither the position of the proto-hadrome vessels, nor the number of hadromatic rays or of the individual vessels is to be depended upon as a constant character.

A few examples of these structural irregularities are as follows. One of the thick roots possessed at the base eight rays of proto-hadrome, each consisting of a single vessel, five of which had penetrated the pericambium, thus bordering immediately on endodermis. Nearer the apex of the same root the number of rays decreased from eight to seven and to six, five of which had broken through the pericambium, as in the first case. At the apex itself there were only five rays, all of which were bordering on the endodermis; thus the number of interruptions of the pericambium was five in the entire length of this root. In other roots only five rays were found at the base, four of which had broken through the pericambium; and here also there was a similar decrease in number of rays when approaching the apex, where finally all the proto-hadrome vessels bordered on the endodermis. The number of interruptions may vary in the same root, instead of being five, for instance, throughout the entire root; or there may be roots in which all these vessels border on the endodermis, the most frequent condition (*fig. 1*). Van Tieghem ascribes six to eight hadrome rays to this species, each consisting of two vessels, but such regularity in number was not observed in my material. Not only did the number of rays vary, usually decreasing from base to apex, but five was the most common number, each ray consisting of a single proto-hadrome vessel (*fig. 1, H*) instead of two. The largest number of rays observed was eight, but this number, as well as seven, was rather rare, while six or four was not uncommon. While the proto-hadrome vessels were observed as being mostly one in each ray, sometimes two, three, or even four together were observed, either in the same radius or side by side. This multiplication of vessels was found in the same root in which the majority of sections showed only a single vessel in each ray.

In considering the pericambium itself another irregularity in respect to the number of cells between each two proto-hadrome vessels was observed. Two may be found in many roots, and is no doubt the commonest number; three cells were found, however, in the same roots, but seldom four or five. The leptome forms groups which are roundish in transverse section, and the proto-leptome is plainly visible. The central portion of the root was constantly found occupied by one or two wide reticulated vessels, mostly surrounded by a thin walled conjunctive tissue.

The thinner secondary roots show much the same structure as described above, but root hairs abound. The innermost stratum of the cortex is sometimes distinctly thick walled, and the endodermis often exhibits a similar thickening of its walls. These roots show the same irregularities in the structure of the pericambium and the hadrome as described above, and there is also a wide central vessel surrounded by a thin walled conjunctive tissue.

The lateral roots exhibit a very simple structure (*fig. 3*). No hypoderm is developed, the cortex bordering immediately on epidermis, and composed of only two or three strata, the innermost of which persists (*fig. 3, C*), while the others sometimes collapse radially. The endodermis (*fig. 3, E*) is very thin walled, the spots being very plainly visible; and the pericambium is interrupted by the two rays of proto-hadrome, which alternate with two minute groups of leptome. No central vessel was observed. The peculiar course of the lateral roots in the cortical parenchyma before they break through the hypoderm and epidermis has been described, and it might be added that root hairs are absent from the enclosed part of these roots, but are developed as soon as the root became free.

The roots of Eriocaulon may well be classified as simply "nutritive," as has been described by Rimbach,[6] since they possess no pronounced power of resistence, and are not contractile or especially adapted for storage.

THE RHIZOME.

According to Gray's Manual (sixth edition) all our species should be "stemless," but Morong[7] has corrected this and describes for *E. decangulare* a short thick caudex one or two inches in length. This species has a nearly horizontal or ascending rhizome, densely covered by remnants of old leaf bases, with no internodes. The numerous long hairs developed from the epidermis are very characteristic, being pluricellular, the cells in a single row, and the basal cell very short. The cortex is differentiated into two or three subepidermal strata, the cells of which are mostly pentagonal in tranverse section, with distinct but narrow intercellular spaces, and an inner tissue of many layers of nearly roundish thin walled cells containing starch. This portion of the cortex is very open on account of large intercellular spaces, but no lacunes were observed. Within the cortex is an endodermis, the cell walls of which are not thickened and do not show the characteristic spots of Caspary. Nevertheless, the endodermis was readily visible by the peculiar clearness of its cell walls in contrast with the surrounding cortical parenchyma, and by the somewhat irregular shape of the cells. Within the endodermis is a large, solid, fundamental tissue, consisting of somewhat thick walled cells with distinct intercellular spaces, and containing starch. The mestome bundles occur in the cortex and in the fundamental tissue. Those in the latter tissue, being thus within the endodermis, are not arranged in any order, and are mostly bicollateral and perihadromatic, but not always completely so. They are not surrounded by any special sheath, and the vessels are either scalariform and quite narrow or reticulated and wider.

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[6] Beiträge zur Physiologie der Wurzeln. Ber. d. deutsch. Bot. Gesell. **17**: 18. 1899.

[7] Notes on the North American species of Eriocauleæ. Bull. Torr. Bot. Club **18**: 354. 1891.

When the mestome bundles break through the endodermis to the cortical parenchyma, they appear much smaller and are then surrounded by a thin-walled endodermis, showing the same power of resisting concentrated sulfuric acid as does the main endodermis. They are almost regularly arranged in two concentric bands, and are either strictly collateral or more or less bicollateral, in the same manner as those of the fundamental tissue. The general structure of the rhizome, therefore, does not differ from that of other monocotyledonous plants, with the exception of the development of the epidermis into long hairs, which is known in a very few other orders. The mestome bundles of Eriocaulon being collateral or more or less completely perihadromatic do not differ from those of rhizomes of most of the other monocotyledonous orders. Attention may be called, however, to a very peculiar structure which Poulsen discovered in the rhizome and stem of *Actinocephalus polyanthus* Kth. (Eriocaulaceæ), and which may be found in some of the other genera. The mestome bundles exhibit a form very unusual among the phanerogams, in being perileptomatic in the cortex and exohadromatic in the fundamental tissue; in the latter the perihadromatic bundles are surrounded by a tissue which is suggestive of leptome, and around this again is a band of vessels, each mestome bundle consisting thus of a central group of leptome surrounded by two bands of hadrome separated from each other by a band of apparently leptomatic tissue.

THE SCAPE.

The inflorescence, a capitulum, is borne at the apex of a long, slender, solid and twisted scape, which is distinctly furrowed and consists of only one internode with a single leaf, the long tubular sheath of which surrounds the scape to about its middle. In a transverse section of the free part of the scape, there is shown an epidermis of roundish cells, covered by a thin, smooth cuticle. The size of the cells varies somewhat, and the largest are observable in the furrows, where they cover the green cortex. Stomata and hairs are present and exhibit the same structure as in the leaves, under which they will be described. Underneath the epidermis is either a chlorophyll bearing cortical parenchyma (in the furrows) or a mechanical tissue (in the ridges). The former in our species occurs in nearly rectangular groups in transverse section, separated from one another by the mechanical tissue. There is but one stratum of palisade cells, directly beneath the stomatiferous epidermis; while the other part of the green cortex consists of loosely connected cells of irregular shape and with very wide air spaces. No proper lacunes are developed in the cortex, nor are there any such diaphragms as in the leaves.

The mechanical tissue constitutes quite a prominent portion of the stem section. It is this tissue which forms the eight ridges, and it extends inwards to the mestome bundles, which it surrounds as a closed ring, and also occurs as a few layers on the hadrome side of the mestome bundles. A close examination of this tissue, however, shows that even if it may be designated as "mechanical" throughout, it nevertheless represents two distinct kinds of tissues, collenchymatic and stereomatic, both somewhat modified in our species. The collenchymatic tissue reaches its highest development in the ridges of the scape, just beneath the epidermis. It appears there composed of distinctly thickened cells, but roundish in cross section and with plainly visible intercellular spaces; viewed in longitudinal sections these cells are rectangular and quite long. As mentioned above, this tissue extends inwards between the groups of green cortex to the mestome bundles, and occurs here as a closed ring of two or three strata. I have been unable to discover any distinction between the strata which surround the band of mestome bundles and those which form the ridges. The thickening of the cell walls is of course most pronounced in the ridges, and especially near the epidermis, but if the tissue is followed inwards to the mestome bundles the thickness decreases very gradually, and the shape of the cells remains the same in both longitudinal and transverse sections. The term "collenchymatic," as suggested by Schwendener for this special tissue in

Eriocaulon, seems more suitable than "stereomatic"; moreover, it appears that it attains a still further development in other genera of the order, where it sometimes resembles true collenchyma much more than in our species.

The second form of mechanical tissue in the scape so much resembles stereome in its structure that it may be considered as stereomatic, but not as stereome proper. This tissue is but sparingly developed, and occurs only in one or two strata covering the leptome of the bundles within the collenchymatic ribs, and as a few cells on the hadrome side of these same bundles. The lumen of these stereomatic cells is much narrower than in any portion of the collenchyma; moreover, the cells are longer and the cross walls are almost oblique. In no instance, however, did I observe this stereomatic tissue form a sheath around the mestome bundles; it seems to be restricted to a few strata on either face, separated from one another by the large vessels on the sides of the bundles. The small mestome bundles which are located within the chlorophyll bearing cortex are destitute of such stereomatic support. It would thus appear as if the mestome bundles are merely surrounded by continuous strata of collenchyma which only differs from that in the ridges in being less thick walled; and there is no indication of such structural peculiarities as might lead to a separation of it into two tissues, as a collenchymatic and an endodermal. The cells showed exactly the same shape and size all around the central cylinder, and in no place were the spots of Caspary, or any special arrangement usually noticeable in an endodermis, observed. However, when the sections were placed in concentrated sulfuric acid, a true endodermis became at once plainly visible. The collenchyma was rapidly destroyed, while a continuous ring of a single stratum of cells persisted for some time surrounding the mestome bundles and bordering on the leptome, but separated from it by the few strata of stereomatic tissue. The scape thus possesses an endodermis of the same structure as that observed in the rhizome.

It has been stated already that the mestome bundles occur of two sizes, both constituting a single band, the larger situated in the same radius as the collenchymatic ridges, the smaller in alternation with them within the cortex. The leptome forms quite a large oval or roundish group in both kinds of bundles, all of which are collateral; and the hadrome is composed of very wide reticulated vessels which form a continuous arch in the smaller bundles, sometimes in the shape of a V. In the larger mestome bundles the arch is less complete, and here a small lacune with remains of an annular vessel was observed. This structure of the mestome bundles suggests what is known among other orders of monocotyledons, especially the larger ones. Finally, the pith, which occupies the inner portion of the central cyclinder, is solid, not hollow, but the cell walls are very thin, and no deposits were observed.

The base and apex of the scape show the same arrangement and relative development of the various tissues, but no stomata or hairs were observed on the part enclosed by the tubular leaf sheath. It might be stated, also, that although the mestome bundles were noticed to be strictly collateral in a large number of sections, one instance was found in which a few (three) narrow scalariform vessels were situated outside the leptome, this mestome bundle being thus approximately perihadromatic. It was only in one bundle, however, and very near the inflorescence. The structure of the bundles, therefore, does not seem to be invariably identical throughout the whole length of the stem. It must be remembered, also, that in the rhizome the bicollateral bundles within the endodermis pass gradually over into collateral when they enter the cortical parenchyma, whence they proceed to the leaves, in which they are constantly and strictly collateral.

THE LEAF.

The proper leaves are linear, nearly flat or with the margins somewhat involute, and have no sheath. They form a dense rosette at the apex of the rhizome, and in their axils the flower bearing scapes develop on very short one leaved shoots, while the terminal bud of the rhizome itself is purely vegetative. In contrast with the proper leaf, the leaf of the floral shoot has a long tubular sheath and a very short blade, and this leaf is by some authors considered as representing the prophyllum of the floral shoot. No other leaf is developed on this shoot, but its true position in relation to the mother axis cannot be ascertained, since the scape becomes twisted during its growth and forces the leaf away from its natural position. Thus the little blade may sometimes turn to the side or to the front, instead of turning its dorsal face towards the main axis, as is the normal position of such a prophyllum. As will be shown later, the structure of this leaf is very different from that of prophylla as a rule, though some analogous cases do exist in other orders, where a similarly developed leaf unquestionably represents a true prophyllum. Attention might be called especially to the clado-prophyllum in the inflorescence of certain Cyperaceæ, as for example, *Scirpus silvaticus*, *S. polyphyllus*, *Cyperus phymatodes*, *C. strigosus*, and many others. So far, there is no very strong objection to considering the leaf of Eriocaulon as a prophyllum, even if its position cannot be determined accurately. There is no very pronounced difference between these two kinds of leaves, but they will be treated separately in order that the view of their general structure may be made as distinct as possible.

The proper leaf, in sections taken from the middle of the blade, shows a large celled epidermis on both surfaces, especially on the upper. There is a thin, but visible cuticle, which shows minute wrinklings on the lower surface, but is smooth on the upper. None of the epidermal cells are arranged so as to form longitudinal rows of bulliform cells, such as are so well known in many genera of Cyperaceæ and Gramineæ, where they especially abound above the keel of the blade or between some of the larger mestome bundles. The cells in Eriocaulon are very large on the upper face, but decrease very gradually in size from the middle towards the margin, the outermost part of which is composed only of the two strata of epidermis corresponding to the two leaf surfaces. Viewed *en face* the radial cell walls are perfectly straight on both surfaces, and the outer cell wall of the dorsal epidermis is somewhat thicker than the others. The inner wall may sometimes show a peculiar bend inwards, the lumen of the cell thus becoming diminished, while at the same time a wide air space is formed beneath the cell. This case was noticed only on the lower face of the blade, and Poulsen found a similar structure, but much further developed, in the leaves of Dimeranthus and Actinocephalus. While hairs are present on both faces of the blade, stomata are restricted to the lower surface. The hairs are small and much shorter than those on the rhizome, consisting of but three cells, the terminal one being the longest. They are closely appressed to the leaf blade and point towards its apex. This form of hair was also observed by Poulsen in *E. helichrysoides*, and its early stage of development is represented in his *pl. 5, figs. 2–4.*

The stomata occur only on the lower surface, outside the mesophyll, and possess very narrow guard cells and subsidiary cells, both of which, especially the former, are raised a little above the surrounding epidermis.

The mesophyll in our species constitutes a very uniform structure throughout, and the leaf in this respect may be considered isolateral. There is no continuous layer of palisade cells on the upper face, but the tissue consists of a single stratum, only some of the cells of which represent true palisade. Most of the other cells are roundish and very loosely connected with one another. On the lower face the cells of the mesophyll show a similar roundish form, but the intercellular spaces are not so wide as on the upper face. A like structure is represented by the mesophyll around the mestome bundles, where it is also composed of a single stratum bordering on the mechanical tissue. The inner portion of the mesophyll is broken down into wide lacunes, one between each two mestome bundles, in which are found numerous diaphragms of star shaped, chlorophyll bearing cells, exhibiting much the same structure as those in the root.

Attention has been called, in connection with the stem, to the difficulty in designating the proper term for the mechanical tissue as it is developed in Eriocaulon; and the same is true in regard to it in the leaf, where there is to be observed collenchyma and another form of tissue which superficially resembles stereome, but which shows such strange occurrence and development that it is not even to be considered as a modification of this tissue. The collenchyma in the leaf is thinner walled than in the stem, and accompanies the mestome bundles mostly as hypodermal groups on both faces. It appears to be more strongly developed on the lower face than on the upper, but each group is composed of only three or four layers of these cells (*fig. 4, M*). Around each mestome bundle is a sheath, which at first glance was considered identical with the parenchyma sheath (*fig. 5, M*), as seen in many genera of other orders. A longitudinal section, however, showed a structure very unlike that of a typical parenchyma sheath. The cells were relatively very long, and I was unable to separate them from the adjoining cells of the collenchyma, inasmuch as they both showed the same rapid dissolution when treated with concentrated sulfuric acid. It is somewhat strange, also, that no trace of this outer sheath was found in the stem, a fact which seems to be in favor of the supposition that it is not identical with a true parenchyma sheath. When such sheaths are developed, they seem to follow the mestome bundles not only in the leaves but also in the stem, at least in those which are in the cortex, but not in the pith.

An examination of one of the large mestome bundles (*fig. 4*) reveals the fact that still another sheath (*S*) occurs within the first. This is distinctly thicker walled than the outer, the cells are very much smaller, and the walls are very bright yellow in contrast with the surrounding collenchyma. In longitudinal section the cells of this inner sheath are quite long, with mostly horizontal cross walls. A study of its occurrence throughout the leaf has assured me that it does not show the same development in all the mestome bundles. In smaller bundles the sheath is a mere arch on the leptome side, while the vessels border immediately on the outer collenchymatic sheath. In the larger mestome bundles there is the same arch on the leptome side, besides one (*fig. 5*, *S*), or sometimes two or three cells on the hadrome side, between the large vessels. Selecting one of the largest bundles in the leaf, the sheath appears as a closed continuous sheath (*fig. 4*, *S*) all around the leptome and hadrome. It seems characteristic of this inner sheath to show interruptions in the small mestome bundles, and to become confined in the leptome alone in the smaller of them. I regret that I was unable to decide whether the inner sheath is also developed in the smallest of the mestome bundles, the anastomoses. The tissues are so little differentiated in these that it seemed impossible to decide whether the sheath was present or not; the outer one, however, was plainly visible. So far there would be no valid objection to considering the inner sheath as identical with a mestome sheath,[8] which, in several Gramineæ, exhibits the same kind of interruptions in the various forms of mestome bundles. However, there are two reasons for feeling uncertain about its identity. It is absent in the mestome bundles of the scape, where two or three strata of stereomatic tissue have taken its place within a true endodermis, and in longitudinal section the cells differ in a marked degree from those of a mestome sheath, being very long, with almost horizontal cross walls. Moreover, the thickening of the inner cell wall does not show the same structure as in typical mestome sheaths, where this wall almost constantly exhibits a conspicuous thickening in contrast to the outer wall. When treated with concentrated sulfuric acid, however, the sheath in Eriocaulon showed the same resistance as in the endodermal sheaths in the mestome bundles in the cortex of the rhizome. If the outer sheath represents a parenchyma sheath, one might feel justified in considering the inner as a somewhat modified mestome sheath; but since it does not seem possible to separate the outer sheath from the collenchyma, I can at present suggest no other term for the inner one than simply a protective sheath.

Poulsen attributes two sheaths to the mestome bundles in the

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[8] SCHWENDENER, S.: Die Mestomscheiden der Gramineenblätter. Sitzungsber. K. Acad. Berlin 405. 1890.

leaves of the genera which he examined, and, in accordance with his opinion, the outer sheath would represent true parenchyma, the inner sclerenchyma. He saw, however, that the so-called sclerenchyma does not show the same development in all the bundles, but he makes no allusion to its possible identity with a mestome sheath. The outer sheath is only described as being composed of thin walled cells "stretched longitudinally," which does not seem to indicate that a true parenchyma sheath was observed. The testing of these sheaths with sulfuric acid seems to have been omitted.

The mestome bundles of the leaf are almost parallel from the base to near the apex, where they unite and form an apparently single bundle. When viewed superficially the nerves might appear without anastomoses, since the numerous diaphragms filled with chlorophyll make the inner portion of the leaf very indistinct. When the blade is divided into halves the anastomoses may be seen, not at all infrequent, connecting the larger nerves at more or less acute angles. In this way anastomoses become plainly visible even without any further treatment with potassium hydrate, and they are often seen in transverse sections. It seems very surprising that Poulsen did not notice them in any of the fifteen species which he examined, and that he points out the absence of anastomoses as one of the principal characteristics of the order. It may be that they are not developed in any of these fifteen species, but they are certainly very plainly visible in *E. decangulare*, and I have found them also in *E. gnaphalodes* and in *Lachnocaulon Michauxii*.

The structure of the main nerves is very uniform. None of the mestome bundles near the middle of the blade are of any considerable size when compared with others, and it might be said that the leaf has no midrib. It has already been stated that some of the nerves are smaller than others, and that a corresponding variation in regard to the development of the inner sheath is noticeable. However, the hadrome and leptome are common to all the main nerves, but are naturally larger in the thicker mestome bundles than in the thinner. The leptome shows the same structure as in other orders, for example Cyperaceæ, Gramineæ, etc. The hadrome shows several relatively wide vessels (reticulated) besides a lacune, in which there occurs a ring vessel. The arrangement of the vessels is the same as in Gramineæ, etc., and in no instance was there seen the V-shaped hadrome as in the scape. The very smallest of the mestome bundles exhibit both leptome and hadrome in two well differentiated groups, and several narrow vessels are developed in them, bordering immediately on the collenchyma, while the leptome has an arch-shaped support of an inner sheath, constantly incomplete in such small bundles.

The base of the leaf differs but slightly in structure from the middle of the blade. The lacunes are wider, the mesophyll is more irregular, and no palisades were observed; furthermore, the inner sheath of the mestome bundles is somewhat more thickened, but shows otherwise the same kind of interruptions in the small bundles. The epidermis does not seem to have become modified in any respect, and both hairs and stomata occur. The structure of the apex, however, is very different. The epidermis is unchanged, but the mesophyll presents a solid palisade tissue in three layers on the lower face, while the upper one consists of more roundish cells with narrow intercellular spaces; the mestome bundles are fused together into one oval group surrounded by a sheath of thin-walled cells, which evidently corresponds to the outer one, the collenchymatic; and it may be added also that in the apex this sheath is not able to resist sulfuric acid. There is thus a single group of mestome in the apex, and the leptome seems much reduced, while the hadrome occupies a broad space and contains many very wide vessels, especially reticulated. This single mestome bundle is not supported by any hypodermal mechanical tissue or by an inner sheath, as farther down the blade.

THE PROPHYLLUM.

The prophyllum consists of a very long tubular sheath and a short free blade, in both of which there is much the same structure as in the proper leaf. The tubular portion, however possesses an epidermis of several (three) layers on its morphologically ventral face, and this epidermal tissue is homogeneous in structure, the cells being of the same size and shape throughout. The dorsal epidermis consists of only one stratum, and the cells are about the same size as those of the ventral epidermis. The mesophyll is very open on account of wide lacunes, as in the proper leaf. The mechanical tissue is developed further in the prophyllum than in the other leaves in having larger groups on the dorsal face and in being distinctly thick walled, almost like collenchyma. The mestome bundles are surrounded by this tissue, and also by the inner sheath, which is much less differentiated, however, in this leaf, being totally absent in the smallest bundles. Furthermore, a somewhat weaker development of the hadrome and leptome is to be seen in this portion of the prophyllum. It may be stated that the structure of the collenchyma was plainly followed to several of the cells of the outer sheath; thus there seems little doubt that this sheath actually represents a part of the mechanical tissue itself, instead of being a specially developed parenchyma sheath.

The little blade resembles very much that of the proper leaf, in regard to the epidermis with its hairs and stomata, and the mesophyll with its lacunes; while the collenchyma is separated from the dorsal epidermis by strata of small palisade cells. There is the same distinct thickening of the collenchyma, and very plainly so where it surrounds the nerves; the inner sheath is but very incompletely developed in this portion of the leaf. The mestome bundles are almost orbicular in transverse section, and exhibit the same difference in relative size as described above; and finally anastomoses more frequently occur in the prophyllum from apex to base. Thus the inner sheath is present also in the mestome bundles of the prophyllum, though less completely developed; and the same result was obtained as before when treating the sections with concentrated sulfuric acid, that is, the outer sheath dissolved at once, together with the adjoining cells of the collenchyma, from which it must be considered as inseparable, while the inner sheath showed some resistance wherever it occurred.

CONCLUSIONS.

In comparing the general structure of *E. decangulare* with that of *E. helichrysoides*, as described by Poulsen, there seem to be certain peculiarities in common which may be characteristic of the order, inasmuch as they have also been observed in some of the other genera. The presence of collenchyma is one of these, although this tissue should not be considered so rare in monocotyledonous orders as Poulsen claims it to be. It is common, for instance, among the Gramineæ, where it is well developed in the nodes; it is also found in the small "pulvini" which occur at the base of the lateral branches in paniculate inflorescences of a number of genera. Moreover, in the Cyperaceæ collenchyma occurs in the basal portion of both rachis and prophyllum in certain species of Cyperus of the subgenera Eucyperus, Diclidium, and Mariscus; besides in such species of Scirpus as possess a large open inflorescence (*S. atrovirens*, *S. polyphyllus*, and others). A still more advanced development of this tissue may be observed in Commelinaceæ, Smilaceæ, and Dioscoreaceæ. It does not seem, therefore, as if this tissue exists only in "a very few monocotyledons." But it seems characteristic of the Eriocaulaceæ examined that the collenchyma, or to be more exact "collenchymatic tissue," occurs as prominent ridges in the stem, that it replaces the stereome in the leaves, and that it surrounds the mestome bundles as a closed sheath. The inner mechanical sheath, noted in the leaves, appears to have several points in common with the mestome sheath of the Gramineæ, yet it does not seem to be identical with this, and perhaps may be characteristic of Eriocaulon. The hairy rhizome constitutes an excellent character of the order, even if a few instances are known in other orders of hairs on underground stems, viz., Corallorhiza, Scheuchzeria, and Mercurialis. Otherwise the structure of Eriocaulon does not differ so very much from that of certain other orders, as Cyperaceæ and Juncaceæ, in which a similar leaf structure is provided with a uniform large celled epidermis (Kyllingia, Cyperus, Fimbristylis, etc.). Also, the structure of the rhizome and roots is not to be separated from that of a number of Gramineæ, Cyperaceæ, etc. The most peculiar structure is exhibited by the scape, not only in the presence of collenchymatic ridges, but also in the mestome bundles surrounded by a common endodermis.

But neither the order nor even the genus can be characterized especially by absence of anastomoses in the leaves, since both occur in Eriocaulon and Lachnocaulon; and the continuity of interruption of the pericambium by the proto-hadrome vessels in the root is not of any importance as a family character, as it is not constant, at least in *E. decangulare*.

It appears, therefore, as if Eriocaulon and its allies possess some characters in common with other monocotyledonous orders, and a few which seem peculiar to themselves. The singular inflorescence which is unique among the monocotyledons, and the floral structure, together with the peculiar habit of these plants, make them very distinct among the other orders, to none of which they make any special approach, not even in respect to their morphological characters.

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PHYSIOLOGICAL STUDIES WITH REFERENCE TO THE GERMINATION OF CERTAIN FUNGOUS SPORES.

B. M. DUGGAR.

INTRODUCTORY AND HISTORICAL.

THIS study was entered upon with the view of ascertaining somewhat more definitely than previous researches have indicated what may be some of the special factors which influence germination. As particular lines of inquiry the following may be mentioned as suggestive. In how far does there exist in the spores of fungi an essential physiological difference, whereby some may germinate by the mere absorption of water, while others may require for this germination a food supply from without? Where a food supply is required, does germination require a perfect food or a particular food? May a chemical irritant, or poison, which is not primarily a food substance, thus function as a stimulus? Is it possible by mechanical means, or by a change of conditions, to furnish the necessary stimulus for germination? Considering the broad field thus suggested, it has yet been possible to study but a very limited number of fungi. Moreover, there are numerous minor questions which must be considered in a subsidiary way.

Using the term germination in its broadest sense, it may be well at the outset to notice some of the conditions of food supply or stimulation characterizing germination in general. As a rule, the seed of the phanerogam requires for germination only water, along with suitable conditions of temperature and requisite oxygen supply. Not even does the force of imbibition of the seed coats have any special action in inciting to activity the dormant faculties. In about a dozen plants upon which I have experimented, the uninvested embryo, that is, entirely free from integuments or externally stored food material, is capable of manifesting the first stages of germination in distilled water.

A few phanerogams which have become adapted to a peculiar environment may require a stimulus of this environment. Koch[1] and Heinricher[2] have shown that seeds of Orobanchaceæ germinate only with the presence of a host plant. Heinricher found that the seed usually germinates in spring or autumn, in periods of greatest humidity. He states that the germination of the seed is indirectly a partial indicator of the health of the host — a substance excreted by the latter being evidently the source of the stimulus. What may be the nature of this attractive substance has not been determined. On the other hand, seeds of Rhinanthus seem to germinate without such stimulus.

According to Wiesner[3] the seeds of *Viscum album* are known to germinate only in light, and although apparently mature in autumn, they are not to be forced to germination until the following spring. The same was found true of *Loranthus Europaeus;* and, although light is required for germination, the most favorable conditions of the tropical climate of Buitenzorg could not induce this activity without the intervention of the resting period. Wiesner then surmised that the factors concerned are the gradual availability of the reserve food, a phylogenetic light influence, and the effect of the viscous substance of the integuments. If there are other phanerogams growing in peculiar situations for which a particular stimulus is necessary for germination, the matter seems to await study. We cannot appropriately include in this place seeds of some Rosaceae, for example, which germinate better after passing through the digestive tract of birds, or after artificial treatment with acids.

The germination of pollen has been very much studied, and it is surprising that this has yielded so little of special interest relative to particular or peculiar stimuli. It is of special

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[1] KOCH, L.: Die Entwickelungsgeschichte der Orobanchen 119. 1887. Heidelberg.

[2] HEINRICHER, E.: Die Keimung von Lathrea. Ber. d. deut. bot. Gesells. **12**: 117–132. 1894.

[3] WIESNER, J.: Vergleichende physiologische Studien über die Keimung europäischer und tropischer Arten von Viscum und Loranthus. Sitzb. d. kaisl. Akad. d. Wissenschaften zu Wien **103**: 423–437. 1894.

significance that the pollen of so many species of plants germinate either in sugar solution or in water. According to Molisch[4] many forms germinate best in about 10 per cent. sugar solution, and concentrations of from 15 to 40 per cent. are often required. This might suggest an osmotic stimulus. Nevertheless, there are many forms germinating well in water, and for other forms perhaps the idea of a special stimulus should be further applied to a study of pollen. Molisch indeed found minute quantities of malic acid a stimulus to the germination of Ericaceae; but, in general, my results indicate that it is only a stronger stimulus than pure water, not equal to sugar, for example.

Lidforss[5] has recently made extensive studies with pollen germination in "pure water," and among many plants whose pollen is so adapted may be mentioned Orchidaceae, Salicaceae, and many Liliaceae, Geraniaceae, etc. Following in the path of still earlier workers along that line, Borodin[6] clearly indicated that light has a stimulating effect for the germination of fern spores. Kny[7] and others further determined the necessity of this factor. Heald[8] has more recently shown that this stimulus may find a substitute in high temperatures; and apparently he has also cleared up some previous inconsistencies. In the same paper, Heald has demonstrated the necessity of light for the germination of moss spores. In a nutrient solution containing peptone or sugar, on the other hand, good germination resulted in darkness; and higher temperatures alone had no stimulating

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[4] MOLISCH, H.: Zur Physiologie des Pollens mit besonderer Rücksicht auf die chemotropischen Bewegungen der Pollenschläuche. Sitzb. d. kaisl. Akad. d. Wissenschaften zu Wien **102**^{1}: 423-427. 1893.

[5] LIDFORSS, B.: Weitere Beiträge zur Biologie des Pollens. Jahrb. f. wiss. Bot. **32**; 237-312. 1899.

[6] BORODIN, —: Bull. de l'Acad. imp. de St. Petersbourg: 433-440 1867. (ref. Heald, l. c.).

[7] KNY, L.: Beiträge zur Entwickelunsgeschichte der Farnkräuter. Jahr. f. wiss. Bot. **8**: 1-15. 1877.

[8] HEALD, F. DE F.: Gametophytic regeneration exhibited by mosses and conditions for the germination of cryptogam spores. Inaugural-Dissertation. Leipzig, 1897.

influence, as likewise small quantities of poisonous substances. The further interesting fact was disclosed that the effect of light is not one of photosynthesis. Equisetum spores, moreover according to Sadebeck,[9] germinate well either in light or in darkness.

Notwithstanding the excellent culture methods for the fungi, a study of germination in relation to the stimuli involved has been largely a matter of incidental consideration. A study of growth phenomena, thermal limitations of growth, toxic effect, etc., have furnished some data relative to the stimulus of particular substances. It seems, however, that no summation of the results has been made since the work of DeBary.[10]

METHODS.

The most convenient method of observing spore germination is undoubtedly the hanging drop-culture. The principal points to be considered in properly handling the drop-culture, or Van Tieghem cell, where nutrient media are employed, have been recently set forth clearly by Clark.[11] These notes bear repetition to a certain extent. The employment of large rings is desirable, and they should be cemented to the glass slips by a mixture of refined beeswax and pure vaseline. The cover should be cemented to the ring with vaseline. The same character of liquid should be used at the bottom of the cell as employed in the drop.

While the form of cell culture above described is highly accurate for culturable forms in nutrient media, it is by no means accurate in all other cases. When a careful study is to be made of particular stimulants in water, or in a medium not ordinarily causing abundant germination, and the like, recourse should be had to a different method. My experience has been that the

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[9] SADEBECK, R.: Ueber die Entwickelungsgeschichte d. Prothallien u. s. w. der Schachtelhalme. Sitzungsber. d. Versammlung deutscher Naturforscher u. Aerzte zur Hamburg, 1876.

[10] DEBARY, A.: Morphologie und Biologie der Pilze, 376–377. 1884.

[11] CLARK, J. F.: Dissociation and toxic effect. Journal of Physical Chemistry 3: 263–316. 1899.

results may be untrustworthy if any volatile or soluble substance besides the medium employed is used in connection with the cultures. As subsequently mentioned, even the purest vaseline may have an effect on sensitive forms. In all cell cultures in which full nutrient media were not employed, I have used a modified method. The cells were used in small Petri dishes. On the bottom of the Petri dish was placed filter paper with holes made for the insertion of the cells, thus securing them against movement. The covers were laid on without vaseline, and only in a few cases with volatile substances was any vaseline placed on the outer rim of the Petri dish. Dishes with ground-glass tops are preferable. All cultures were kept in moist chambers. The one difficulty remains of opening the cultures for examination, but as it is done only once, or at most twice during the continuance of the experiment, it is perhaps a matter of small significance.

All cells, dishes, flasks, etc., used in these experiments were first cleaned with an alkali, then an acid, and finally, after thorough washing in distilled water, steamed for an hour or two before use. Particular care was taken with the covers, which were also boiled in the cleaning materials, and kept soaking either in distilled water, or in some cleaning agent when not in use. Cultures were kept in the warm room at a temperature of about 25° C., this temperature being especially commendable on account of ease of examination at the same temperature.

After considerable experience with vegetable decoctions for the growth of fungi, I have generally adopted a decoction of green string beans or of sugar beets as the best culture medium for most readily culturable fungi. Any absolute standard of strength is impossible, but as a working basis, fifty grams of dry matter for each liter of water has been found convenient; thus for green beans, from an average of analyses, three hundred and ninety-two grams would be required per liter.

The chemicals used have been the purest obtainable; and the sugar was recrystallized by the alcohol method, and subsequently washed with ether. As a standard nutrient-salt solution the following well-known formula was adopted:

Ammonium nitrate	1.0 gram
Acid potassic phosphate	0.5 "
Magnesium sulfate	0.25 "
Iron sulfate	Trace
Cane sugar	3–5 grams,
Water	100^{cc}

As a standard salt solution the above formula has been used without the sugar, the osmotic influence being neglected as of little consequence in comparison with the desirability of having equivalent salt constituents. The experiments with the so-called paraffin water resulted from a test of the value of a paraffin lining for flasks in which distilled water was to be used or kept on hand.

It is evident that so far as the fungi are culturable only pure cultures should be used for inoculation purposes. It is desirable, moreover, to avoid old cultures, and cultures which have been exposed to direct sunlight. When possible, I have used spores from cultures five to ten days old.

EXPERIMENTAL.

Table I will serve as the basis of some general comparisons with regard to the amount of germination on various nutrient media. In general a perfect food is the best stimulus for the germination of saprophytic forms, but in particular cases special stimuli are necessary. The standard organic solution has for germination purposes less strength than decoctions of plants. Generally speaking, the standard inorganic solution has about the value of sugar, except for the Mucoraceae. There is considerable difference, however, even with related species of fungi.

Of the purely saprophytic fungi studied, *Oedocephalum albidum* is the only one capable of germinating to considerable extent on pure water. This one exception is suggestive in that it is not necessarily a characteristic of saprophytic fungi that the spores do not contain within themselves the nourishment required for germination. Botrytis, though parasitic at times, would further

TABLE I.

PERCENTAGE OF GERMINATION.

In all cases the cultures were examined 15 hours after the spores were sown, then in most cases 24 and 48 hours later. When germination was not complete at the end of 15 hours there was very rarely germination. The results as given, however, are for the second or third observation.

Spores of		Culture media				
		Water	Bean decoction	Standard nutr. salt sol.	Standard inorg. sol.	Sugar solution
Aspergillus flavus		0†	100	100	75	75
Sterigmatocystis nigra		0	100	100	3–75	20±
Penicillium glaucum		0	100	100	20–50	1—
Œdocephalum albidum		100‡	100	100	50–75	100
Botrytis vulgaris		100	100	100	100	100
Monilia fructigena		75	100	100	100	100
Circinella umbellata		0	100	0	5	1—
Mucor erectus		?§	100	**	***	25±
Mucor racemosus		?§	100	100—	?§	80±
Mucor spinosus		0	100	100*	0	1—
Phycomyces nitens		0†	100	50–100	0	2–10
Chaetocladium Jonesii		0	100	100	0	80±
Coprinus fimetarius		0	5–10	0	0	0
Coprinus comatus		0	0	0	0	0
Coprinus micaceus		0	100	0	0	0
Boletus sp.		0	0	0	0	0
Ustilago perennans	summer	1	100	...	...	...
	autumn	50–70				100‡
Ustilago avenae	summer	2–10	...	...	...	50
	autumn	50				100‡
Ustilago striiformis		0	...	...	...	2±
Urocystis anemones		0	0	0	0	0
Uredo (P. graminis on wheat)		5	20	...	...	0
Uredo (P. graminis on rye)		50–95	20	...	...	50–100
Uromyces caryophillinus		100‡	75	...	...	100‡
Exoascus sp.		**	**	...	...	**
Ovularia primulina		100‡	75	...	...	75±

* Abnormal. ‡ Nearly. ** Budding.
† Usually. § Small. *** Some budding.

confirm this view. With the exception of *Coprinus micaceus*, most of the Hymenomycetes employed fail to germinate readily on bean decoction. Brefeld and others have determined that a large number of Coprini, Clavariae, and Tremellineae germinate well upon dung decoctions.

Glycerin, although slow in action,[12] often gives somewhat

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[12] DUCLAUX,—: Annales de l'Institut Pasteur 3: 112. —.

TABLE II.

PERCENTAGE OF GERMINATION.

Spores of	Strength of solution %	Peptone	Strength of solution	Cane sugar	KH_2PO_4	NH_4NO_3	$MgSO_4$	Strength of solution	KNO_3
Aspergillus flavus	1	100	$\frac{n}{2}$	20	? †	0	15–30	$\frac{2n}{1}$	5–10
	0.1	100 −	$\frac{n}{10}$	20–75	? †	20	10–20	$\frac{n}{1}$	5–10
	0.01	50 ±	$\frac{n}{100}$	75–100	? †	70–100	5–10	$\frac{n}{2}$	5–10
	0.001	10–25	$\frac{n}{1000}$	50–75	? †	5–30	....	....	....
	....	....	$\frac{n}{10000}$	30–50	....	....	....	....	....
Sterigmatocystis nigra	1	100*	$\frac{n}{2}$	10–50	? †	0	? †		
	0.1	10‡	$\frac{n}{10}$	50–100	0	0	0		
	0.01	10	$\frac{n}{100}$	20–50	0	0	0		
	0.001	? †	$\frac{n}{1000}$	5	0	0			
			$\frac{n}{10000}$	5	0				

* Nearly, when spores are single. † Very small. ‡ At edges of drop.

TABLE III.

PERCENTAGE OF GERMINATION IN GLYCERIN.

Strength of solution	Aspergillus flavus	Sterigmatocystis nigra	Penicillium glaucum	Œdocephalum albidum	Botrytis vulgaris	Ustilago avenae	Mucor spinosus
$\frac{n}{1}$	75	0	....	100*	75	50–90	0
$\frac{n}{2}$	100*	0	....	100	10–25	100*	0
$\frac{n}{10}$	75–100	0	....	100*	25	100*	0
$\frac{n}{20}$	....	....	20†	....	....	....	....

* Nearly. † After two days.

more germination than sugar, yet with Sterigmatocystis the case is reversed. In general, the difference in action has seemed to bear no particular relation to the physical properties of the substance, as for example its power of penetrating membranes.

Most of the smut forms gave good germination on bean decoction, although less on pure distilled water than has been reported by observers using ordinary tap water. *Uromyces caryophillinus* not only germinated less efficiently in bean decoction than in distilled water, but in beet decoction it failed entirely to germinate.

Of the three salts generally used in the standard nutrient salt solution, ammonium nitrate at a particular concentration gives abundant germination with *Aspergillus flavus*, but has no effect upon Sterigmatocystis. In general, the neutral salts give a greater stimulation than the one with acid properties. In this connection, reference should be made to the interesting results of Benecke.[13] He considers the presence of potassium absolutely necessary, and that without this metal no germination, or only traces of germination, can occur. Since his cultures were made in flasks, it is perhaps to be asked if he refers to germination (growth) visible to the unaided eye. Not only do some of the mold fungi germinate to considerable extent in solutions of

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[13] BENECKE, W.: Die zur Ernährung der Schimmelpilze notwendigen Metalle. Jahrb. f. wiss. Bot. **28**: 487–530. 1895.

simple substances, but the form of Botrytis which I have used germinates within a few hours on large surfaces of pure distilled water. Moreover, the potassium compounds alone are only very slightly stimulating for germination, and I have found no marked increase in germination of Phycomyces and Penicillium by the addition of potassium nitrate to a solution of sugar. The above remarks are also partially applicable to the conclusions which Molisch[14] has drawn from his most interesting experiments with Aspergillus and Penicillium. He found no germination without magnesium, saying: "da ohne Magnesium nicht einmal ein Auskeimen der Pilzsporen stattfindet, und dieses Element weder durch die Elemente der alkalischen Erden (Ca, Str, Bar) noch durch die der Zinkgruppe vertreten werden kann." He also applied these results to all "lower" fungi, that is, apparently, to all culturable forms.

Pepsin and asparagin gave almost no germination with Sterigmatocystis. The latter substance had also very little effect on *Aspergillus flavus*, while the percentage of germination with the former substance was as high as ninety.

EFFECT OF SPECIAL STIMULI ON GERMINATION.

Under the head of special stimuli, or substances which are not normal sources of food supply, are also included, for convenience, certain carbon compounds, as well as the metallic salts and mineral acids.

In this connection an unexpected result was obtained with cultures of *Aspergillus flavus* on distilled water which had been standing in paraffin-lined flasks. Nearly all of the spores on the edge of the drop, or where single, germinated; and a large per cent. of germination occurred throughout the drop. In similar cultures Sterigmatocystis gave usually only 10 to 20 per cent. of germination. Penicillium and Phycomyces were not stimulated.

Ethyl alcohol affords a marked stimulus for the germination of aspergillus; germination being more nearly perfect on the edge of the hanging drop, but occurring markedly throughout.

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[14] MOLISCH, H.: Die mineralische Nahrung der niederen Pilze. Sitzungsber. d. Kaisl. Akad. d. Wiss. zu Wien **103^{1}**: 554–574.

TABLE IV.

PERCENTAGE OF GERMINATION.

Spores of	Stren'th of solution	Ethyl alcohol	Methyl alcohol	Stren'th of solution	Phenol	Strychnin	tren'th of olution	Ether	Stren'th of solution	Camphor	Petroleum	Vaseline	Clove oil
Aspergillus flavus	$\frac{n}{5}$	2	10-20	$\frac{n}{100}$	0	3–5	$\frac{n}{76}$	1–2	conc.	50	1–3	50–75 ‖	0
	$\frac{n}{50}$	3–5	20–25	$\frac{n}{1000}$	80	1–3	$\frac{n}{760}$	2–5	$\frac{1}{10}$	10	2	50–75 ‖	1
	$\frac{n}{500}$	75	10–50	$\frac{n}{10000}$	10–40	2–3	$\frac{n}{7600}$	1	$\frac{1}{100}$	10–25	....	50–75 ‖	1
	$\frac{n}{5000}$	50–70	10–75	$\frac{n}{100000}$	20–60	‡	$\frac{n}{76000}$	1	$\frac{1}{1000}$	5–10	....	50–75 ‖	0
	....	....	....	....	....	....	$\frac{n}{760000}$	10–25	....	....	....	.....	..
Sterigmatocystis nigra	....	....	....	....	....	....	....	....	conc.	30–70	....	....	0
	$\frac{n}{0}$	0	0	$\frac{n}{100}$	0	0	$\frac{n}{76}$	0.	$\frac{1}{10}$	0	0	0	0
	$\frac{n}{50}$	0	0	$\frac{n}{1000}$	? †	0	$\frac{n}{760}$	0	$\frac{1}{100}$	0	§	5	0
	$\frac{n}{500}$	0 *	1	$\frac{n}{10000}$	1–5	0	$\frac{n}{7600}$	0	$\frac{1}{1000}$	0	....	25–50 ‖	0
	$\frac{n}{5000}$	5–20	0	$\frac{n}{100000}$	0	0	$\frac{n}{70000}$	0	....	....	....	....	..
	....	....	....	....	....	....	$\frac{n}{760000}$	0	....	....	....	....	..

* Practically. † Small. ‡ Considerable at edges. § Irregular. ‖ When single.

Methyl alcohol is slower in action, and eventually less effective. Immersion of spores for short periods of time in injurious concentrations of ethyl alcohol, and subsequently sowing these spores in water cultures, afford no stimulus for germination.

The results with phenol, here only partially given, were unusually variable. More than with any other substance used, difficulty was here experienced from the evaporation and changes in form of the drop within the culture cell, which may partially account for the dissimilarity of results.

Experiments with chloroform were not made in drop culture, but an exposure of half an hour in a saturated atmosphere was found fatal to Aspergillus and Phycomyces, and without beneficial effect upon Sterigmatocystis.

Ether has proved of little consequence as a stimulus, except with Aspergillus at the lowest concentrations used. This was hardly to be expected in consideration of its action on the cell activities. It is to be noted that all of the above mentioned substances penetrate membranes immediately.[15]

At the end of fifteen hours there is an almost inappreciable stimulus with camphor, but its effect gradually increases to the third day.

With *Aspergillus flavus* germination in pure water was increased 10 to 20 per cent. when vaseline was used for cementing the covers to the rings.

The above experiments with Aspergillus on alcohol, camphor, strychnine, and vaseline were repeated in flask cultures. Again a concentration of $\frac{n}{500}$ alcohol gave more than 50 per cent. germination; but under these conditions camphor, strychnine, and vaseline gave uniformly little or no germination. This, as well as other experiments, suggested conditions in the hanging drop more favorable for germination than in flask culture.

Besides the results presented in Table V, an interesting fact is noted in connection with hydrochloric acid, as well as later

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[15] OVERTON, E.: Ueber die osmotischen Eigenschaften der lebenden Pflanzen- und Tierzelle. Vierteljahrsch. d. Naturf. Ges. in Zurich **40**: 1–43. 1895.

TABLE V.

PERCENTAGE OF GERMINATION AFTER THREE DAYS.

	Strength of solution	HCl	HNO_3	Acetic acid	Tartaric acid	Oxalic acid	$Cu(NO_3)_2$	Strength of solution %	$CuSO_4$	MnCl+ $FeSO_4$	$ZnSO_4$
Aspergillus flavus	$\frac{n}{10}$	....	....	0	0	0	....	1.0	....	....	0
	$\frac{n}{100}$	0	0	15	5	0	0	0.1	0	3	1
	$\frac{n}{1000}$	1	5–25	20	10	1–5	0	0.01	0–40	10–20	1–5
	$\frac{n}{10000}$	20–30?*	1–2	15	25–50	1–5	?†	0.001	3–5	10–20	0
	$\frac{n}{100000}$	....	0	2–4	....	....	5–10	0.0001	25	30	....
	....	....	....	....	....	....	....	0.00001	3–10	....	....
Sterigmatocystis nigra	$\frac{n}{10}$	....	....	0	5	0	....	1.0	....	....	0
	$\frac{100}{n}$	1–3	0	10	1	25‡	0	0.1	0	0	0
	$\frac{n}{1000}$	3	1–3	10–20	1–5	2–10	0	0.01	0	0	0
	$\frac{n}{10000}$	5–10	0	20	2–3	3–5	0	0.001	15–30	?†	0
	$\frac{n}{100000}$	....	0	2–4	....	....	0	0.0001	0	?†	....
	....	....	....	....	....	....	....	0.00001	0	....	....

*On edges. †Very small. ‡Throughout; 100 per cent. on the edges.

for some other substances. The spores of *Aspergillus flavus* readily fly off from the surface of the drop, and such spores, falling on the cover glass beyond the limits of the medium, but of course moistened by the slight water of evaporation, gave at $\frac{n}{100}$ and at $\frac{n}{1000}$ a germination of 50 to 70 per cent.

The salts of the heavy metals have generally caused a slight increase in the germination of Aspergillus, but in no case have they acted very strongly.

A repetition of the experiments with nitric acid, $CuSO_4$, $Cu(NO_3)_2$ and $FeSO_4$ were also made in flask cultures at concentrations ranging from $\frac{n}{100}$ to $\frac{n}{100{,}000}$. Nitric acid of $\frac{n}{1000}$ and below has in every case given a small percentage of germination. The spores thus germinated show a considerable length of germ tube. Iron has had a similar but weaker effect. So far as could be ascertained from flask cultures, the copper compounds have at most caused a swelling of the spore, and in isolated cases the very slight protusion of a tube.

Although the stimulating action of the organic acids here included, as also the action of alcohol, may be a very different one from that of the inorganic acids, yet this stimulus of the organic acids is in no case a very remarkable one. As to whether or not these organic substances act as peculiar stimuli, or as food substances direct, there is evidently no good clue, for it is not yet possible to draw the line between those concentrations which should be considered stimulating or poisonous and those at which there may be an action merely as food. Clark's results previously mentioned have shown that alcohol at $\frac{n}{4}$ is the lowest concentration at which any inhibition of the germination of Aspergillus in nutrient media occurred.

In general, the action of the organic acids as food substances has been determined by means of the corresponding salts, and further than this we know very little about them. The stimulus given by $\frac{n}{100}$ or less of acetic acid to both fungi deserves mention, although the percentage of germination is not great.

Oxalic acid stands quite alone as a substance stimulating Sterigmatocystis more than Aspergillus, in fact causing its maximum stimulus at a concentration which affords no germination with Aspergillus. This effect on Sterigmatocystis was so variant and marked that this acid is to be regarded as a peculiar stimulant for that plant.

THE INFLUENCE OF CERTAIN PHYSICAL STIMULI.

From some variations in results obtained it became evident that by the form of the drop and the amount of evaporation therefrom, or perhaps by some other physical force closely connected with these conditions, a considerable stimulus was given to germination. When the cultures of *Aspergillus flavus* were prepared at the same temperature at which they were to be incubated, with all possible precautions being observed as to purity of water and cleanliness of cover glasses, there was seldom more than a fraction of 1 per cent. of germination, provided the culture drop retained its original form and dimensions. In cases of some evident change of conditions within the culture, however, whether by slight dispersal of the drop or by a certain amount of evaporation, the percentage of germination was often greatly increased. In special cases the percentage of germination was as high as 90 after an incubation of fifteen hours, this maximum being reached particularly when the spores were free from each other and collected on the periphery of the drop next to the glass.

Many experiments were introduced with the hope of eliminating the single factors which might be involved and of accurately determining the cause of the stimulus. Unfortunately the matter is as yet very inconclusive.

If even very small amounts of some salts were present in the drop, these during evaporation would be concentrated at the periphery, especially at the edge in contact with the glass. This would hardly be sufficient, however, to account for the germination observed, and such an occurrence of salts could only come from the well-cleaned glass surface.

As a check on the carefully prepared distilled water, cover glasses were moistened over a steam jet, and upon this condensation the spores were sown as before, the results also being parallel to those previously obtained.

The possible stimulus of rapid evaporation gave only negative results in the following experiment: Properly cleaned ground-glass slips were placed on benches (glass rings) in Petri dishes of distilled water. Strips of filter paper which had been soaked for days in acidulated water and then in distilled water were passed over the edges of the slips with the ends reaching into the water. A clear ground-glass surface of nearly an inch was left between the strips, and on this the spores were sown. This arrangement sufficed to keep a constant thin film of moisture over the glass from which evaporation might readily ensue. The covers of the Petri dishes were slightly raised, and these cultures were placed in a fairly dry atmosphere, in ordinary laboratory atmosphere, and in a moist chamber. After twenty-four hours there was from 10 to 20 per cent. of germination, and those cultures in the dry atmosphere gave perhaps less than the other two. Surface tension could hardly be considered a factor, for these fungi remained practically unchanged after a month on the surface of water in flask cultures.

To test the effect of contact and surface tension with the evaporation factor eliminated, well cleaned glass tubes were drawn out into a capillary end to be used as a culture cell. The tube was partially filled with water and the spores inserted. The water was then forced out until the spores reached capillary parts, when the larger end was also closed with water. Such cultures gave very slight germination after two days.

Attempts to increase the surface tension by means of small quantities of oil in the water gave only negative results. Massart[16] found surface tension productive of contact phenomena in

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[16] Massart, J.: La sensibilité tactile chez les organismes inférieures. Journ. de la soc. méd. et nat. de Bruxelles, December 1890.

bacteria, amoebae, flagellates, etc. Busgen[17] found that Botrytis reacts to surface tension by the formation of little bundles of branches perpendicular to the touched surface.

Besides the previously mentioned contact experiments, recourse was also had to the clinostat. By shaking, spores were submerged in flasks containing a small amount of distilled water. These flasks were then rotated horizontally so that there was constant movement of the spores and considerable contact with the glass surface. The results were negative. Likewise experiments made with a shock-imparting clinostat, and also with a combination of the rotation and shock, failed to give any positive results.

A small number of experiments was made to test the effect of evaporation caused by a lowering of the vapor tension. To effect this the cells were arranged in the Petri dishes as before. Water was used in the hanging drop above, except in control experiments, and below was placed the salt solution of various strengths. Over solutions of $MgSO_4$, varying in strength from $\frac{3}{2}n$ to $\frac{3}{8}n$, by far the best germination occurred over $\frac{4}{3}n$. where drying out was quite gradual.

According to Lesage,[18] who made a number of experiments to determine the dampness of the air in which spores would germinate best, the spores of Penicillium germinate well at all of the higher densities, but reached the lower limit between 82 and 84 per cent. humidity. Aspergillus germinates so well ordinarily at the higher humidities that the factor of evaporation seems of more significance.

The action of a change of concentration of the medium was tested in a small way. Spores of *Aspergillus flavus* were sown in Erlenmeyer flasks containing respectively 20, 10, and 5 per cent. KNO_3 in one series, and in another the same strengths of $MgSO_4$. After twenty-four hours about 5 to 10 per cent. of germination had occurred in the KNO_3 cultures and about 10

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[17] Büsgen, M.: Ueber einige Eigenschaften der Keimlinge parasitischer Pilze. Bot. Zeit. **51**: 53–72. 1893.

[18] Lesage, P.: Recherches expérimentales sur la germination des spores du *Penicillium glaucum*. Ann. d. sci. nat. Bot. **8**: 309–322. 1895.

per cent. in the $MgSO_4$. Water was then added to these cultures until the liquid was reduced tenfold in concentration. A second examination after the lapse of two days showed little or no increase of germination in the original 10 and 20 per cent. KNO_3, but an increase to about 25 per cent. in the 5 per cent. solution, and a similar increase in the 5 and 10 per cent. $MgSO_4$. In the culture containing 20 per cent. $MgSO_4$, the increased germination and the amount of growth was greater than in any other.

EFFECTS OF TEMPERATURE AND OXYGEN SUPPLY.

As previously mentioned, Heald found that fern spores kept at high temperature were incited to germination as by light, but a longer period of time was required and the response less uniform. In general I have found very little difference between the germination in water of fungi at 25° C. and at temperatures nearer the maximum. At 32° C. there is some increase in the germination of *Aspergillus flavus* in hanging drop, but not in flask cultures. The former might well be due to other conditions than to any augmentation from the higher temperature. On nutrient solution *Coprinus fimetarius* was slightly benefited by the same temperature. Such forms as *Coprinus comatus*, *C. micaceus*, *Boletus* sp., and *Urocystis anemones* could not be incited to germination at higher temperatures when no germination occurred at 25°. Botrytis and Phycomyces were both injured at the temperature of 32° C., Botrytis failing to germinate on water, and Phycomyces giving a slight growth at the bottom of the liquid. Changes of temperature from 28° to 32° C. and *vice versa* did not materially affect the germination of Aspergillus and Sterigmatocystis. After experiments of various kinds with the aecidiospores of *Puccinia graminis*, Eriksson and Henning[19] found that the best results were secured by placing the spores for a time on melting ice, and then sowing them on water. The next best results were obtained when the spores were soaked in water at 3° C. for three hours, and then sown at room temperature.

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[19] ERIKSSON and HENNING: Die Getreideroste, 71. 1896. Stockholm.

The poorest results were secured when the fresh spores were directly sown at the room temperature. Cooling also had a favorable influence upon the uredospores. This excessive cooling is hardly a natural stimulus. It may be regarded perhaps as a substitution stimulus, able effectually to replace some other incitation of the natural environment.

A few experiments were made with reduced oxygen supply, mainly to see if slight variations in this regard would at all vary the results. With cultures at room temperature with an air pressure of 60^{mm} there was no noticeable effect on germination, either in water or in nutrient solution. At below 40^{mm} of air pressure there was marked retardation, but since such lower pressures were of little concern in these results, the matter was not carried farther.

INHIBITION OF GERMINATION BY NUTRIENT SOLUTIONS.

Various authors have made casual reference to the fact that ordinary nutrient solutions may injure the germination of certain fungi normally germinating in water alone. A thorough study of this matter should throw some light upon the conditions necessary for the penetration of the host plant by the parasite. As yet I have had opportunity to make but few experiments in this direction, but an accidental attempt to make a substitute for bean decoction by adding peptone to the standard nutrient salt solution gave some results of interest with certain smuts used. *Ustilago Avenae* and *U. perennans* gave but a small per cent. of germination on any solution containing 1 per cent. of a German preparation of peptone; and the pure peptone solution gave only 1 or 2 per cent. of germination. An American manufacture of peptone did not act as an inhibiting agent; but the pure peptone solution afforded no better germination than distilled water. On the other hand, Ustilago was not inhibited by either preparation of peptone.

Certain rust fungi also comport themselves somewhat peculiarly towards nutrient solutions, as seen in Table VI.

TABLE VI.

PERCENTAGE OF GERMINATION.

	Distilled H_2O	1% peptone	Beet decoction	Bean decoction	$\frac{n}{10}$ Sugar Solution	$\frac{n}{5}$ Glycerin	$\frac{n}{10}$ NH_4NO_3
Puccinia Helianthi (uredospores)	100—	20	25*		50	10*	0
Uromyces caryophillinus (uredospores)	100—	100—	0	75*	100—	100—	100—*

*Germ tubes very short and often ill-formed.

DeBary and others have noted an injurious effect of nutrient media upon the formation of zoospores in certain Peronosporeae. The effect is to suppress the amount of zoosporic germination, and to develop germ tubes instead. Wuthrich[20] found the same phenomenon characterizing the germination of *Phytophthora infestans* under the influence of small amounts of poisons. From experiments with *Plasmopara viticola*, I have found no germ tube development; but many nutrient media inhibit the germination of the species. Winogradski and Omeliansky[21] have determined that a number of organic compounds act even at considerable dilutions to hinder or prevent the normal action of the nitrite and nitrate bacteria, and often even to sterilize the solution in which it was attempted to grow these organisms. Among these inhibiting substances are peptone and other albuminoids, glycerin, salts of organic acids, and also ammonia.

We are at this time far from a rational conception of the most important problems concerning the relation between host and parasite. The resistance of species and varieties cannot be viewed merely from a histological standpoint, and so far as the problem is capable of solution, a complicated set of factors is to be expected. If peptone and other nutrient media may be injurious to the germination of certain fungi, not only the

[20] WUTHRICH, E.: Ueber die Einwirkung von Metallsalzen auf die Keimfähigkeit der Sporen einiger parasitischen Pilze. Inaugural-Dissertation, Berne, 1892.

[21] WINOGRADSKI und OMELIANSKY: Ueber den Einfluss der organischen Substanzen auf die Arbeit der nitrifizierenden Mikroben. Centrlb. f. Backt. u. Parasitenk. 5^2:319–343, 371–387, 425–440. 1899.

poisonous excretions of plants, but all excretions may have their rôle to play regarding infection. At any rate, from the point of view of the fungus, a further study of chemotropism, of stimulants to germination, and of the inhibition of germination and growth by injurious substances cannot fail to lead us somewhat farther toward a knowledge of parasitic attack.

RESTING STAGES AND DRYING-OUT OF SPORES.

It is well known that seeds of certain phanerogams do not readily germinate on reaching maturity. From the researches of Weisner and others with rather peculiar phanerogams, it is seen that this resting period is not merely due to an absence of the best conditions, but that the element of time, as far as we know, is absolutely essential. Whether we may in some cases substitute for this element of time artificial changes of condition is mostly a matter of conjecture.

The same remarks will hold in a general way for the so-called resting stages of fungi. For the maturity of the spores of the Peronosporaceae and many of the teleutospores of the Uredineae, as examples, a certain resting period is indispensable. From the cytological studies of Wager,[22] it would appear probable that in the case of *Cystopus candidus* the maturity of the oospores, so far as the external appearances are concerned, does not denote the maturity of the zoosporangium with reference to the full quota of nuclei as a basis for the formation of zoospores. It appears that a resting stage must intervene before the final divisions of the nuclei.

Teleutospores of *Puccinia graminis* germinate best when they have been subjected to all the changes of the winter months. Observations on the presence of a certain coloring matter in the walls of such spores led Dietel[23] to attribute to this certain properties for the prevention of the germination, and for protection against unfavorable conditions. DeBary[24] has found that the teleutospores of the previous harvest cannot be brought to germi-

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[22] WAGER, H.: Reproduction of *Cystopus candidus*. Ann. Bot. **10**: 245–339.

[23] DIETEL, P.: Flora **74**: 151. 1891.

[24] DEBARY, A.: l. c.

nation later than August of the following year, and the optimum germination occurs during the spring of the latter year. Eriksson and Henning[25] are of the opinion that a passage through the animal body will not act as a substitute for the dormant period. Such lines of work have not been systematically followed out, and even for the Uredineae, which are very variable in their disposition toward the resting period, the limitations are not sufficiently known. According to Kühn, Brefeld, and others, as previously mentioned, germination of certain smuts in water can only be induced after a period of rest, while immediate germination may result from the addition of food material. My own results also show that the per cent. of germination with *Ustilago Avenae* and *U. perennans* increases considerably from summer to autumn, even though the material is kept in dry condition.

In other experiments, *Sterigmatocystis nigra* kept dry in the laboratory for five years gave no germination, while material one and two years old gave good germination in nutrient media. This age of the material did not act as a stimulus to germination, however, since only a fraction of 1 per cent. germinated when sown on distilled water. After drying out for four days on slide at 25° C. neither *Aspergillus flavus*, *Penicillium glaucum*, nor *Sterigmatocystis nigra* showed any germination as tested by distilled water.

SUBMERGENCE OF SPORES.

Ordinarily the spores of such molds as *Aspergillus flavus* and *Sterigmatocystis nigra* float on the surface of solutions; and, depending upon the solution, they may or may not tend to collect at the line of attachment to the glass in drop cultures. The spores of Phycomyces and other Phycomycetes, as well as many Hymenomycetes, however, very readily sink beneath the surface. To test the capacity of Aspergillus for submerged germination, spores were sown in bean infusion between the parts of a strip of mica lightly separated. The mica was then dropped into a flask of bean decoction. After two days the removal and examination of the mica showed that all spores were germinated, those

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[25] ERIKSSON and HENNING: op. c. 54.

in the middle, however, having developed a germ tube only about ten times the diameter of the spore, while those on the margin were growing luxuriantly. Under pressure submerged spores do not germinate.

Spores of *Aspergillus flavus* were also sown on a layer of agar beneath a considerable layer of the same material, the upper layer being poured on while the first was still soft. Germination readily resulted. Also spores in flask cultures of $\frac{n}{50}$ alcohol, submerged by shaking, germinated readily.

SOME PECULIARITIES OF GERMINATION VERSUS GROWTH.

The Hymenomycetes will doubtless form an interesting field for the study of germination relative to special stimuli. With studies which are yet merely preliminary I have secured only a single positive result of interest, but in many cases failures are likewise suggestive.

Brefeld, in his *Untersuchungen über Schimmelpilze* (part III), records that spores of Gasteromycetes and of Phallus (p. 174) particularly, as well as other members of the fleshy fungi, do not germinate under any conditions tried. On the other hand, *Coprinus stercorarius* (p. 14), *C. lagopus* (p. 99), and *C. ephemeroides* (p. 117) germinate well on any plant decoction, as likewise spores of Clavariae and Tremellinae (p. 181). *Coprinus ephemerus* (p. 109) is said to germinate once in perhaps ten trials. While I have not been able to germinate *Coprinus comatus* and *Boletus* sp., these forms have been studied only from fresh spores and from spores kept in the laboratory about two months. *Coprinus fimetarius* has given various small percentages of germination in different vegetable decoctions, but otherwise no germination. A species, which unfortunately was not determined while fresh, but later identified as *Coprinus micaceus*, has given little or no germination in all solutions containing no plant decoction. In bean and dung decoction the same material has furnished perfect germination. The question then of interest was to determine if there might exist in the bean decoction a substance stimulating germination but unnecessary for growth; in other words, if we may here distinguish between a medium for germination and a growth medium. Spores of this fungus, caught with all possible sterilization precautions, were germinated on bean decoctions in flask cultures. About eight hours after the sowing, the liquid was filtered off in a sterile filter, and the collected mass of germinated spores was removed by a needle to a second filter. Here the spores were washed, and finally transferred to a flask of sterile water. In the latter they remained two days, the water being then poured off and the standard nutrient salt solution added. Growth proceeded gradually, and at the end of one month there was a thick mat covering the bottom of the flask, as if with a circular piece of canton flannel. With all of the precautions observed, and by a comparison of the mycelium, this must be taken to justify the belief that we may here deal with a case in which a medium failing to stimulate to germination may yet afford growth. Bean decoction, moreover, is a better growth medium, and it would seem that the stimulus to germination would be a food stimulus. Nevertheless, the addition of peptone to the standard nutrient salt solution also gave no germination, and if the stimulus is that of a food, it must be considered in the class of peculiar foods.

Some other results, scarcely comparable to the above, may, however, be mentioned at this place. Janczewski[26] has determined that *Ascobolus furfuraceus*, a plant growing normally on the dung of herbivorous animals, could only be prepared for germination by being passed through the digestive tract of such animals. White rabbits were the animals used in his experiments. We have here evidently a case in which the spore is immediately capable of germination provided it may be first acted upon chemically or otherwise, so that it is rendered capable of using the stimulus of the medium on which it normally grows.

DeBary[27] also found that *Onygena corvina*, growing on the feathers of birds of prey, seemed to require a particular stimulus

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[26] JANCZEWSKI: Morphologische Untersuchungen über *Ascobolus furfuraceus*. Bot. Zeit. **29**: 257–262. 1870.

[27] DEBARY, A.: op. c. pp. 376–377.

of its normal environment in order that germination might be effected.

Coprinus comatus, *Boletus* sp., and a few other forms failed also to germinate on filtrates or decoctions of the soil in which the plants grew. The soil filtrate cultures were of course swarming with the bacteria which would thrive under such conditions. Equally futile have been the attempts to germinate these spores in the presence of alkaline substances, in a slightly acid medium, or in the presence of a reducing agent. Hartig[28] mentions the germination of *Merulius lacrimans* in the presence of ammonium and other alkaline compounds, after the failure of many other substances.

Brefeld[29] found that *Tilletia caries* fails to germinate in nutrient solution. If already germinated in water and then transferred to nutrient solution the death and bursting of the promycelium soon occurs.

DILUTION OF FOOD MATERIALS.

Concerning the minimum food supply necessary for more or less perfect germination there seem to be almost no references in the literature. The concentration, however, at which some substances begin to attract chemotropically, or practically this lower concentration, has been determined by Miyoshi.[30] For example, cane sugar at 0.01 per cent. attracted the hyphae of *Mucor stolonifer*, and ammonium nitrate attracted the same fungus at 0.05 per cent.; while meat extract of 0.005 per cent. was attractive for Saprolegnia. On the other hand, Eschenhagen[31] and others have found that germination and growth of the mold fungi may occur at very high concentrations.

Examining horizontal lines in table VII, these experiments are more or less comparable from the point of view of the concentrations of the medium. The standard nutrient salt solution

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[28] HARTIG, R.: Der echte Hausschwamm.

[29] BREFELD, O.: Vgl. Unters. a. d. Gesammtgebeit der Mykologie. Part V, p. 152.

[30] MIYOSHE, M.: Ueber Chemotropismus der Pilze. Bot. Zeit. **52**: 1–28. 1894.

[31] ESCHENHAGEN, F.: Ueber den Einfluss von Lösungen verschiedener Concentration auf das Wachstum von Schimmelpilzen. Inaug.-Dissertation, Leipzig. 1889.

TABLE VII.

	Bean decoction			Standard nutr.-salt solution		Sugar solution		
	Strength of solution	Per cent. of germination	Remarks	Per cent. of germination	Remarks	Strength of solution	Per cent. of germination	Remarks
Aspergillus flavus						$\frac{n}{2}$	20	From 10–30%
	Standard	100		100		$\frac{n}{10}$	20	" " "
	$\frac{s}{10}$	100		100		$\frac{n}{100}$	75	Drops poor, spreading
	$\frac{s}{100}$	100*		65±		$\frac{n}{1000}$	10–50	Varying from middle to edges
	$\frac{s}{1000}$	60±	From 40–90% in different cultures	?‡	3% in middle of drop to 20% on edges	$\frac{n}{10000}$	5–20	" " "
	$\frac{s}{10000}$	20±	From 5–40% in different cultures	?‡	1% in middle of drop to 20% on edges			
	$\frac{s}{100000}$	?†		?†	Slight germination on edges only			
Sterigmatocystis nigra						$\frac{n}{2}$	5	Very few in middle
	Standard	100		100		$\frac{n}{10}$	20–75	Varied from center to edges
	$\frac{s}{10}$	100		100		$\frac{n}{100}$	10–50	" " "
	$\frac{s}{100}$	20±	Varied from 10–50% about 60%			$\frac{n}{1000}$	5–10	" " "
	$\frac{s}{1000}$	3±		2±		$\frac{n}{100000}$	5–10	" " "
	$\frac{s}{10000}$	0‖		0				
	$\frac{s}{100000}$	0		0				

* Nearly. † Very small. ‡ Small. ‖ Practically.

contains 5 per cent. of sugar, the beet decoction about 3 per cent., and the $\frac{n}{10}$ sugar solution 3.4 per cent. It is noticeable that with Aspergillus on bean decoction practically normal germination takes place as low as $\frac{s}{100}$ (standard solution diluted one hundred times), and otherwise the coefficient of maximum germination is constantly above $\frac{s}{100}$. Parallel with the results cited above, flask cultures were made with the more variable Aspergillus. These cultures for the first two media showed at s and $\frac{s}{10}$ complete germination, at $\frac{s}{100}$ very good germination, at $\frac{s}{1000}$ a very small per cent., and at further dilutions none. Equivalent cultures on sugar solution are interesting, $\frac{n}{2}$ giving almost no germination; $\frac{n}{10}$, 25–40 per cent.; $\frac{n}{100}$ and $\frac{n}{1000}$ perhaps about 10 per cent.; and $\frac{n}{10000}$ a very small percentage. From this it will be seen that a tenfold dilution of the ordinary culture media affords perfect germination, and a dilution below one thousand times gives practically no germination except with very sensitive fungi.

INDIVIDUAL VARIATION OF SPORES.

No studies of importance seem to have been made upon the variation in capacity for germination of individual spores produced under similar conditions, or of spores from the same conidiophore or sporangium. Nevertheless, great individual differences exist, and in any medium which is not a strong stimulus for germination, varying percentages of perfect germination will invariably occur, whatever precautions of method may be observed.

CAPACITY FOR GERMINATION OF SPORES LONG INCUBATED ON WATER SURFACES.

Spores of *Aspergillus flavus* and *Sterigmatocystis nigra* were sown on distilled water in Erlenmeyer flasks. At the end of 10, 30, and 90 days some of these were transferred to bean decoction. Practically no germination had occurred on the water, and in nutrient solution of the new cultures these spores gave perfect germination. After 125 days, some germination had occurred among spores in masses, but this germination was by no means general. The ungerminated spores of these fungi were entirely uninjured as to their capacity for germination after this period of incubation.

LENGTH OF LIFE OF GERMINATED SPORES IN WATER.

Spores of *Aspergillus flavus* and *Botrytis vulgaris* were sown in weak bean decoction, and after about eight hours, or when all had germinated, they were filtered and thoroughly washed. The masses of spores were then transferred to fresh distilled water and so preserved. The last sowing from these germinated spores was made after eighty days with Aspergillus, and at this time all were yet alive. With Botrytis, the last inoculation was made after forty days, with the same result. In the cultures in which these spores were tested, general growth alone was not depended upon, but individual germ tubes were located and growth from these directly observed.

LENGTH OF LIFE OF SPORES DRIED OUT AFTER GERMINATION.

Spores of Aspergillus and Botrytis were germinated as in the above experiments, and then dried on filter paper. With Botrytis no further growth could be secured from spores thus dried after twenty-four hours, thus in perfect agreement with the results of Nordhausen.[32] On the other hand, inoculations from the Aspergillus material and careful marking and observation of individual germinated spores gave a very general new growth after being dried out twenty days. After sixty-five days there was new growth from about half of those transferred, and after one hundred days there was no sign of growth from germinated spores. It would be interesting to compare further the behavior of parasitic and saprophytic forms in this respect. We know in a general way that the germ tubes of parasitic forms die quickly when dried. Indeed in an early paper by Hoffmann[33] it is stated that "Austrocknen im gekeimten Zustande,

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[32] NORDHAUSEN, M.: Beiträge zur parisitärer Pilze. Jahrb. f. wiss. Bot. **33**: 1–46.

[33] HOFFMANN, H.: Untersuchungen über die Keimung der Pilzsporen. Jahrb. f. wiss. Bot. **2**: 267–337. 1860.

also Austrocknung des Keimfadens, für das Weiterwachsen absolut tödlich ist."

I am pleased to express my thanks to Professor Pfeffer for his kind advice and encouragement in the progress of this work completed in his laboratory at Leipsic.

CORNELL UNIVERSITY,
Ithaca, N. Y.

CURRENT LITERATURE.

BOOK REVIEWS.

Agricultural botany.[1]

THOSE practically interested in the cultivation of plants have felt the need of a text-book of botany adapted to their wants. They are interested in the science of botany only in so far as it applies to their operations, and the great mass of material in current text-books is of little value to them. It is noticeable, also, that as the science advances the authoritative text-books deal more and more with recondite matters, and are growing away from the needs of the practical cultivator. The appearance of a text-book definitely designed to meet the needs of this class, therefore, is very timely, especially when it is so excellent as the one written by Professor Percival. The author has had many years of experience in teaching and lecturing to students, practical farmers, and gardeners, and is in a position to select his material wisely. What is equally to the point, he is evidently in touch with what is best in the science of botany; and while captious criticism might point out omissions which destroy the philosophical perspective of the science, and deny to the reader any adequate conception of the plant kingdom as a whole, one cannot help but feel that this is an ideal demand which the constituency addressed have no time or inclination to realize. The author's style is that of a good teacher, the presentation being clear and logical.

This book is divided into eight parts. The first deals with the gross structures of seed plants, the topics being seeds, the root, the vegetative shoot, the leaf, the flower, the inflorescence, and the fruit. The account is clear and simple, and the terminology is not excessive, as is too often the case. The emphasis, of course, is laid upon the plants and structures most commonly met in cultivation. One of the excellent features of the book is the constant insistence upon practical demonstration and experiment, and these are suggested at every step. The second part deals with histology, and includes a brief but adequate and up-to-date presentation of the cell, cell division, tissues, and the anatomy of root, stem, and leaf.

The third part is devoted to plant physiology, and it is a pleasure to meet in such a book a good presentation of the formal aspects of the subject. Perhaps they are too formal, but the experiments are numerous and usually good, and well adapted to the constituency. The only criticism which seems

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[1] PERCIVAL, JOHN: Agricultural Botany, theoretical and practical. 8vo. pp. xiii + 798, illustrated. New York: Henry Holt & Co. 1900. $2.50.

worth mentioning is that little idea is given of the plant as an irritable organism, irritability being scarcely alluded to except in connection with movements. The subjects treated are the chemical composition of plants, osmosis, absorption of water, transpiration, absorption of food materials, photosynthesis, formation of proteids, translocation and storage of foods, enzymes, respiration, growth, reproduction, cultivated plants and their origin, and plant breeding. Under the head of sexual reproduction of seed plants the author in the main steers clear of the usual misleading terminology, but evidently finds it impossible to make clear the real situation without more training than the book demands.

The fourth part has to do with the "classification and special botany of farm crops." After a general discussion of the classification of plants, in which the emphasis is naturally laid upon seed plants, the author selects for special presentation the following families: Cannabaceae, Chenopodiaceae, Cruciferae, Rosaceae, Leguminosae, Umbelliferae, Solanaceae, Compositae, and Gramineae, with special chapters on cultivated and wild oats, cultivated barleys, rye, wheats, grasses, and clovers. The fifth part discusses the weeds of the farm. A general discussion of the injurious effects of weeds, their duration, their habit of growth, how they spread, and their extermination, is followed by an account of special weeds.

The sixth part presents the subject of farm seeds, the purity, germination capacity, germination energy, weight, form, color, etc., of seeds being discussed. The seventh part considers fungi chiefly in relation to some common diseases of plants. After a presentation of the structure and habits of fungi in general, the different diseases which they produce in farm crops are discussed. The last part is devoted to a consideration of bacteria. The morphology and reproduction of bacteria are first presented, and afterwards their work in lactic, butyric, and acetic fermentations, and in putrefaction, nitrification, denitrification, fixation of free nitrogen, and diseases of animals.

It will be observed that the scope of the book is broad, and that it includes the subjects of special interest to cultivators of plants. It certainly deserves to be received eagerly by agricultural schools and those engaged in agricultural pursuits.— J. M. C.

A botanical dictionary.

THE making of a good dictionary, even though limited to the special vocabulary of a single science, is not the easy task a novice might imagine. It is fortunate, therefore, that the task was undertaken by so competent a person as Mr. B. Daydon Jackson, who, if we may judge by his works, delights in painstaking labor of a kind that is intolerable drudgery to most men. He fully realizes the difficulties of the present task and the meager appreciation it is likely to receive, for he aptly quotes Dr. Johnson: "Every other author may aspire to praise, the lexicographer can only hope to escape reproach."

It will be only just, therefore, to express at once our hearty commendation of the work which Mr. Jackson has done, and to say that the glossary, as he modestly calls it,[2] is not only by far the largest and most comprehensive botanical dictionary in the English language, but by far the best. Concise definitions, brief derivations, and the accents are given for almost 15,000 words, which is about three times the number in Crozier's hastily compiled dictionary, issued a few years ago in this country. The only English botanical dictionaries are long since out of date and practically useless.

Mr. Jackson has succeeded remarkably well in traversing the whole range of our terminology. Even very new words have not escaped him, for he includes such terms as *edaphic*, *tropophyte*, *geophyte*, *coenocentrum*, *compound oosphere*, etc. Most of the definitions are concise and good; some, however, are incomplete, *e. g.*, *tree*, *xerophyte;* some are careless or ambiguous, *e. g.*, *coenocentrum*, *mycorhiza* (misspelled mycorrhiza), *geophyte;* and some are antiquated or erroneous, *e. g.*, *archesporial cells*, *chlorovaporization*, *oogenesis*, *fertilization*, *sperm cell*, etc. The accent given does not always coincide with lexicons, *e. g.*, *medúllary* and *eláter*. In the former case it does not coincide with usage in this country though the author says medúllary is the usage in England. And if usage even permits eláter, it violates all rules of quantity.

Part, perhaps a large part, of the faults are due to the extreme condensation of the definitions. This might have been avoided, without making the volume of inconvenient size, by dispensing with a number of words derived from Crozier's dictionary, which, as inquiry and search indicate, neither have nor have had botanical use in literature, *e. g.*, *gusset*, *ensate*, *hydroid*, *polydelphous*, *secondine*, etc. Greater fullness of the definitions might also have been compensated for by using thinner paper, instead of the thick and stiff stock, which, together with the stiff binding (entirely unfit for such a reference book), prevents the book from opening comfortably or lying open. But blemishes such as these, the more noticeable because so easily avoidable, may well be overlooked in view of the good qualities, too many to enumerate, which distinguish this book from its predecessors. Every laboratory needs a copy on its shelves.—C. R. B.

MINOR NOTICES.

THE FOURTH PART of the "Catalogue of Welwitsch's African plants," by W. P. Hiern, and published by the British Museum, has just appeared, including Lentibulariaceæ to Ceratophylleæ. The occasion of the publication was stated in the review of the first part, published in the GAZETTE (**23**: 210. 1897). The present part contains some important families, as Acanthaceae, Verbenaceae, Labiatae, Euphorbiaceae, etc. Approximately ninety

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[2] JACKSON, BENJAMIN DAYDON: A glossary of botanic terms, with their derivation and accent. 12mo. pp. xii + 327. London: Duckworth & Co. Philadelphia: J. B. Lippincott Co. 1900.

new species are described, about one third of which are Labiatae; and to the same family the single new genus (*Symphostemon*) belongs.—J. M. C.

THE SERIES OF PUBLICATIONS by de Wildeman and Durand, setting forth the flora of Congo, has now reached the completion of the second fascicle.[3] In this fascicle it is stated that the number of spermatophytes, which a year ago was estimated to reach 1500, has now reached 2000. The fascicle deals with collections made by Belgian explorers, officers, and missionaries, and contains the descriptions of about twenty-five new species.—J. M. C.

THE FIRST VOLUME of Wiesner's *Die Rohstoffe des Pflanzenreiches* is now completed by the publication of the fifth part.[4] The subject of yeasts is completed; products of algæ and lichens are elaborated by Dr. F. Krasser (31 pp.), of which the most important is agar, and carrageen or "Irish moss," dye-yielding lichens, "Iceland moss," and "reindeer moss." Dr. W. Figdor treats the galls (27 pp.), and Dr. F. von Höhnel the barks (96 pp.), with which important section the volume concludes.—C. R. B.

DR. H. A. HARDING, of the N. Y. Agricultural Experiment Station at Geneva, has found that the black rot of cabbage and allied plants is a widespread disease in Europe,[5] which has been overlooked by continental pathologists. He observed it in the vicinity of Versailles, Bern, Zürich, Karlsruhe, Bonn, Harlem, Fulda, Halle a. S., Berlin, Kiel and Slagelse in the course of some months of travel in France, Germany, Switzerland, Belgium, Holland, and Denmark in the autumn of 1898. Only in Switzerland and Denmark did the disease seem to be of economic importance.—C. R. B.

THE *Proceedings of the Indiana Academy of Science* for 1889, just received, contains the following botanical papers: "Contributions to the flora of Indiana," and "Some unrecognized forms of native trees" (*Asimina triloba, Juglans nigra, Liriodendron Tulipifera,* and *Disopyros Virginiana*), by STANLEY COULTER; "A list of plants collected at Cedar, Shriner, and Round Lakes," by C. C. DEAM; "The resin ducts and strengthening cells of Abies and Picea (illustrated), by HERMAN B. DORNER; "A proteolytic enzyme of yeast," and "Saccharomyces anomalus," by KATHERINE E. GOLDEN; "Some problems in Corallorhiza," and "The disappearance of *Sedum ternatum*," by M. B. THOMAS.—J. M. C.

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[3] WILDEMAN, EM. DE ET DURAND, TH.: Annales du Musée du Congo. Botanique, série II. Contributions a la flore du Congo. Tome I. Fasc. 2. (2^{me} Partie.) 4to. pp. 49–83. Bruxelles: Charles Vande Weghe. July 1900.

[4] WIESNER, JULIUS: Die Rohstoffe des Pflanzenreiches. Versuch einer technischen Rohstofflehre des Pflanzenreiches. Ed. 2. Lief. 5. pp. 641–795, *figs. 123–153*. Leipzig: Wm. Engelmann. 1900.

[5] Die schwarze Fäulniss des Kohls und verwandter Pflanzen, eine in Europa weit verbreitete bakterielle Pflanzenkrankheit. Centralbl. f. Bakt. II. **6**: 305–313. *pl. 2* and *map*. 1900.

NOTES FOR STUDENTS.

IN THE *Gardener's Chronicle* for November 10 last, Mr. W. G. Smith figures a curious malformation on the pileus of *Agaricus albus*, recently collected and now in the British Museum. On the lamellar surface of the obconical pileus there are five smaller pilei, each raised on a short stipe, arising almost in the same plane, midway from stipe to margin.—C. R. B.

CZAPEK's recent paper[6] upon the sensitiveness of the root tip to geotropic influence will be read with exceptional interest by all who have attempted to repeat, for class demonstration or otherwise, his ingenious experiments with bent glass caps. There appeared last year, in Russian, a paper by Wachtel[7] containing a mass of experimental evidence which the writer believed to disprove Czapek's thesis entirely. Wachtel failed to obtain the curvatures described by Czapek for capped roots, and he obtained other curvatures which seemed to prove the absence of any localization of the sensitive region in such organs. Czapek has retraversed the whole disputed ground in his usual careful manner. He was able to reproduce all of Wachtel's results and shows that they were due to imperfect manipulation in the preparation of the glass caps. The walls of Wachtel's capillary tubes were too thin, thus bringing about either a narrowing of the bore at the angle, or the production of an angle too blunt for the desired purpose. Either of these conditions prevents the success of the experiment. The present article contains a translation into German of a good part of Wachtel's paper, with critical remarks, and a discussion of the difficulties of manipulation, including a very detailed account of Czapek's own methods.

There is also added a new experimental proof of the fact that only the formative region of the root tip is sensitive to the earth's gravitation. Briefly, this is as follows: Vertically placed roots are allowed to grow into right-angled caps in the usual way; then the caps are removed, the seedlings placed upon the revolving klinostat, and their behavior is observed. Within a few hours a bending becomes evident, the after effect of the stimulus received by the stationary horizontal tip while still within the cap. Various positions of the roots were tried and all point to the same conclusion. The new method is even more elegant than the older one, and in itself amounts to a proof of Darwin's hypothesis of the localization of the sensitive region.—BURTON EDWARD LIVINGSTON.

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[6] CZAPEK, FRIEDRICH: Ueber den Nachweis der geotropischen Sensibilität der Wurzelspitze. Jahrbücher für wiss. Bot. **35**: 313. 1900.

[7] WACHTEL, M.: Zur Frage über den Geotropismus der Wurzeln. Berichte der neurussischen Gesellschaft der Naturforscher in Odessa **23**: 48. 1899.

NEWS.

DR. A. NESTLER has been appointed assistant professor in the German University at Prag.

DR. R. HEGLER, *privat-docent* in the University of Rostock, died at Stuttgart on September 28.

SIR JOSEPH HOOKER has been elected one of the foreign associates of the French Academy of Sciences, Institute of France.—*Gard. Chron.*

THE SECOND MEETING of the naturalists of the central states was held at Chicago, on December 27 and 28, in the biological buildings of the University of Chicago. There was a good attendance of both zoologists and botanists. Among the latter were Messrs. Ramaley of Colorado, Pound of Nebraska, Thom of Missouri, Shimek of Iowa, MacMillan of Minnesota, Timberlake, Densmore, and Smith of Wisconsin, Millspaugh, Hill, Caldwell and Holferty of Illinois, Mottier and King of Indiana, Grover of Ohio, Copeland of West Virginia, and Jeffrey of Toronto. The visitors, together with the botanical staff of the University of Chicago, and the ten or twelve graduate students who were still at the University during the holidays, made up a satisfactory botanical attendance. The papers were numerous enough to demand the division on Friday afternoon into botanical and zoological sections. The botanical papers were as follows: H. C. COWLES, H. N. WHITFORD, and C. C. ADAMS: The relation of base-leveling to specific differentiation. A symposium, treated from the standpoint of both plants and animals. B. M. DAVIS: Coenogametes. H. G. TIMBERLAKE: Swarmspore formation in Hydrodictyon. G. H. SHULL: Variation in the florets and bracts of *Aster puniceus* Linn. H. N. WHITFORD: The genetic development of the forests of northern Michigan and a consideration of the factors controlling the distribution of coniferous forests. E. C. JEFFREY: An anatomical classification of vascular plants. H. C. COWLES: Application of the quantitative method to the dynamical study of plant societies. R. B. THOMSON: North American Chalazogams. O. W. CALDWELL: The use of color photography in demonstration work. J. H. FAULL: Some interesting features in the anatomy of the Osmundaceae. E. B. COPELAND: Stomata of some Liliaceae. The success of this meeting justifies the expectation that a society of the naturalists of the upper Mississippi valley meeting at this time of year, can be made successful. A third meeting, at which a formal organization may be effected, will be held in Chicago in December 1901.


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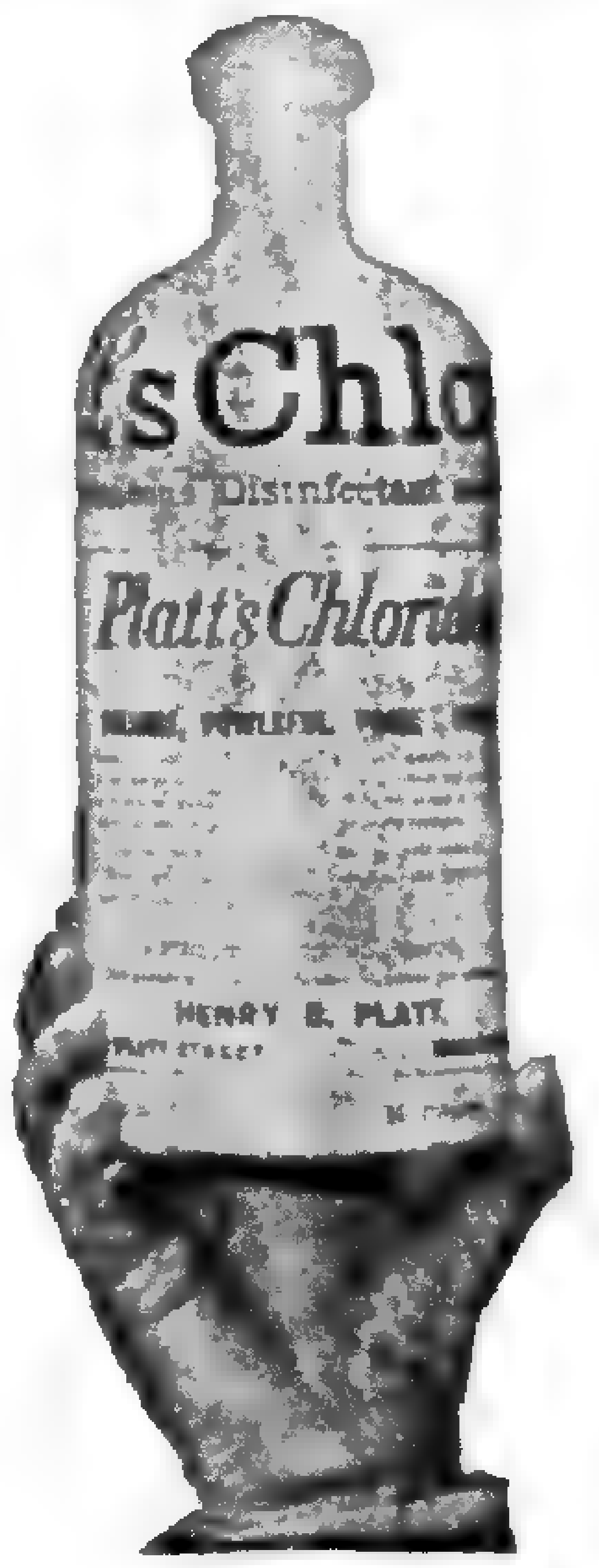
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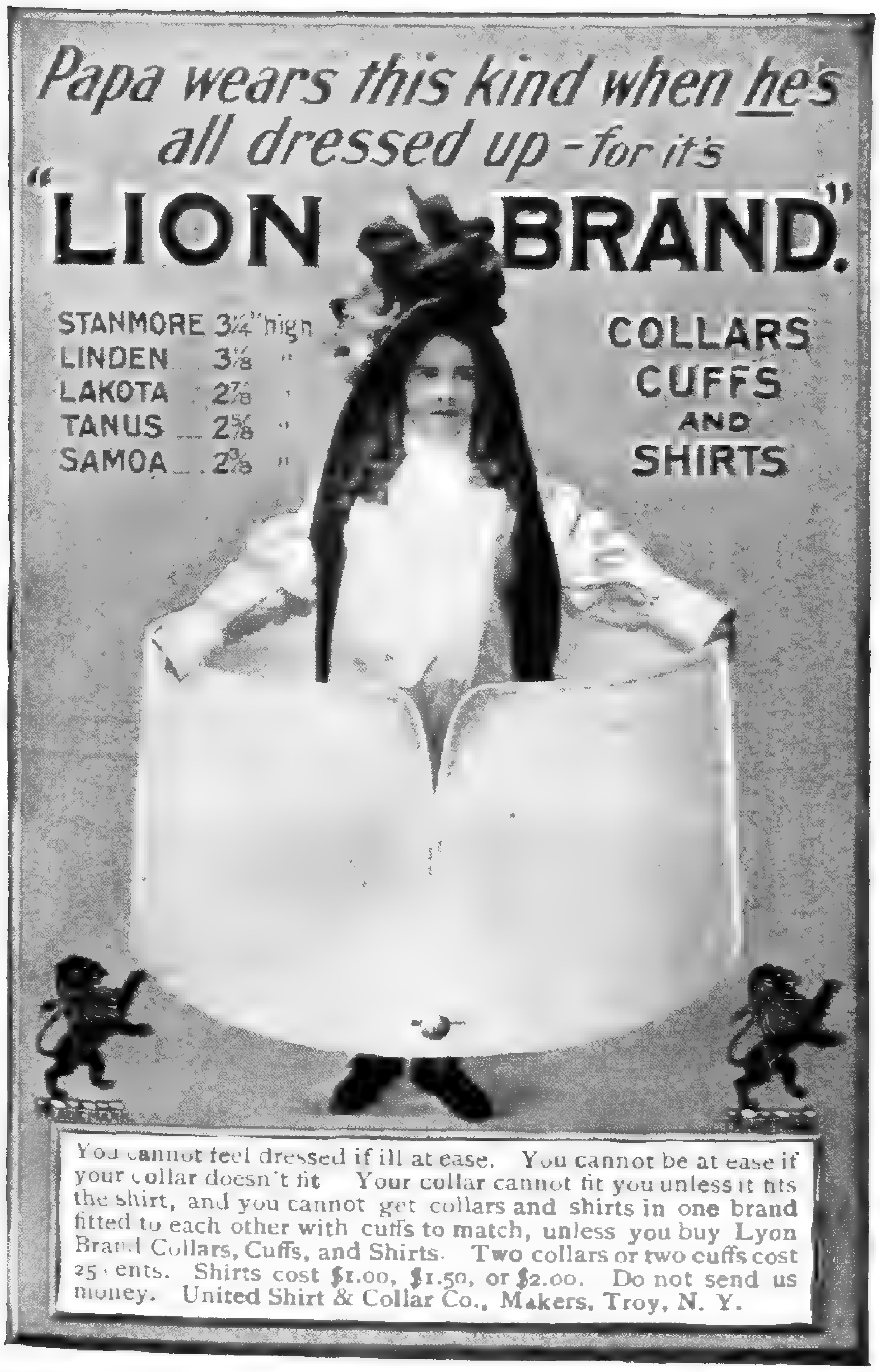

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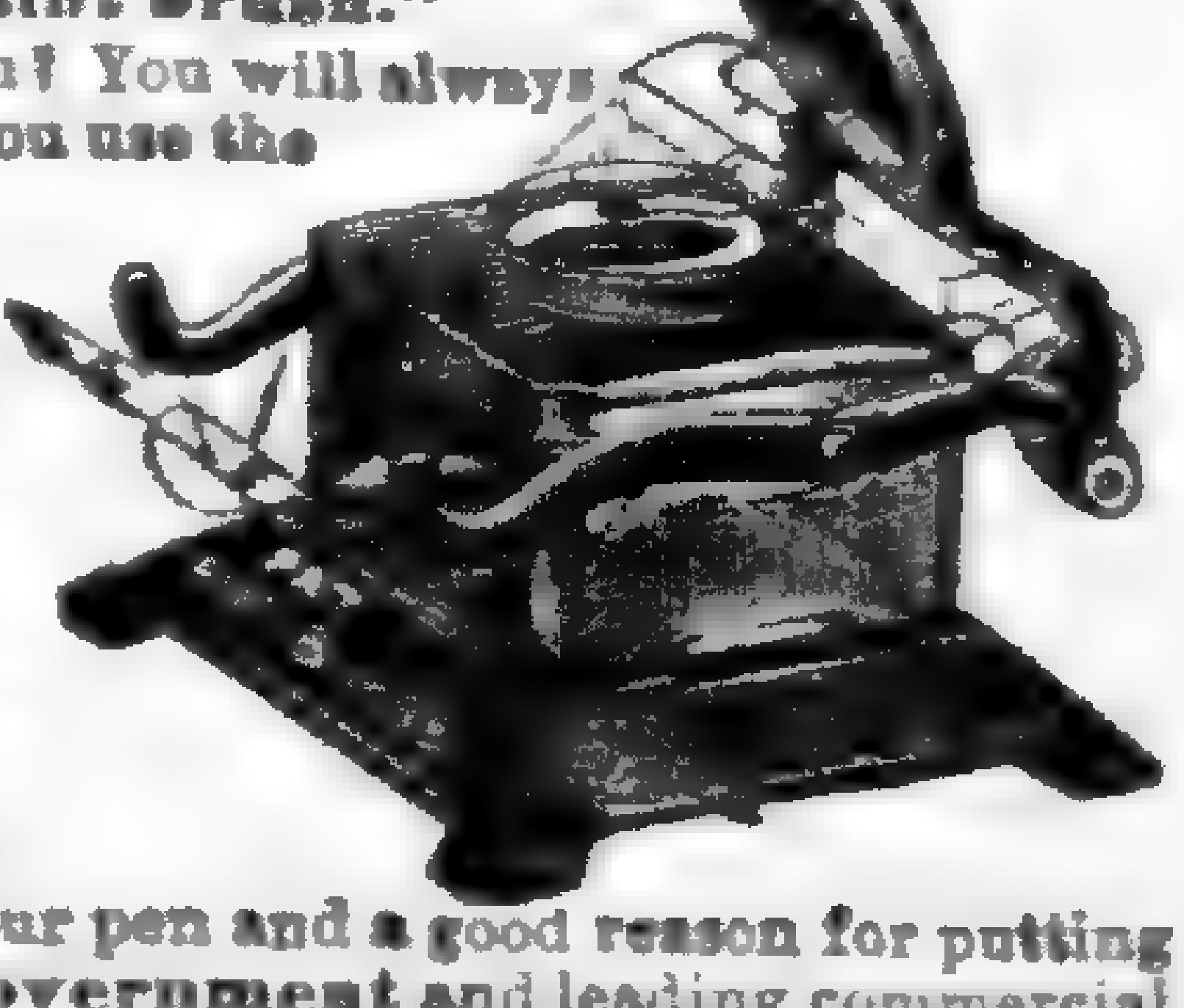

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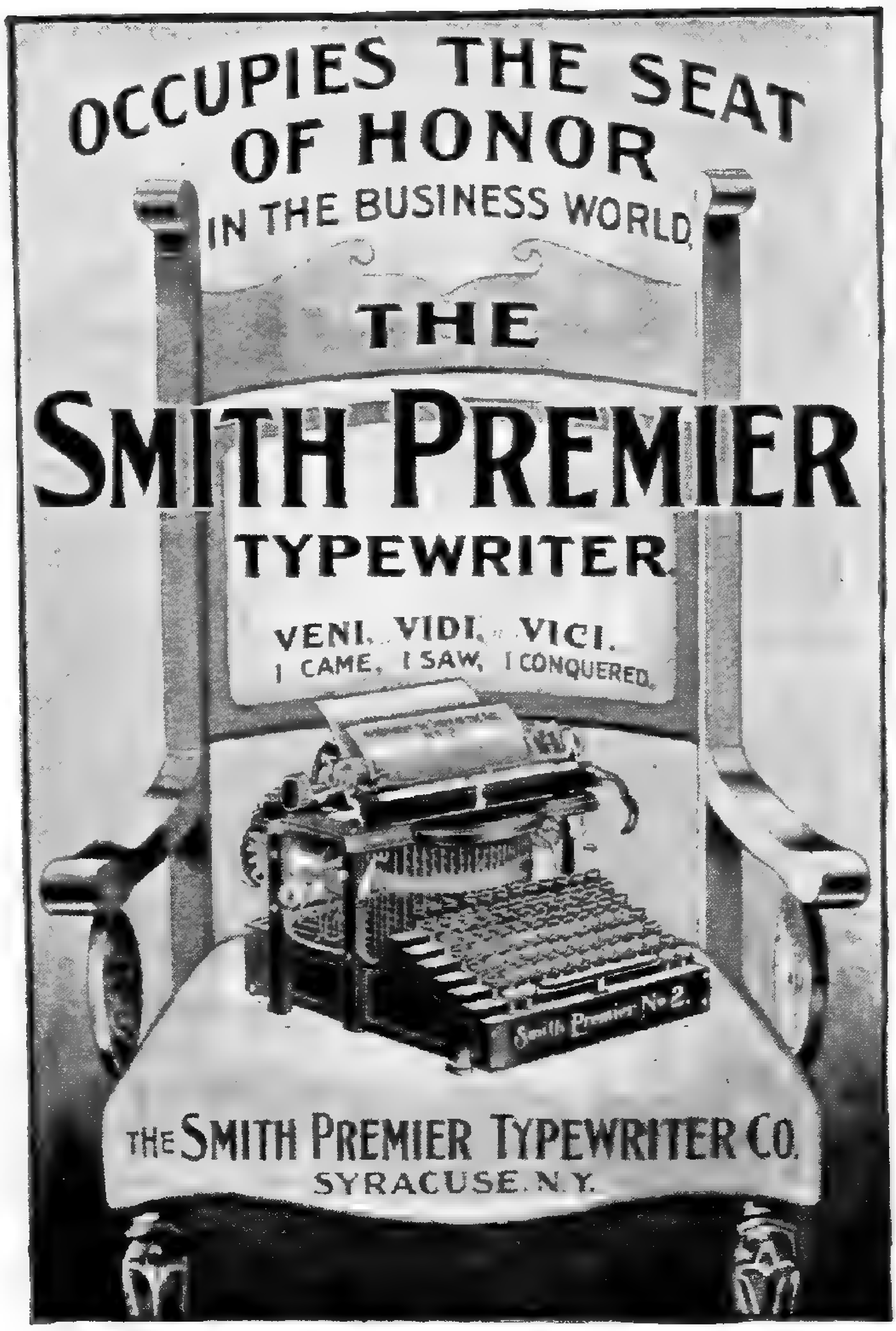
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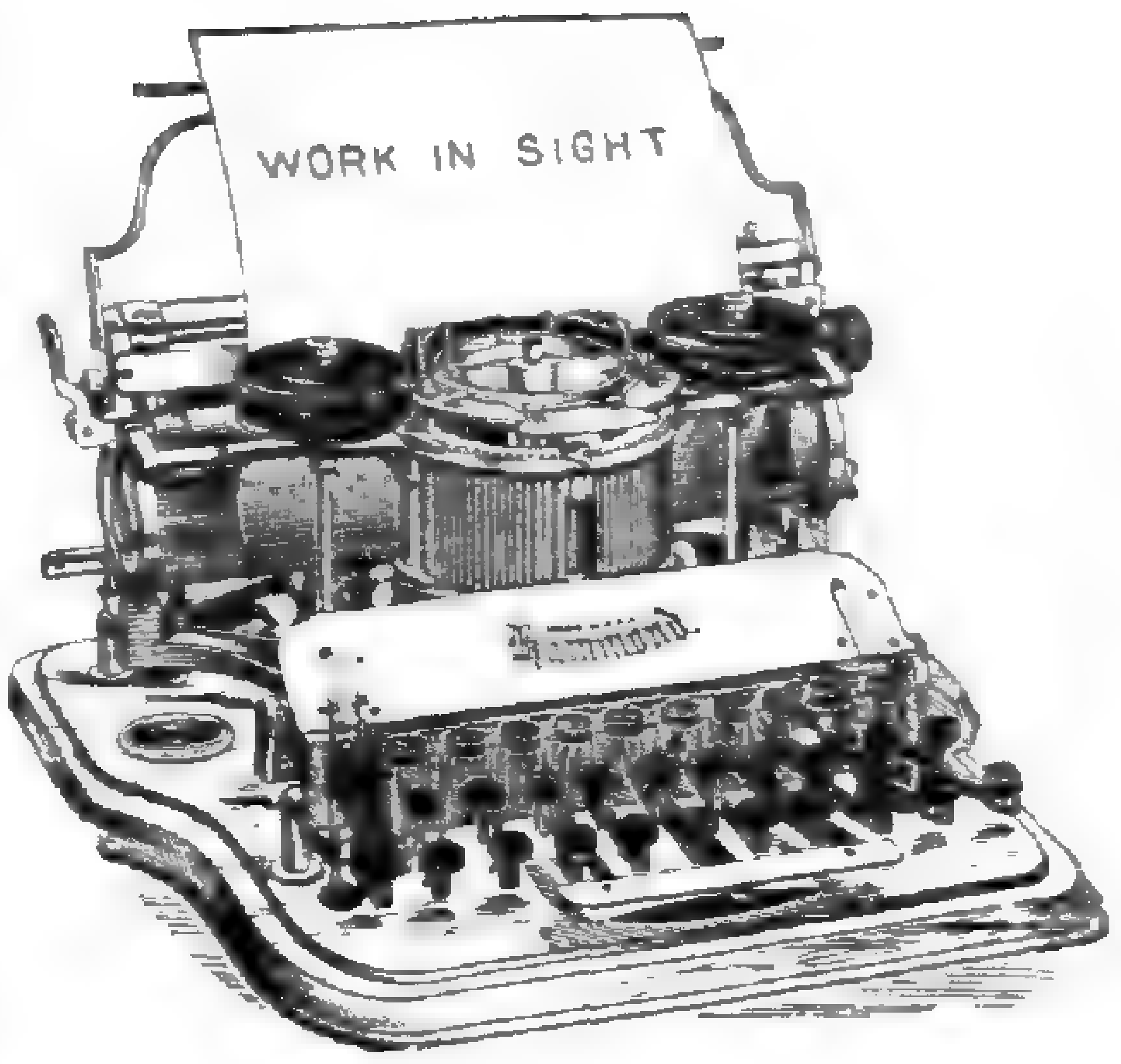
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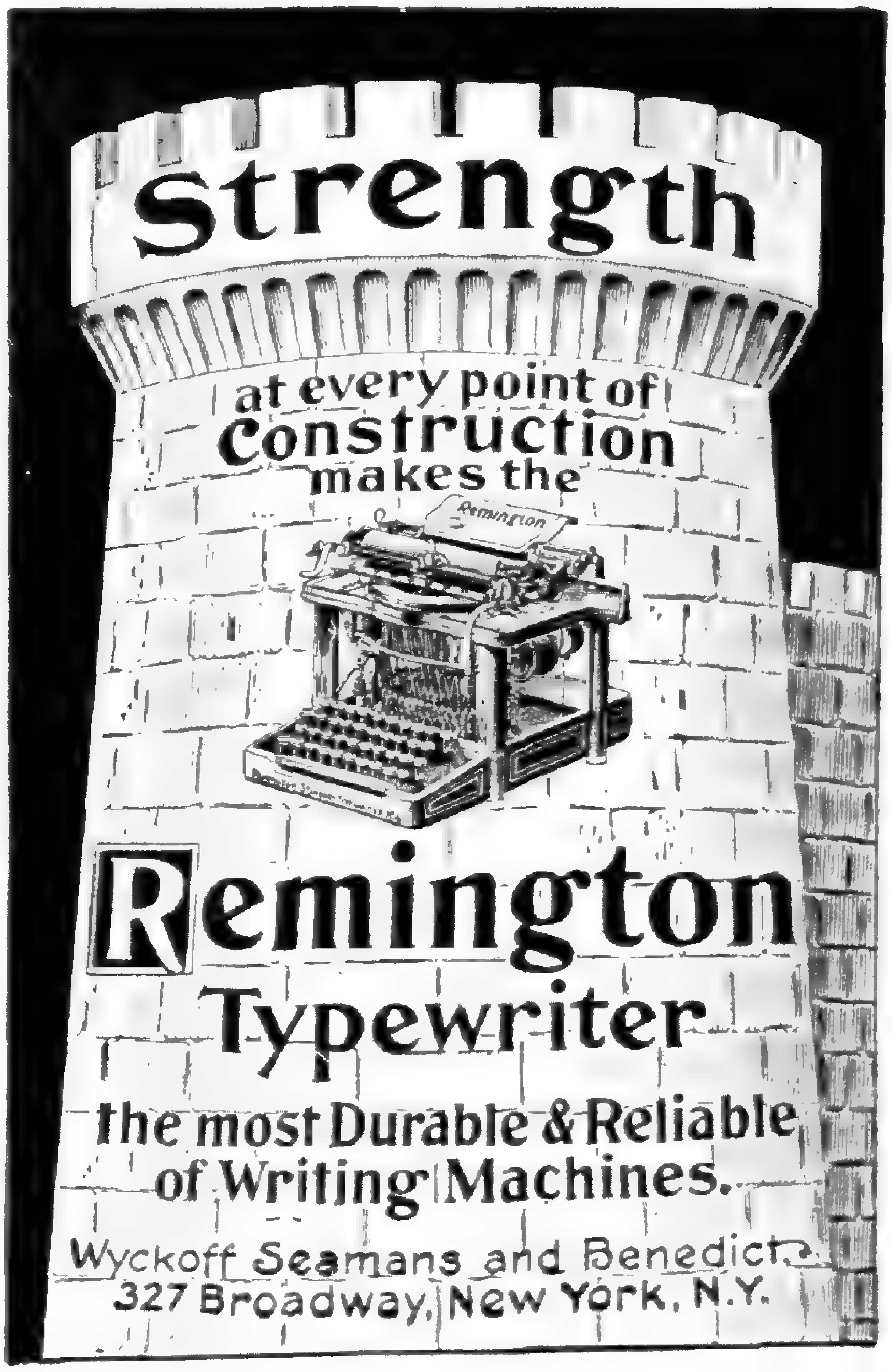

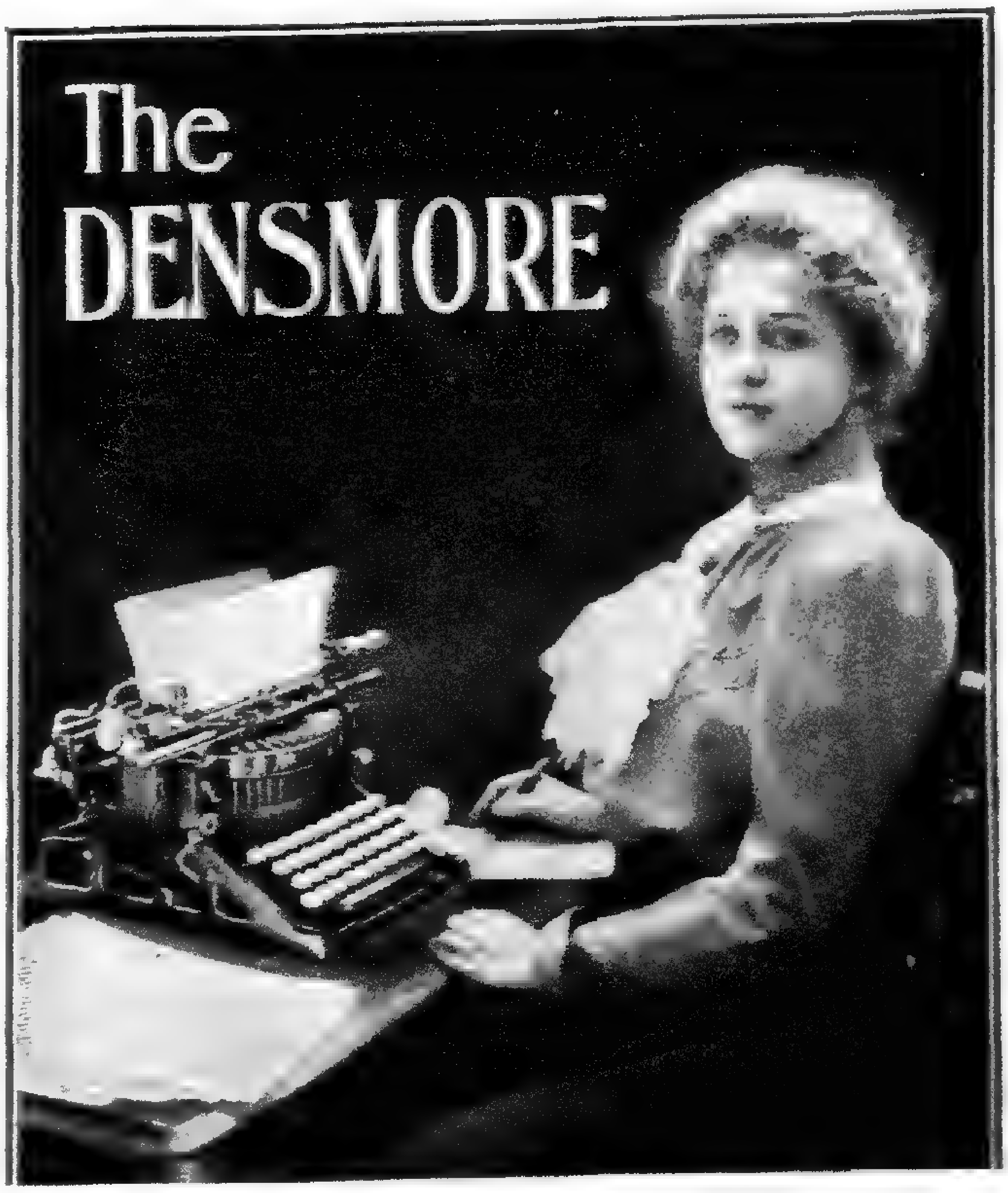

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BOTANICAL GAZETTE

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WITH OTHER MEMBERS OF THE BOTANICAL STAFF
OF THE UNIVERSITY OF CHICAGO

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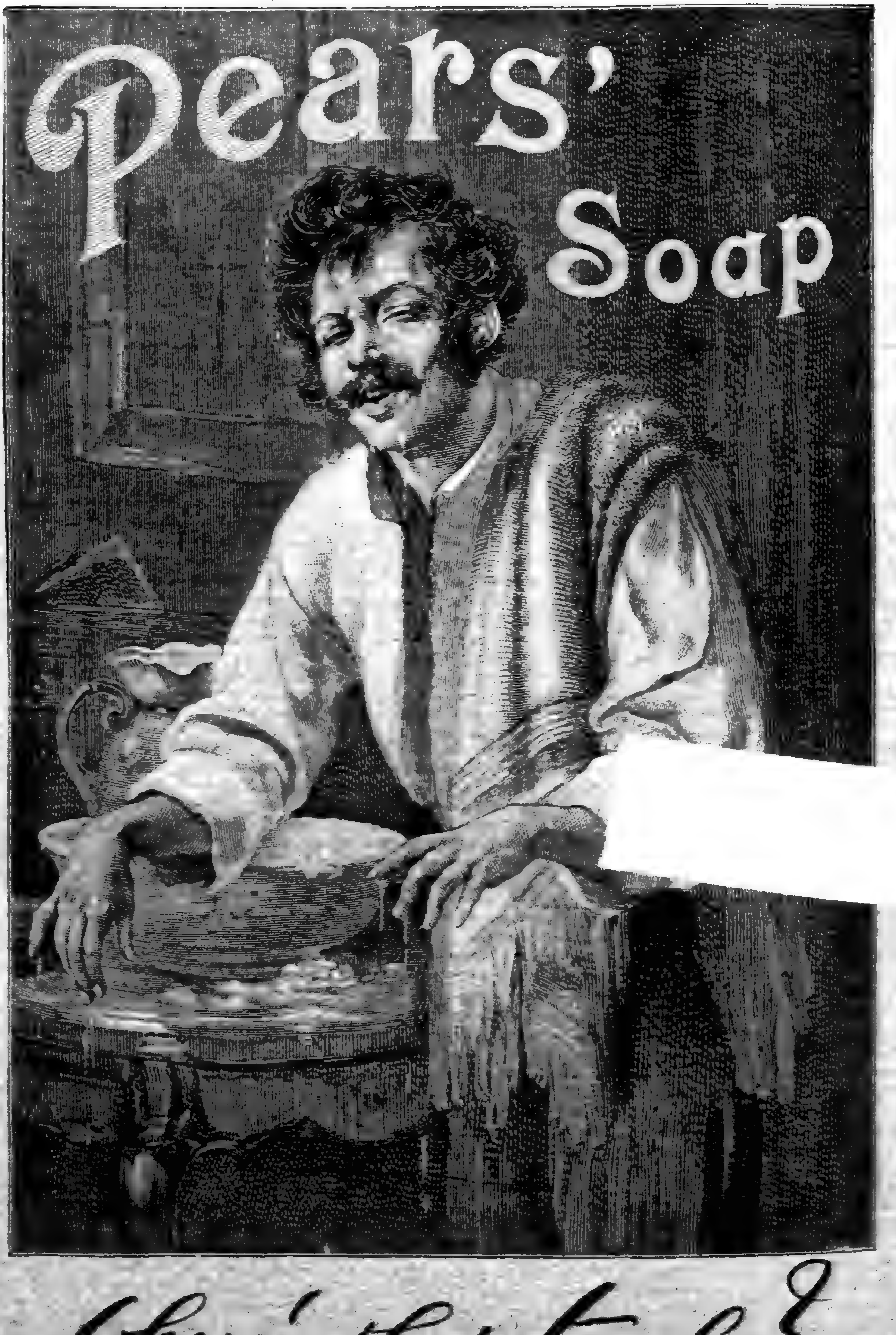
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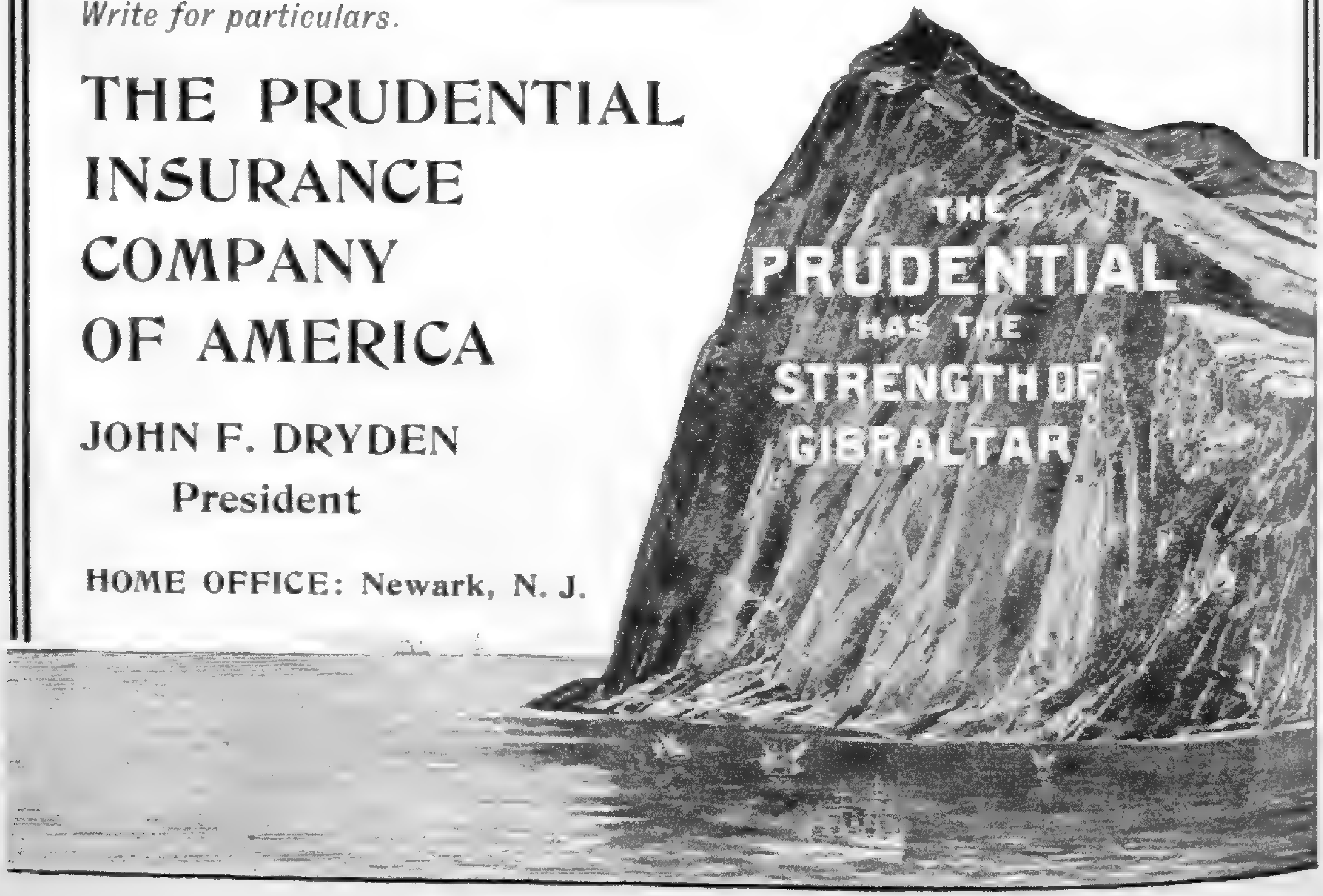
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VOLUME XXXI NUMBER 2

BOTANICAL GAZETTE

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THE PHYSIOGRAPHIC ECOLOGY OF CHICAGO AND VICINITY; A STUDY OF THE ORIGIN, DEVELOPMENT, AND CLASSIFICATION OF PLANT SOCIETIES.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. XXIV.

HENRY CHANDLER COWLES.

(WITH THIRTY-FIVE FIGURES.)

I. The content and scope of physiographic ecology.

WITHIN the last few years the subject of ecology has come to find a place of more or less importance wherever botany is studied in its general aspects. The limits of the subject, however, have not yet been defined, nor have many attempts been made to bring order out of the chaos which exists with regard to the arrangement of the subject-matter. The main purpose of the present paper is to suggest a classification of a portion of the ecological field.

Whatever its limits may be, ecology is essentially a study of origins and life histories, having two well-marked phases; one phase is concerned with the origin and development of plant structures, the other with the origin and development of plant societies or formations. The plant structure side again has two aspects, one viewing organs or plant forms as a whole, the other viewing the tissues which make up the organs; the former might be called organographic ecology or even organography, while the latter may be called ecological anatomy.

It may be well to speak more in detail concerning the distributional phase of ecology. There are two distinct aspects here also, the one local, the other regional. Climatic factors, particularly temperature and atmospheric moisture, permit the subdivision of the earth into great zones or regions with characteristic plant formations which extend over wide areas. Examples of this type are tropical evergreen forests, deserts in continental interiors, prairies, deciduous forests, arctic tundras. These formations are widespread because the factors that produce them are widespread. We might call these formations climatic formations (following Schimper[1]) and the subject that deals with them geographic ecology or ecological plant geography. In contrast with the above there are the local or edaphic factors, such as soil (including its moisture, air, and temperature relations), slope, light; in other words, factors that are largely due to the physiographic nature of the district. Where the climate is the same these factors produce marked changes locally, and there results a variety of plant societies, such as swamp, dune, bottom forest, river bluff, etc. These correspond to Schimper's[1] edaphic formations or Warming's plant societies, and the subject that deals with them may be called physiographic ecology.

In order to justify the terminology here given it will be desirable to trace briefly the history of the study of plant societies and then to depict the intimate relations which exist between the physiography of a region and its flora. Before the appearance of Warming's ecological plant geography[2] there had been no attempt to classify the plant formations of the globe in a systematic manner. Warming introduced the term plant society in place of plant formation, because of the varied use of the latter,

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[1] SCHIMPER, A. F. W.: Pflanzengeographie auf physiologischer Grundlage 173–176. Jena, 1898.

[2] WARMING, E.: Plantesamfund. Copenhagen, 1895. German edition, translated by Knoblauch. Berlin, 1896.

and made variations in the water content of the soil a basis of classification. Plant societies were divided into hydrophytes, mesophytes, and xerophytes; further than this, however, little attempt was made by Warming to subdivide the plant societies, except in the case of swamp and dune plants. In these two instances, as will appear later, Warming adopted the order of succession in his method of treatment.

Since Warming's great work appeared, ecologists have in general followed his ideas and have attempted to work them out. Noteworthy contributions have also been made which make a comprehensive view of the subject more possible. Schimper[3] has analyzed in a most thorough manner the conditions which determine the distribution of plants in the large, though he has discussed but briefly the purely local or habitat factors. We owe to him, however, the first clear statement of the distinction between edaphic and climatic factors and formations. The minuter treatment of the edaphic formations did not lie within his field, and he has attempted in no sense to give a classification, except in the case of climatic formations.

Graebner[4,5] has published a classification of some of the German vegetation formations, which has not received the attention it deserves. This classification is based in the main on the chemical and physical characteristics of the soil. The primary divisions are chemical, depending on the richness or poverty of the soil in plant foods. The secondary divisions are based chiefly on soil moisture.

N. H. Nilsson[6] in some preliminary notes on Swedish swamps and their vegetation called attention to the striking difference between hydrophytic and xerophytic swamps, and

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[3] *Op. cit.*

[4] GRAEBNER, P.: Gliederung der westpreussischen Vegetationsformationen. Schrift. Naturf. Ges. Danzig **9**: 43–74. 1898. See Bot. Centralb. **75**: 277–279. 1898.

[5] GRAEBNER, P.: Ueber die Bildung natürlichen Vegetationsformationen im norddeutschen Flachlande. Archiv der Brandenburgia **4**: 137–161. 1898. See Bot. Centralb. **77**: 212–214. 1899.

[6] NILSSON N. H.: Einiges über die Biologie der schwedischen Sumpfpflanzen. Bot. Centralb. **76**: 9–14. 1898.

gave expression to the view that differences in food supply may account for the facts observed. Schimper[7] has a somewhat similar view, but explains differences in the vegetation of various swamps more along the line of relative ease or difficulty of absorption in the swampy soils. Both Nilsson and Schimper regard peat bogs as essentially xerophytic.

In this historical sketch mention should be made of the work of Flahault[8,9], who has projected and begun to execute a detailed map of the plant societies of France. Conventional color tones are chosen for the various plant societies, and they are plotted on topographic contour maps. Robert Smith[10,11] had just entered upon a similar work in Scotland when death put a stop to his labors. So far as the author knows, Flahault has not concerned himself particularly as yet with the matter of classification. Alb. Nilsson[12] has recently published some interesting studies of Swedish plant societies, tracing the order of succession of vegetation on cliffs and moors. Still more recently Meigen[13] has published a series of short articles, tracing the order of succession in a number of plant societies. Besides the authors named thus far, Drude[14], MacMillan[15], and Pound and Clements[16] have given excellent treatments of the plant formations in their respective regions.

[7] *Op. cit.* 18.

[8] FLAHAULT, Ch.: Projet de carte botanique forestière et agricole de la France. Bull. Soc. Bot. France **41**: 56–94. 1894. Ann. de Géographie **5**: 449–457. 1896.

[9] FLAHAULT, Ch.: Essai d'une carte botanique et forestière de la France. Ann. de Géographie **6**: 289–312. 1897, etc.

[10] SMITH, ROBERT: On the study of plant associations. Nat. Sci. **14**: 109–120. 1899.

[11] SMITH, ROBERT: Botanical survey of Scotland. I. Edinburgh district. II. North Perthshire district. Scot. Geog. Mag. **16**: 385–416; 441–467. 1900.

[12] NILSSON, ALB.: Några drag ur de svenska växtsamhällenas utvecklingshistoria. Bot. Not. **1899**: 89–101; 123–135.

[13] MEIGEN, FR.: Beobachtungen über Formationsfolge im Kaiserstuhl. Deutsch. Bot. Monatsschrift **18**: 145–147, etc. 1900.

[14] DRUDE, O.: Deutschlands Pflanzengeographie, I. Teil. Stuttgart. 1896.

[15] MACMILLAN, C.: Observations on the distribution of plants along shore at Lake of the Woods. Minn. Bot. Stud. **1**: 949–1023. 1897.

[16] POUND and CLEMENTS: The phytogeography of Nebraska. I. General Survey. Lincoln. 1898.

During 1896 and 1897 the author of this paper, in company with his students, endeavored to classify the vegetation about Chicago in accord with Warming's principles. In 1898 a similar and more careful study of this kind was made in northern Michigan. It was of course found to be possible to classify the plant societies by the amount of water in the soil, but it was found that such a classification put together plant societies radically different in their character, and separated plant societies that were obviously closely related. The best instances of these difficulties were seen in the case of heaths and moors. Not only were heaths and moors found to have closely similar species and vegetative adaptations, but these plant societies were often found grading into each other. In water content these societies were very different, the peat moor or bog being hydrophytic and the heath xerophytic. Thus some factor other than water content is responsible for both. In that same year (1898) Nilsson and Schimper published their views on the causes of the xerophytic character of moor vegetation, as outlined above. Furthermore the vegetation of peat bogs is radically different from that of river swamps which have the same water content.

Further field study but added to the difficulties of the situation, and the need of another classification was keenly felt. It was seen at once that no one factor could take the place of the water content of the soil, since that is obviously the most important of all direct factors in distribution, as Warming so ably shows. An attempt was therefore made to relate the facts of distribution to combinations of factors, with the following results. The classification which is about to follow is based in the main on two ideas, viz., that a classification to be true must be genetic and dynamic. In other words, an attempt is made to group plant societies according to their relationship and their evolution.

The influences which govern the distribution of plants reside in the air or soil (regarding water as soil, for the sake of convenience). The atmospheric influences (light, heat, air) operate over wide areas and have subordinate edaphic importance, whereas the soil influences (soil heat, soil air, soil water, soil chemistry and physics) are of predominant edaphic importance, though of little account when distribution over wide areas is considered. We may say then that atmospheric or climatic factors determine distribution in the large, while local differences are produced by changes in the edaphic or soil factors.

The soil conditions are chiefly determined by the surface geology and the topography. The original character of the soil, whether rock, sand, clay, or marl, depends upon the geological relations. From the vegetation standpoint the topographic relations are commonly much more important, since they condition the presence or absence of drainage, and hence cause striking variations in air content and humus. Doubtless the characteristic features of peat bog vegetation are due to the absence of drainage and consequent poor aeration and accumulation of organic products. Moreover, in so far as the atmospheric factors have an influence on distribution locally, it is largely due to topographic diversities, such as angle and direction of slope.

Having related the vegetation largely to topography, we must recognize that topography changes, not in a haphazard manner, but according to well-defined laws. The processes of erosion ultimately cause the wearing down of the hills and the filling up of the hollows. These two processes, denudation and deposition, working in harmony produce planation; the inequalities are brought down to a base level. The chief agent in all these activities is water, and no fact is better established than the gradual eating back of the rivers into the land and the wearing away of coast lines; the material thus gathered fills up lakes, forms the alluvium of flood plains, or is taken to the sea. Vegetation plays a part in all these processes, the peat deposits adding greatly to the rapidity with which lakes and swamps are filled, while the plant covering of the hills, on the contrary, greatly retards the erosive processes. Thus the hollows are filled more rapidly than the hills are worn away. As a consequence of all these changes, the slopes and soils must change;

so, too, the plant societies, which are replaced in turn by others that are adapted to the new conditions.

There must be, then, an order of succession of plant societies, just as there is an order of succession of topographic forms in the changing landscape. As the years pass by, one plant society must necessarily be supplanted by another, though the one passes into the other by imperceptible gradations. Here then is a classification both genetic and dynamic, a classification which has a place for all possible ecological factors. It is based on the normal physiographic changes of a region and hence should be called a physiographic classification. One thing more must be recognized, and that is that environmental influences are normally cumulative. A plant society is not a product of present conditions alone, but the past is involved as well. For example, a hydrophytic plant society may be seen growing in a mesophytic soil; the author has seen a mesophytic tamarack swamp which can be explained only in this way. We have in this phenomenon a lagging of effects behind their cumulative causes, just as the climax of the heat in summer comes long after the solstice.

In a classification like this great emphasis is placed on border lines or zones of tension, for here, rather than at the center of the society, one can best interpret the changes that are taking place. Of course the order of succession referred to above is a vertical or historical one. One plant society is said to follow another if it is actually superimposed upon the one preceding. In many cases, if not in most, there is a horizontal order of succession at the present time that resembles the vertical succession of which we now have only the topmost member. Instances of similarity between vertical and horizontal orders of succession are well shown in peat swamps and along shores and flood plains. Along a sandy shore it is only by studying the horizontal succession that one can get any idea of the vertical, since all fossil traces of preceding plant societies have passed away. In peat swamps one can sometimes verify the results of a horizontal zonal study by investigating the fossil remains beneath

We may now outline the main features of a physiographic classification of plant societies. Speaking in the large, the tendency of the erosive processes is to reduce the inequalities of the topography and produce a base level. This base level may not soon be reached, though geological history furnishes instances of extensive base leveling. Crustal movements interfere with the erosive agencies and a mature base level topography may become rejuvenated by a great uplift of the land, or sinking on the other hand may check the rapid action of erosion. Yet even with the crustal movements there go these topographic changes and with them the plant societies must change. Putting the facts of physiography in the terms of ecology, the conditions become more and more mesophytic as the centuries pass. In a young topography, such as the recently glaciated areas of Michigan, Wisconsin, and Minnesota, there is a great variety of topographic conditions and of plant societies. Among these are many hydrophytic lakes and swamps and many xerophytic hills. The hills are being denuded and the swamps and lakes are being filled, so that the hydrophytic and xerophytic areas are becoming more and more restricted, while the mesophytic areas are becoming more and more enlarged. In passing from youth to old age then, a region gradually loses its hydrophytic areas and also its xerophytic areas, though in the latter case there is usually at first an increase in the xerophytic areas which is due to the working back of the young streams into the hills. The latter conditions are well shown in Iowa; in the comparatively recent Wisconsin drift of north-central Iowa the topography is much less diversified and there are fewer xerophytic areas than in the older Iowan drift farther south, which has been greatly dissected by stream erosion. Later, however, the inequalities are removed, and we find great mesophytic flood plain areas, such as are seen along the lower Mississippi.

From what has been stated it will be seen that the ultimate stage of a region is mesophytic. The various plant societies pass in a series of successive types from their original condition to the mesophytic forest, which may be regarded as the climax or culminating type. These stages may be slow or rapid; some habitats may be mesophytic from the start; undrained lakes and swamps fill up and become mesophytic with great rapidity, whereas granite hills might take many centuries or even geological epochs in being reduced to the mesophytic level. Again the stages may be direct or tortuous; we have already seen how the first consequences of stream erosion may be to make mesophytic areas xerophytic. So, too, in flood plains, the meanderings of the river may cause retrogressions to the hydrophytic condition such as are seen in oxbow lakes, or the river may lower its bed and the mesophytic flood plain become a xerophytic terrace. But through all these changes and counterchanges the great mesophytic tendency is clearly seen; mesophytic areas may be lost here and there but many more are gained, so that the approach to the mesophytic base level is unmistakable. Moreover, the retrogressive phases are relatively ephemeral, while the progressive phases often take long periods of time for their full development, especially in their later stages.

The above phenomena postulate congenial climates and more or less static crustal conditions. It is obvious, however, that erosive processes in a desert region do not result in a mesophytic flora; the same is true of alpine and arctic climates. Again, the climate of all regions is doubtless changing, as it has changed in past ages. So, too, there are crustal movements up and down. In other words the condition of equilibrium is never reached, and when we say that there is an approach to the mesophytic forest, we speak only roughly and approximately. As a matter of fact we have a variable approaching a variable rather than a constant. These conditions do not destroy the validity of a physiographic classification, but rather they require an enlargement of conception. Retrogressive phases, *i. e.*, away from the mesophytic and toward the hydrophytic or xerophytic, must be included, as well as progressive phases away from the hydrophytic or xerophytic and toward the mesophytic. In this way all possible conditions are accounted for. For example, upward crustal movements make hills more xerophytic and swamps more mesophytic, whereas downward movements make hills more mesophytic and swamps more hydrophytic. Thus in the upward movement of hills and the downward movement of swamps, physiographic processes are more or less neutralized and we may speak of retrogressive tendencies ; in the other two cases physiographic processes are accelerated and we have more rapid progress toward the mesophytic climax. If a climate grows colder or more arid, we find retrogressive tendencies toward the xerophytic condition, while in a climate that is getting more moist or more genial the mesophytic tendencies of the erosive processes are accelerated. Furthermore, climatic and crustal changes are commonly so slow in comparison with physiographic changes, that it is usually difficult to decipher their tendencies. We can be far more sure, in other words, with relation to the past and future of a topographic form and its plant societies, so far as erosion is concerned, than we can as to the actual effect that changing climatic and crustal conditions are making.

One other modification of the physiographic theory is necessary, as has been clearly shown by recent field studies. While changes in plant societies are certain to follow changes in topography, it does not necessarily follow that plant societies remain the same if topographic conditions remain unchanged. In other words, changes may take place in plant societies more rapidly than in the topography. A cycle of vegetation may be much shorter than a cycle of erosion. One of the most interesting cases of this is seen in a growing river system. In the ravine stage there may be a rapid change from the xerophytic to the mesophytic plant societies on the slopes. As the valley widens xerophytic conditions appear on the slopes once more. This first and relatively short-lived mesophytic condition may be called a temporary climax, in distinction to the more permanent climax of the base level.

In a study of plant societies such as this, it must be recognized that orders of succession are not the same in various regions. There is probably a close analogy between the various society life histories where climatic conditions are the same, but it remains true, nevertheless, that each region must be worked out by itself. The general principles that are involved in the dynamics of plant societies, however, ought to be essentially the same everywhere. Some instances will be given which will show the necessity for working out the life history of the plant societies in all regions. While the culminating type throughout the northern states east of the Mississippi river is probably a deciduous mesophytic forest, yet the elements of this forest differ greatly in different localities. In central Michigan the maple, beech, and the evergreen hemlock appear to be the leading character trees of the mesophytic forest. In Indiana and Illinois the hemlock is not one of the dominant trees of this forest. In the Alleghanies of Tennessee a large number of tree species assume a place of almost equal importance in the mesophytic forest. Again, in the Chicago region the tulip tree and buckeye are rare and confined to the flood plain forests, while in Tennessee these trees are found in many other plant societies. In the Chicago region the arbor vitae is confined to undrained swamps and xerophytic cliffs, while in northern Michigan it is found in many other habitats. We may perhaps summarize these data by saying that each species varies in habitat in different regions, and that in general a species can grow in the largest number of plant societies at its center of distribution, since there the climatic conditions favor it most highly. In other regions, especially near its areal limits, it can grow only in those plant societies which resemble most closely in an edaphic way the climatic features at the distribution center. Thus the tulip and buckeye, which flourish best in the mesophytic forest climate of the Alleghanies, are found near Chicago only in the most pronounced of our mesophytic societies, those of the flood plain. Again, the arbor vitae, and with it many conifers and heaths, grow near Chicago only on the cliffs and dunes or in the undrained swamps, since these are the most pronounced of our xerophytic habitats and most closely resemble the xerophytic northern climates.

A few words should be said in the way of indicating the relationship between this and other classifications. Warming's classification, based on the water relations, at two points agrees with the physiographic theory, viz., in the treatment of swamps and dunes. Each of these is treated from the standpoint of the order of succession as revealed by zonal distribution, though in the case of the dunes this order is not one of decreasing or increasing water content. Alb. Nilsson and Meigen (see above), and for that matter many other authors, have studied various plant societies from the standpoint of their order of succession, but so far as the author is aware no previous attempt has been made to establish a comprehensive theory on this basis. Graebner's classification (see above) has several points in common with the physiographic theory, especially as it relates heaths with moors. In this connection it will be of interest to refer to a paper by J. B. Woodworth[17] which indicates a fertile line of research that is but now being taken up by biologists. He shows how the base-leveling processes must influence the evolution of species, since these processes constantly erect new and destroy old barriers, and hence cause isolation in the one case and intermingling of species in the other. Woodworth gives a number of instances of the influence of base leveling upon animal life, and he refers, although but slightly, to the changes which must take place in the plant life as regions are uplifted or approach base level. It seems surprising that such a great field of study has been neglected until now. C. C. Adams, in a paper as yet unpublished, and C. T. Simpson[18] have recently given special cases of the interrelations between physiographic changes and animal distribution.

The general principles of the physiographic theory have been developed as a result of studies in various sections of the country. Since 1898, when the author first began to work along these physiographic lines, the main thought has been to subject

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[17] WOODWORTH, J. B.: The relation between base-leveling and organic evolution. Am. Geol. **14**: 209–235. 1894.

[18] SIMPSON, C. T.: On the evidence of the Unionidae regarding the former course of the Tennessee and other Southern rivers. Science N. S. **12**: 133–136. 1900.

the theory to the most rigid test possible. In connection with a number of students, investigations have been carried on about Chicago, in northern Michigan, in Tennessee, and along the Atlantic coast. In all cases it has been possible to find a general consonance between the facts of distribution and the principles as stated above. The theory has suffered many modifications since its first conception, and doubtless it will suffer more. Indeed, it may be discarded altogether for some other better theory. Nevertheless, publication at this time seems to be justified, and it is hoped that this paper may aid in solving some of the riddles of ecology.

The author especially wishes to mention in this place the work of his student and associate, Mr. H. N. Whitford, who has in preparation a physiographic study of the forests of northern Michigan. The author is likewise especially indebted to another of his students, Mr. W. B. McCallum, who has taken all of the photographs with which this paper is illustrated, with the exception of *figs. 7* and *13*, which were contributed by Professor J. J. Allison, of Joliet. Acknowledgment should also be made of the help given by three excellent papers which deal with the general physiographic and geographic features of the Chicago area. To these works by Leverett,[19] Blatchley,[20] and Salisbury and Alden[21] the author has made constant reference. The author has likewise freely used the work of Higley and Raddin.[22]

In the following pages the various series of the Chicago area are discussed in some detail. Two general groups are made, the inland and the coastal. The inland group is subdivided into three series, river, swamp, and upland. The coastal group is subdivided into two series, lake bluff and dune. The river series

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[19] LEVERETT, F.: The Pleistocene features and deposits of the Chicago area. Chicago, 1897.

[20] BLATCHLEY, W. S.: The geology of Lake and Porter counties, Indiana. Reprint from the Twenty-second Annual Report of the Department of Geology and Natural Resources of Indiana. Indianapolis, 1897.

[21] SALISBURY, R. D., and ALDEN, W. C.: The geography of Chicago and its environs. Chicago, 1899.

[22] HIGLEY, W. K., and RADDIN, C. S.: The flora of Cook county, Illinois, and a part of Lake county, Indiana. Chicago, 1891.

is remarkably tortuous, involving constructive and destructive, progressive and retrogressive phases. The treatment begins with an erosion gully; then there follow in order the ravine, both in clay and in rock, the xerophytic bluff, and the mesophytic forest. The depositional phases of the river begin with the appearance of a permanent stream; then follow the various stages of the flood plain culminating in the mesophytic forest. The swamp series begins with the pond, treats next the various types of swamps and ends with a brief discussion of the prairie. In the upland series the various stages of the rock hills and then of the clay hills are taken up in turn, culminating in the mesophytic forest. The coastal group is next discussed, beginning with the lake bluff. Finally, there is a brief treatment of the dune series from the beach on through the embryonic and active dune to the established dune on which there finally appears the mesophytic forest.

II. The plant societies.

A. The inland group.

I. THE RIVER SERIES.

A. *The ravine.*—No topographic forms lend themselves so well to a physiographic sketch of the vegetation as do those that are connected with the life history of a river. Beginning with the ravines, which are deep and narrow, because of the dominance of vertical cutting, we pass to the broader valleys, where lateral cutting becomes more pronounced. From this stage on we have to deal with two phases of river action, the destructive, which is concerned with the life history of the bluff, and the constructive, which has to do with the development of the flood plain.

Wherever there is an elevated stretch of land adjoining a body of water, such as a lake bluff, one is apt to find excellent illustrations of the beginning of a ravine. *Fig. 1* shows an embryonic ravine of a type that may be seen frequently along the clay bluffs between Evanston and Waukegan. A ravine of this type is essentially a desert, so far as plant life is concerned.

The exposure to wind and to alternations of temperature and moisture is excessive. The lack of vegetation, however, is due chiefly to the instability of the soil; this instability is particularly great in the case of clay bluffs such as these, where the seepage of water causes extensive landslide action. No plants can get a foothold in such a place, unless it be a few species that may be able to make their appearance between periods of landslide action; among these plants annuals particularly predominate. The perennials that may be found in such places are almost entirely plants which have slid down the bank. Near the center of *fig. 1* is a clump of shrubs that has slid down in this way. Ravines of a similar type may also be seen at many places inland, and wherever found the poverty of vegetation on the slopes is the most striking character.

As a ravine extends itself inland the conditions outlined above may be always seen about its head, but toward the mouth of the ravine the slopes are less precipitous. Torrents cut down the bed of the ravine until a depth is reached approaching the water level at its mouth. From this time on the slopes become reduced and the ravine widens more than it deepens, by reason of lateral cutting, landslide action, and side gullies. After a time a sufficient stability is reached to permit a considerable growth of vegetation. If the erosion is slight enough to allow a vegetation carpet to develop, a high degree of luxuriance may be attained. In fact ravine conditions are usually extremely favorable for plants, after the initial stages have passed. In a comparatively few years the vegetation leaps as it were by bounds through the herbaceous and shrubby stages into a mesophytic forest, and that, too, a maple forest, the highest type found in our region. Nothing shows so well as this the brief period necessary for a vegetation cycle in a favored situation when compared with an erosion cycle.

Of such interest are the facts just noted that it is worth while to mention some of the characteristic ravine plants. Perhaps the most characteristic trees of the Glencoe ravines are the basswood (*Tilia Americana*) and the sugar maple (*Acer saccharinum*), though the ash, elm, and other trees are frequent. The most characteristic undershrub is the witch hazel (*Hamamelis Virginiana*). The herbaceous plants are notoriously vernal forms, such as Hepatica, Thalictrum, Trillium, Mitella, Dicentra, Sanguinaria; mosses abound and liverworts are frequent. A ravine with the above vegetation is shown in *fig. 2*. We can explain this flora only by regarding it as having reached a temporary climax. Ravine conditions are more favorable for plants than those that precede or follow. The instability and exposure of the gully have gone; in their place there is protection from wind and exposure. The shade and topography favor the collection and conservation of moisture, and as a result there is a rapid development into a high-grade forest, as outlined above.

Rock ravines are much less common in the Chicago area than are those of clay, since the underlying limestone rarely comes near the surface. Excellent illustrations of stream gorges are to be seen at Lockport, and also in various tributaries of the Illinois river near Starved rock. A striking difference between these rock gorges or cañons and the clay ravines is in the slope of the sides. The physical nature of the rock excludes landslide action, hence the sides are often nearly vertical for a long time. Lateral cutting is also relatively slow as compared with clay. Thus the conditions for vegetation at the outset are much more favorable than in a clay ravine. Rock-bound gorges are very shady and often dripping with moisture, hence liverworts and many mosses find here a habitat even more congenial than in the clay. Among the higher forms are found the most extreme shade plants that we have, such as Impatiens, Pilea, and shade-loving ferns, plants whose leaves are broad and remarkably thin. *Figs. 3* and *4* represent cañons of the above description, whose rocks drip with moisture.

The stages of development pass much more slowly in cañons than in clay ravines, largely because the primitive conditions of shade and moisture remain for a long period of time. Nor do the steep slopes permit the development of a wealth of trees and shrubs, since a secure foothold is not easily found. However, as the cañon broadens out and the slopes become less steep, shrubs and trees come in, though a typical mesophytic forest is rarely seen. The Starved rock ravines are cut in St. Peters sandstone, those at Lockport in the Niagara limestone, yet the vegetation in the two places is essentially alike; at any rate the resemblances are greater than the differences. Much has been written on the physical and chemical influences of rocks upon the vegetation. The facts seen here seem to show that the physiographic stage of a region is more important than either. The flora of a youthful topography in limestone, so far as the author has observed, more closely resembles the flora of a similar stage in sandstone than a young limestone topography resembles an old limestone topography. A limestone ravine resembles a sandstone ravine far more than a limestone ravine resembles an exposed limestone bluff or a sandstone ravine resembles an

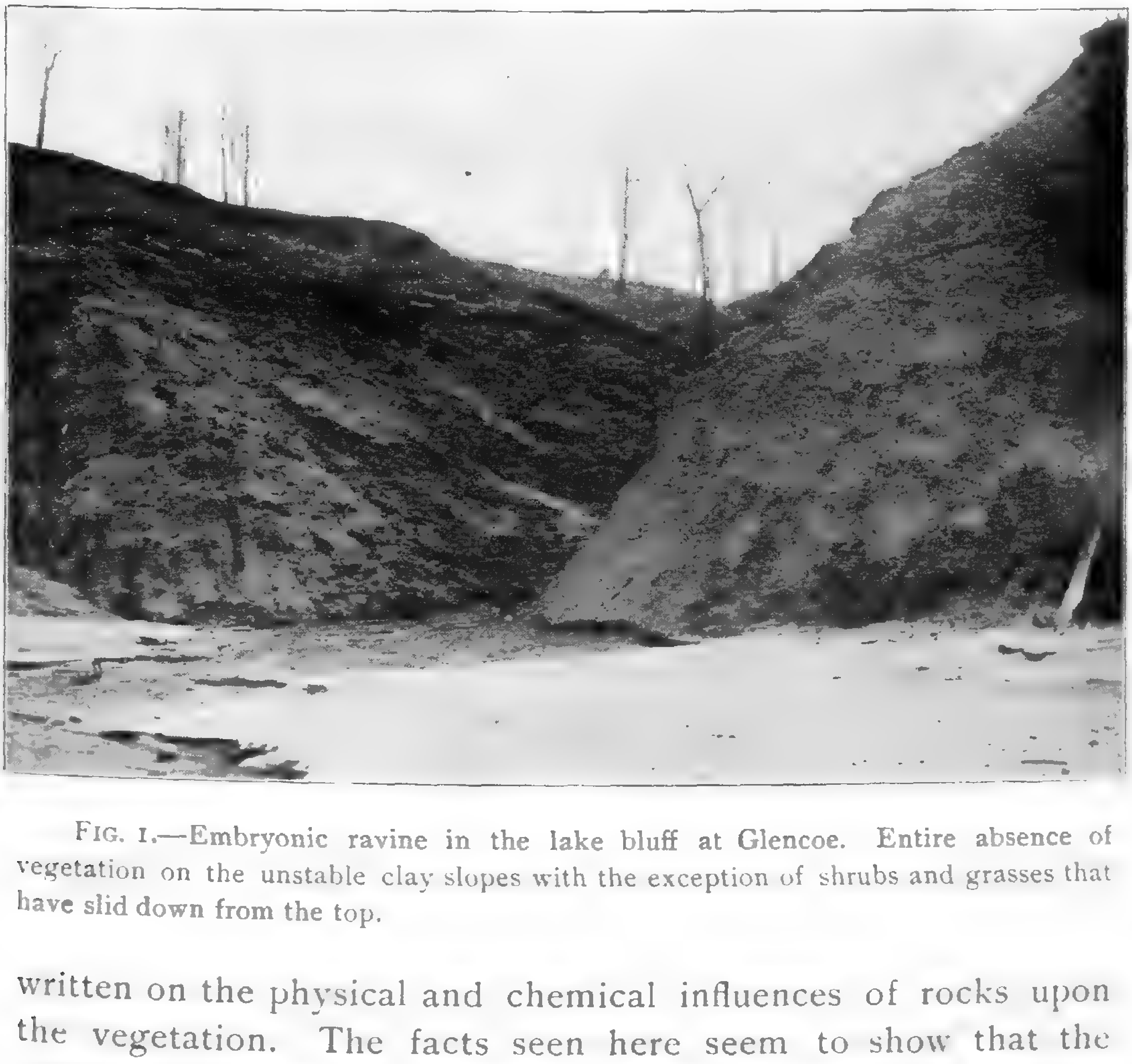

FIG. 1.—Embryonic ravine in the lake bluff at Glencoe. Entire absence of vegetation on the unstable clay slopes with the exception of shrubs and grasses that have slid down from the top.

exposed sandstone bluff. We may make the above statements in another form. Rock as such, or even the soil which comes from it, is of less importance in determining vegetation than are the aerial conditions, especially exposure. And it is the stage in the topography which determines the exposure.

All of the preceding statements as to topographic stages, whether young or old, refer not to times but to constructional forms. Two ravines, equally youthful from the topographic standpoint, may differ widely as to actual age in years or centuries, since erosion is more rapid in one rock than in another. In our region, however, elements of actual time are not very important, except as between rock and clay, since the limestone is less soluble and the sandstone is more easily eroded than is often the case.

FIG. 2.—Ravine at Glencoe with a mesophytic forest vegetation on the slopes (temporary climax). Presence of erosive forces indicated by leaning trees. Water in the stream bed only after rains.

B. *The river bluff.*—As a valley deepens and widens, the conditions outlined above undergo radical changes. From this point it will be necessary to discuss two phases in the growing river, the bluff phase and the bottom phase. We have left the clay ravine bluffs in a state of temporary climax, clothed with luxuriant mesophytic forest trees and with a rich undergrowth of vernal herbs. More and more the erosive processes are conspicuous laterally, and widening processes prevail over the more primitive deepening. As a result, the exposure to wind, sunlight, and changes of temperature increases; the moisture content of the slopes becomes less and less. The rich mesophytic herbs, including the liverworts and mosses, dry up and die. The humus oxidizes more rapidly, and a xerophytic undergrowth comes in. In place of Hepatica and its associates, we find Antennaria, *Poa compressa*, *Equisetum hyemale*, and other xerophytic herbs; Polytrichum also replaces the mesophytic mosses. The first signs of the new xerophytic flora are seen at the top of the ravine slope; indeed the original xerophytic plants may never have been displaced here by the ravine mesophytes. As the ravine widens, the xerophytic plants creep down the slope, often almost to the water's edge. Some of the young ravines between Evanston and Waukegan show xerophytes at the summits of the slopes. *Fig. 5* shows a

FIG. 3.—Head of a cañon in the St. Peters sandstone at Starved rock. Erosive forces prominent, and vegetation slight on the dripping slopes.

widening ravine at Beverly hills; the vegetation is much less luxuriant than that shown in the young ravine of *fig. 2*.

After a few years have passed, xerophytic shrubs appear on the bluff in place of the witch hazel and its associates. And it is not long until xerophytic or semi-xerophytic thickets prevail, in place of the former mesophytic undershrubs. Among the more characteristic of these shrubs are the hop tree (*Ptelea trifoliata*), bittersweet (*Celastrus scandens*), sumachs (*Rhus typhina* and *R. glabra*), choke cherry (*Prunus Virginiana*), nine-bark (*Physocarpus opulifolius*), wild crab (*Pyrus coronaria*). Two small trees are common on stream bluffs, the service berry (*Amelanchier Canadensis*) and the hop hornbeam (*Ostrya Virginica*); this last species is perhaps the chief character tree of river

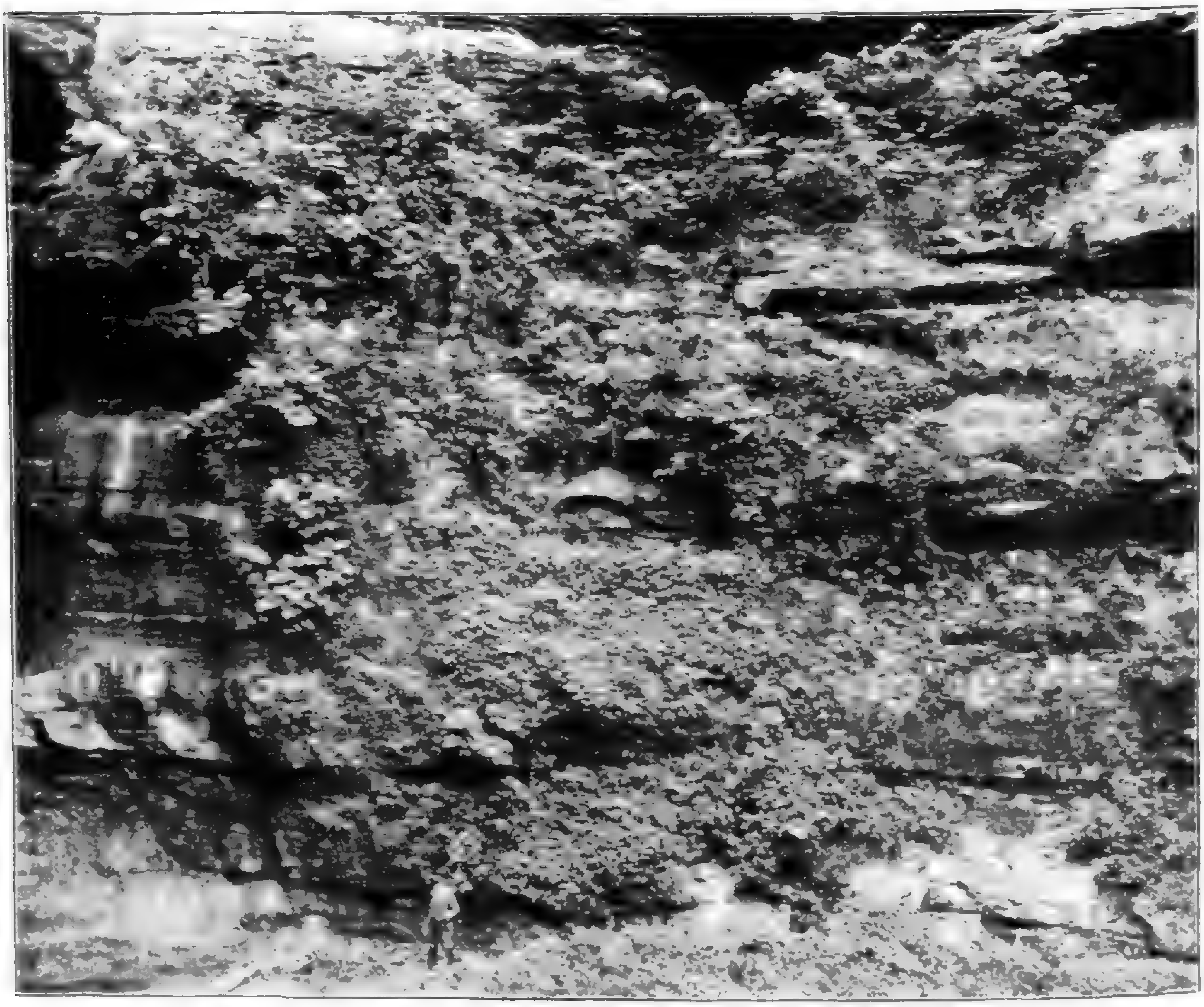

FIG. 4.—Side of a cañon in the St. Peters sandstone at Starved rock. Herbaceous shade vegetation on the precipitous slopes.

bluffs and is rarely absent. Perhaps the best examples of xerophytic stream bluffs near Chicago are along Thorn creek. One of the most interesting things about these bluff societies is the frequent presence of basswoods and sugar maples. Doubtless these trees look back to the mesophytic associations that have otherwise disappeared. As would be expected, the last of the mesophytes to die are trees, because they are longer lived than herbs and shrubs, and also because their roots reach down to the moisture. But they cannot be succeeded by their own kind, inasmuch as the critical seedling stages cannot be passed successfully.

FIG. 5.—Open ravine at Beverly hills, showing gentle slopes covered with a less mesophytic vegetation than is shown in *fig. 2*. Dominance of oaks in place of maples and basswoods.

The life history of the rock ravines or cañons is somewhat different. When the ravine vegetation is at its height, the moisture and shade are greater here than in the clay, hence the high development of liverworts and their associates. As the ravine widens these extreme shade forms are doubtless driven out almost immediately by xerophytes, since intermediate or mesophytic conditions are seldom seen where the soil is rock. Furthermore, the xerophytic conditions become much more extreme on rock bluffs than on clay bluffs. This is well illustrated at Starved rock (*fig. 6*), where the dominant tree vegetation is coniferous, consisting especially of the white pine (*Pinus Strobus*) and the arbor vitae (*Thuya occidentalis*). The herbs and undershrubs here are also pronouncedly xerophilous, resembling the vegetation of the sand dunes, *e. g.*, *Selaginella rupestris*, *Campanula rotundifolia*, *Pellaea atropurpurea*, *Talinum teretifolium*, *Opuntia Rafinesquii*, etc. The entire bluff flora down to the river's edge is xerophytic, except in shaded situations.

FIG. 6.—Xerophytic bluff of St. Peters sandstone at Starved rock, on the Illinois river, showing conifers and other plants of dry rocks. Influence of erosive forces seen at the base.

When a stream in its meanderings ceases to erode at the base of a bluff, increased opportunity is given for plant life. Through surface wash the slopes become more and more gentle. Mesophytic vegetation comes in at the foot of the bluff and creeps up as the slopes decrease. Finally the xerophytes are driven from their last stronghold, the top of the slope, and the mesophytes have come to stay, at least until the river returns and

FIG. 7.—Ravine in the Niagara limestone at Lockport, showing the beginnings of a flood plain.

enters upon another stage of cliff erosion. The growth of a ravine into a valley with xerophytic bluffs is rapid, when expressed in terms of geology, but far less rapid when expressed in terms of vegetation. A ravine in the vigor of youth may develop so slowly that forest trees may grow to a considerable size without any perceptible change in the erectness of their trunks. Thus in *figs. 2* and *5* it will be seen that most of the trees stand approximately vertical. But the activity of the erosive forces, slow as it may be, is nevertheless revealed by occasional leaning or even falling trees. From the above it is easy to understand that cycles of vegetation often pass much more rapidly than cycles of erosion, but never more slowly. During one erosion cycle the mesophytic forest develops at least twice, once on the ravine slopes and then finally on the gentler slopes that betoken approach toward base level.

FIG. 8.—General view of the Illinois valley near Starved rock, showing islands and an extensive flood plain with trees along the margin. Young islands in the foreground, older islands in the background.

C. *The flood plain.*—We may now follow the successive stages in the development of the flood plain vegetation. While the ravine is still young, as in *fig. 2*, there is no permanent stream, but merely torrents which remain but a short time. As the ravine deepens, widens, and lengthens, thus approaching the underground water level and increasing the drainage area, the water remains for a longer and longer time after each rainfall. As the ravine conditions thus become more and more hydrophytic, the original flora, perhaps of shade mesophytes (as Impatiens), becomes replaced by amphibious shade plants, such as the common buttercup (*Ranunculus septentrionalis*), *Plantago cordata*, various mosses, etc. Together with these forms algae of short vegetative period may be found in the wet seasons. When the ravine at last is sufficiently developed to have a permanent stream, a definite hydrophytic flora appears, consisting largely of algae (*e. g.*, Batrachospermum), aquatic mosses, and seed plants with finely dissected leaves and strong holdfast roots (such as Myriophyllum), though these latter plants are more characteristic of ponds. In the early phases of a stream, the currents are rapid and the vegetation (apart from lower forms) is sparse, by reason of the difficulty which plants have in securing and retaining a foothold on the stream bed. This difficulty is due to the rapid erosion and consequent instability of the substratum, as well as to the direct destructive action of the currents. *Fig. 7* shows one of these young streams, whose flora is sparse.

FIG. 9.—Young island in the Illinois river at Starved rock (close view of island in foreground of *fig. 8*), seen from above, and showing the destructive action of the river.

Springs and spring brooks may be classed with ravine streams, but differ from them in the relative absence of erosion phenomena. This type of stream is uncommon in the Chicago area, though there are a few spring brooks near Chesterton. The water supply is much more constant than in ravine streams, and the shade of the ravines is often lacking. Besides the aquatics there may be mentioned a characteristic brookside flora, including such plants as *Symplocarpus foetidus*, *Asclepias incarnata*, *Chelone glabra*, *Polygonum sagittatum*, and two or more species each of Eupatorium, Lobelia, Mentha, Lycopus, and Bidens. The most characteristic spring brook shrub is the alder (*Alnus incana*), though the extensive northern development of alder thickets has no parallel here.

FIG. 10.—Same island as shown in *fig. 9*, but seen from below, and showing the constructive action of the river. Naked sand bar recently formed at the lower end of the island (left hand), Ambrosia farther toward the right, willows on the older part of the island (extreme right).

As the energy of the developing stream is checked, the conditions for plant life become more favorable. In the quiet pondlike waters of an older stream there may be found many of the aquatics that frequent the ponds and lakes. In fact the flora that is given later as characteristic of half-drained ponds and lakes (such as Calumet lake) may be transferred almost bodily to sluggish streams, such as the Calumet and Desplaines rivers.

When streams are old enough and therefore slow enough to support a pond vegetation, they have become essentially depositing rather than eroding streams, and we find there the development of a flood plain. While the river is still confined within narrow walls and may thus be called young, there may be embryonic patches of flood plain, representing alternations of erosion and deposition in the stream. *Fig. 7* shows such a condition of affairs; though the stream is young and more destructive than constructive at that point, there are to be seen small flood plain areas with their typical tree inhabitants.

FIG. 11.—Flood plain of the Desplaines river at Glendon park, showing encroachment on the river. Willows in the foreground, cottonwoods farther back.

There is no place where flood plain development can be better studied than on growing islands in relatively rapid and yet essentially depositing streams, such as the Illinois river at Starved rock. *Fig. 8* gives a general view of the Illinois islands and flood plain. In *figs. 9* and *10* the lower island (foreground of *fig. 8*) is seen close at hand. Any obstacle, such as a partially submerged tree trunk, serves to check the river current and cause a deposition of sand or silt, and before long a sand bar originates. As in the case of a sand dune, the bar itself becomes an obstacle to the currents and hence continually grows larger. The first vegetation, as on the lake beach, consists largely of annuals, especially the giant ragweed (*Ambrosia trifida*); rushes and sedges, some annual and some not, are also present but are less conspicuous. The perennials that manage to survive one season are largely washed away in the winter and spring, so that in reality the vegetation is almost exclusively annual. The first woody plants to get a more or less permanent foothold here are willows (*Salix nigra* and *S. longifolia*).

FIG. 12.—Mesophytic flood plain forest in the bottoms of the Desplaines river at Riverside. Elms and basswoods. Rich herbaceous vegetation, consisting largely of Phlox.

While islands of the above type gain more soil than they lose, a comparison of *figs. 9* and *10* shows that the river erodes above and deposits below. As a consequence these islands migrate down the river, as well as grow in area year by year.

Hence the upper part of the island is the oldest, as the vegetation well shows. *Figs. 8* and *10* show at the lower end the sand bar, which comes to a point and is so young or so exposed to submergence as to be barren of vegetation. Next comes the Ambrosia, then the willows, and finally a characteristic flood plain forest (background of *fig. 8*). The asymmetry of the river island vegetation is in striking contrast with the zonal symmetry of pond islands, as will be shown later (*fig. 19*). The cause is evident, viz., the relative lack of symmetry in river currents as compared with pond currents.

FIG. 13.—Flood plain forest along Fraction run at Lockport, showing a rather striking collection of southern trees (see text). Coffee tree in the foreground.

The gradual encroachment of the land upon a stream through continuous deposition is well shown along the Desplaines river, and to a less complete degree along the Chicago river and Thorn

sloughs along
mississi

creek. In the Desplaines bottoms the sand bar and island formations of the Illinois are largely absent, the currents being much less rapid. In the shallow water near the margin of the river are various hydrophytes, such as Sagittaria, *Rumex verticillatus*, etc. The outermost fringe of land at ordinary low water is often almost as barren of vegetation as are the islands, but the soil is fine and hence makes a mud flat instead of a sand bar. Immediately after the spring freshets have gone, an alga vegetation is frequently found on these flats, consisting especially of Botrydium and Vaucheria. Later in the season annuals, or even scattered perennials, may occur here, though the winter and spring floods uproot or bury most of this vegetation. The Ambrosia and willow vegetation soon appear as described above. The river maple (*Acer dasycarpum*) usually appears with or soon after the willows. After the willows the cottonwood (*Populus monilifera*) and the ash (*Fraxinus Americana*) soon come in. *Fig. 11* shows an advancing flood plain of this type; willows are seen on the margin and cottonwoods farther back.

FIG. 14.—Flood plain of the Calumet river near Chesterton, showing the beginnings of terrace formation, indicated more by the falling elm than by the topography.

Gradually the growing flood plain becomes dry enough to permit the germination and development of a true mesophytic flora. The trees named above, especially the willows, are largely replaced by others that seem better adapted to the changed conditions; among these are the elms (*Ulmus Americana* and *U. fulva*), the basswood (*Tilia Americana*), the walnut and butternut (*Juglans nigra* and *J. cinerea*), the pig-nut (*Carya porcina*). In this rich flood plain forest there are many lianas climbing over the trees, *e. g.*, greenbrier (*Smilax hispida*), grape (*Vitis* spp.), Virginia creeper (*Ampelopsis quinquefolia*), and poison ivy (*Rhus Toxicodendron*).

FIG. 15.—Terrace in the flood plain of the Desplaines river at Glendon park showing how a mesophytic flood plain may become xerophytic. The opposite bank shows deposition and flood plain enlargement (*fig. 11*).

The undergrowth in these river woods is very dense and luxuriant, the alluvial character of the soil making it very fertile. Among the shrubs are the thorns (various species of Crataegus), the gooseberry (*Ribes Cynosbati*), and many others. The herbaceous vegetation is dominantly vernal, the shade being too dense for a typical estival flora. Prominent among the spring flowering herbs are *Trillium recurvatum*, *Phlox divaricata*, *Polemonium reptans*, *Hydrophyllum Virginicum*, *Mertensia Virginica*, *Collinsia verna*, *Claytonia Virginica*, *Erythronium albidum*, *Arisaema triphyllum* and *A. Dracontium*, *Nepeta Glechoma*, *Isopyrum biternatum*, *Caulophyllum thalictroides*, *Viola cucullata*, *Galium Aparine*. Other characteristic herbs are the nettles (*Urtica gracilis*, *Laportea Canadensis*), various umbellifers (Heracleum, Cryptotaenia, Sanicula, Osmorrhiza), and the parasitic dodder (*Cuscuta Gronovii*). *Fig. 12* shows a characteristic mesophytic flood plain forest along the Desplaines river; underneath the elms and basswoods is seen a rich herbaceous flora, consisting largely of Phlox, which the picture shows in full bloom.

FIG. 16.—An oxbow lake in the flood plain of Thorn creek. The willows are subsequent, dating back to a stream margin, while the shrub (Cephalanthus) and herb vegetation is associated with the present undrained condition.

In some of the bottom lands there is a rather striking collection of trees, whose chief range is mainly southward. *Fig. 13* shows a flood plain tree group near Lockport, most of whose members are largely southern, viz., the coffee tree (*Gymnocladus*

Canadensis), seen in the foreground, the papaw (*Asimina triloba*), the sycamore (*Platanus occidentalis*), and the hackberry (*Celtis occidentalis*). In other flood plains there may be found the mulberry (*Morus rubra*), the red bud (*Cercis Canadensis*), the buckeye (*Aesculus glabra*), and the tulip (*Liriodendron Tulipifera*). None of these trees are common in our district, and only Celtis may be regarded as frequent. These relatively southern trees are found not only along the Desplaines and its tributaries, where there is supplied a continuous habitat along the river southward, but also along the Calumet and its tributary, Thorn creek. The occurrence of the tulip tree is full of interest, since it has been found thus far chiefly (perhaps only) in the vicinity of the dunes. Its occurrence has been noted especially at Chesterton along a small stream which empties into Lake Michigan at that point; the tulip tree has also been found away from present streams, but apparently in old valleys whose streams have been diverted by dune activity. The confinement of these southern

FIG. 17.—A dead oxbow lake in the flood plain of Thorn creek. A willow still remains at the right, while the shrubs (Cephalanthus) have closed in upon the lake.

trees to flood plains is not strange, since in such habitats are given the most congenial conditions that can be found in our area.

The vegetation on flood plains is not always as described above. Sometimes meadows are found instead of forests; this condition is particularly well shown along Thorn creek. *Fig. 18* shows a stretch of meadow of this type. Besides various grasses (such as *Poa pratensis* and *Agrostis alba vulgaris*), there are often other plants in abundance, *e. g. Thalictrum purpurascens, Fragaria Virginiana, Anemone Pennsylvanica*. The ecological meaning of the meadow is not clear. Probably mowing or grazing is responsible for the failure of a mesophytic forest to develop. Extensive thorn (Crataegus) thickets sometimes occur in these meadows and probably betoken the beginning of a mesophytic forest. Extensive and apparently natural meadows are found in the Calumet valley.

FIG. 18.—Flood plain of Thorn creek near Glenwood, showing a meadow instead of a forest. At the center is an uneroded island, detached from the morainic mainland, seen at the left. The vegetation of the island is similar to that of the morainic uplands.

As we have seen, the climax type of vegetation on the flood plain is the mesophytic forest, but here, as well as on the river bluffs, the climax may be but temporary. Retrogression is almost sure to come in connection with terrace formation. While it is true that deposition is the main feature of flood plains, it is also true that erosion has not ceased; the downward cutting of the river once more causes vertical banks, though this time in its own flood plain. This action is seen in *fig. 14* which shows the beginning of the new erosive phase, and its indication in the falling elm. There has doubtless been lateral erosion here also, since elms are not usually marginal trees. *Fig. 15* shows the erosion of the flood plain still farther advanced; this bank is just opposite the willow vegetation shown in *fig. 11*, hence there is deposition on one side and cutting on the other. A river may thus swing quite across its flood plain, destroying all that it has built, including the mesophytic forest. Not only is the vegetation destroyed directly, as shown in *fig. 14*, but also indirectly, since the lowering of the river causes the banks to become more xerophytic. In place of the herbaceous mesophytes, Equisetum and other relatively xerophytic forms may appear, though the trees usually live until directly overthrown by the river.

One more phase of river activity may be briefly sketched. In meandering over a flood plain, serpentine curves or oxbows are frequently formed. In time the river breaks across the peninsula and the oxbow remains as a crescentic lake. The conditions radically change almost immediately, and the river life is replaced by pond life. The change is even more striking on the margins, where the old plants pass away and the forms of undrained swamps come in. *Fig. 16* shows the remnant of one of these oxbows; on the farther side are old and dying willows, trees that look back to the well drained river margin. On either side of the pond are seen clumps of the button bush (*Cephalanthus occidentalis*), one of the most characteristic plants of undrained swamps. Thus the willows are antecedent and the button bush subsequent to the formation of the cut-off. *Fig. 17* shows a portion of the same, in which the willows and even the pond itself have gone, and only the marginal button bush is left, though in this case, the margin occupies the center of the original pond. Near Starved rock an extinct oxbow lake on the flood plain of the Illinois river contains an extensive patch of Sphagnum and Osmunda, among the most characteristic plants of undrained swamps. There are many undrained swamps, some with tamaracks, in the Calumet valley. The future of these swamps is like that of other swamps, and will be described in the next section. *Fig. 18* shows a morainic island in the Thorn creek flood plain; the stream has meandered but has thus far left this detached fragment of the morainic mainland with a large part of its original flora.

In closing the section on rivers, all that is needed is to emphasize again the idea that the life history of a river shows retrogression at many points, but that the progressions outnumber the retrogressions. Not only this, but retrogressive phases are relatively ephemeral. Thus a river system, viewed as a whole, is progressive, and through all its vicissitudes there is an ever increasing area of mesophytic forest. When the theoretical base level is reached there seems to be no apparent reason why mesophytic forests should not be developed throughout most of the great plain.

[*To be concluded.*]

UNDESCRIBED PLANTS FROM GUATEMALA AND OTHER CENTRAL AMERICAN REPUBLICS. XXII.[1]

JOHN DONNELL SMITH.

(WITH PLATE I)

Xylosma Turrialbanum Donn. Sm.—Folia magna oblongo-elliptica longe obtuseque acuminata in basin obtusiusculam aut retusam angustata membranacea integerrima glabra minute pellucido-punctata venis venulisque transversis subparallelis. Florum masculinorum pedicelli fasciculato-congesti floribus 4–5-plo longiores ad tres partes longitudinis articulati. Sepala 5. Stamina 15 sepalis paulo breviora. Discus subinteger, glandulis nullis.

Ramis spiniformibus 1–7$^{\text{cm}}$ longis armatum, his florum fasciculis saepe ornatis. Folia 9–13$^{\text{cm}}$ longa 3–5$^{\text{cm}}$ lata pellucida basi nonnunquam minute bilobata, nervis lateralibus utrinque 6–8 subtus prominulis, petiolis 5–10$^{\text{mm}}$ longis. Pedicelli indefiniti 9–11$^{\text{mm}}$ longi pubescentes, bracteis pilosis, bracteolis rudimentariis. Sepala oblongo-ovata 3$^{\text{mm}}$ longa parce pubescentia. Filamenta 2$^{\text{mm}}$ longa infra medium pubescentia, antheris elliptico-globosis dorso affixis. Discus annularis carnosus 2$^{\text{mm}}$ diametralis ciliolatus ceterum glaber. Flores feminini fructusque ignoti.—Inter species Americanas foliis integerrimis insigne.

In fundo Aragon vocato in declivibus Turrialbanis sito, Costa Rica, alt. 630$^{\text{m}}$, Jan. 1899, *Pittier*, no. 7518 Pl. Guat. &c., qu. ed. Donn. Sm. (n. 13217 herb. nat. Cost,).

Monnina saprogena Donn. Sm. (§ HEBEANDRA Chodat, Bull. Herb. Boiss. **4**: 243.)—Folia estipulata crassiuscula glabra lanceolata-elliptica acuminata in petiolum attenuata, nervis lateralibus utrinque 3–4 erecto-patentibus distinctis ante marginem evanidis supra subimmersis, venis obsoletis. Racemi paniculati, floribus pedicellos paulo superantibus. Sepala interiora per duas partes connata. Carina subintegra. Discus conspicue unilateralis, ovario dimidiato-elliptico glabro uniloculari. Fructus

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[1] Continued from BOT. GAZ., **27**: 443. 1899.

inaequilateralis oblongo-ovatus acutiusculus bicarinatus et bicostatus indistincte areolatus.

Arbuscula (Tonduz in schedula), caulibus teretibus glabris. Folia 6–9$^{\rm cm}$ longa 2–3$^{\rm cm}$ lata, petiolis 6–7$^{\rm mm}$ longis. Paniculae terminales et subterminales puberulae laxiflorae 10–16$^{\rm cm}$ longae, bracteis ovatis 4$^{\rm mm}$ longis ciliatis cito deciduis, pedicellis 3–4$^{\rm mm}$ longis, floribus 6$^{\rm mm}$ longis. Sepala pubescentia ciliataque, exteriora inferiora ovalia, superius majus ovatum 2.5$^{\rm mm}$ longum, alae orbiculares 5$^{\rm mm}$ diametrales extus pube punctatae e basi distincte nervosae. Carina ad apicem biplicata, petalis interioribus intus cum vagina staminea cano-pilosis, limbo lingulato 3$^{\rm mm}$ longo. Stylus complanatus ovario bis longior. Fructus glaber sublaevis 6$^{\rm mm}$ longus 2.5$^{\rm mm}$ latus, disco gibboso glanduliformi.

✓In truncis putridis, La Palma, Costa Rica, alt. 1542$^{\rm m}$, Aug. 1898, *Tonduz*, no. 7406 Pl. Guat. &c. qu. ed. Donn. Sm. (n. 12501 herb. nat. Cost.).

MYRODIA GUATEMALTECA Donn. Sm., BOT. GAZ. **16**: 2. 1891.—Hujus speciei e floribus nondum plane evolutis descriptae specimina typica cum *Quararibea Guyanensi* Aubl. satis congruunt. Ejusdem plantae exempla Guatemalensia nuper a Barone de Tuerckheim transmissa et flores evolutos et fructus praebent.

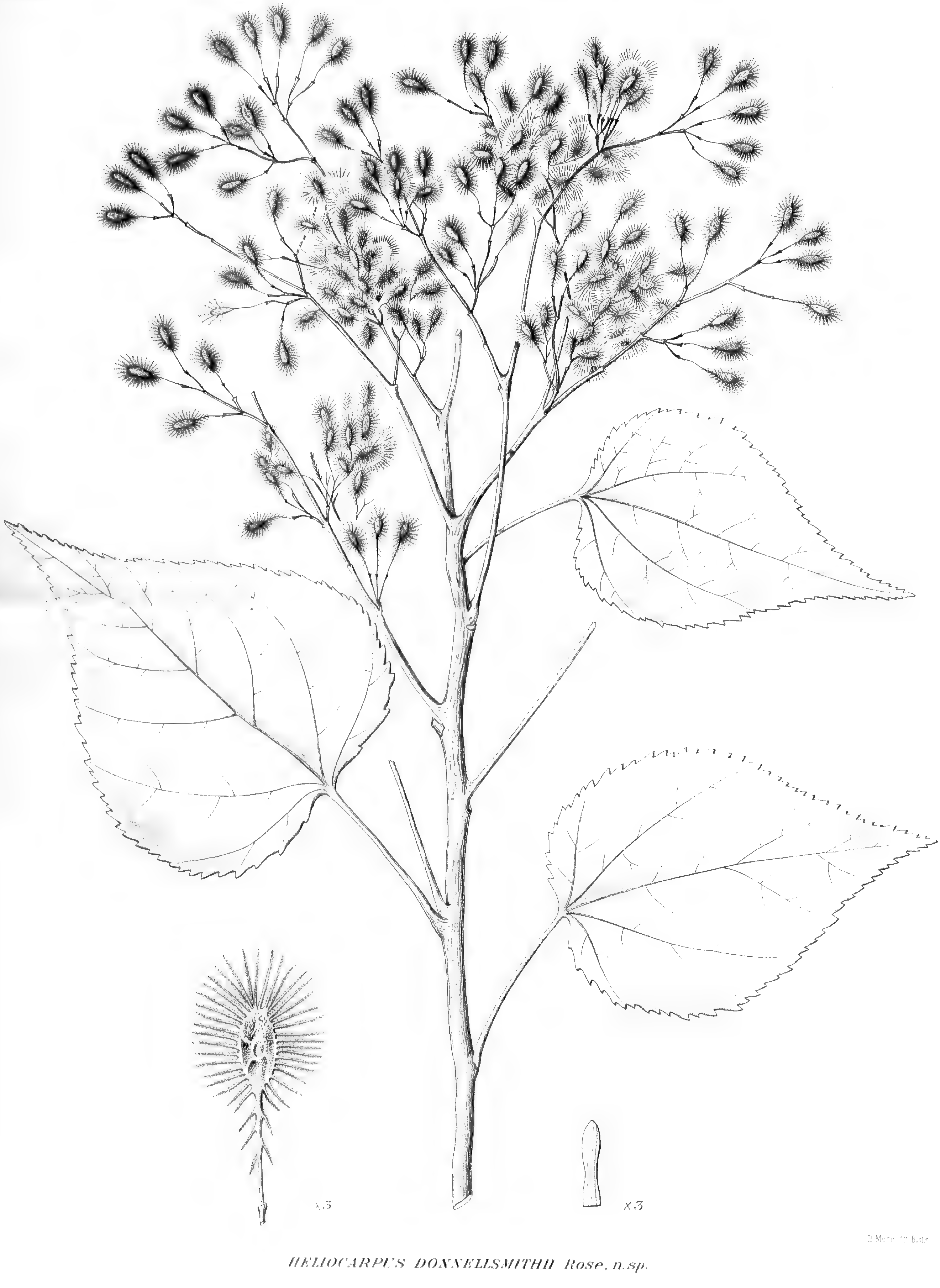
Heliocarpus Donnellsmithii Rose.—Mature leaves nearly orbicular, not lobed, rounded at base, shortly acuminate (tips mostly broken), glabrous and shining above, nearly glabrous below, 3 to 5-palmately veined from the base, somewhat glandular-toothed especially at base; inflorescence a large spreading panicle; sepals not appendaged; stipe slender, 5$^{\rm mm}$ long; body of fruit oblong, 5$^{\rm mm}$ long, somewhat hairy, becoming glabrate and rugose in age.

Near Arenal, Department Alta Verapaz, Guatemala, alt. 1500$^{\rm m}$, April, 1889, *John Donnell Smith*, n. 1722 (type); Coatzacoalcos, Isthmus of Tehauntepec, State of Vera Cruz, Mexico, 1895, *Charles L. Smith*, n. 1002.

This species is very different from the numerous Mexican species, and is near *H. Americanus Schumanni* Baker, but has more glabrous leaves and an absence of hairs both on leaves and inflorescence. Mr. Baker's variety seems to me to deserve specific rank.

EXPLANATION OF PLATE I.—Branch two thirds natural size; fruit × 3.

Villaresia Costaricensis Donn. Sm.—Folia oblongo-elliptica utrinque praesertim apice acuminata submembranacea diaphana



B. Meisel lith. Boston

HELIOCARPUS DONNELLSMITHII Rose, n.sp.

pellucido-punctulata integra, costa cum nervis lateralibus utrinque 4–5 venisque subtus conspicua. Racemi extra-axillares terminalesque foliis breviores spiciformes, glomerulis subsessilibus inferne dissitis. Sepala ovata pilosa. Petala glabra oblongo-elliptica sepalis vix bis longiora. Stamina petala paene aequantia. Ovarium pilosum ovoideum 1-loculare. Drupa magna olivaeformis.

Ramuli petiolique recentiores puberuli. Folia glaberrima aetate provectiore subcoriacea 9–12.5^{cm} longa 4.5–5^{cm} lata, petiolis crassis canaliculatis 5–7^{mm} longis. Racemi pubescentes singuli, floriferi 3–5^{cm} longi, fructiferi incrassati usque ad 8^{cm} longi, floribus 3–8 in pedicello crasso 1–2^{mm} longo sessilibus. Sepala 1.5^{mm} longa. Petala quincuncialia apice cuspidata inflexo-valvata 2.5^{mm} longa. Stamina glabra, antheris cordato-ovalibus 1^{mm} longis. Ovarium biovulatum cum stylo brevissimo glabro adjecto petala paene aequans, stigmate obliquo nudo. Drupa pedicello vix ullo insidens 2.5^{cm} longa 1.5^{cm} lata atque crassa apiculata in sicco nigrescens et reticulata, semisepto 5^{mm} lato, seminis testa pallida et atro-venosa.— Genus in America cis circulum aequinoctialem adhuc non obvium.

In silvis prope Copey, Prov. Cartago, Costa Rica, alt. 1800^{m}, Febr. et Mart. 1898, *Tonduz*, nn. 11664, 11995, 11791 herb. nat. Cost.

Blakea tuberculata Donn. Sm. (§ EUBLAKEA Triana.)— Rami crassi teretes cum petiolis pedunculis bracteis et foliorum tergo ferrugineo-furfuracei et -strigillosi. Folia ovato-orbicularia abrupte caudato-acuminata basi rotundata supra glabra. Flores fasciculati brevissime pedunculati inter maximos. Bracteae exteriores usque ad mediam connatae calycis tubum paulo superantes, interiores breviores omnino connatae. Calycis limbus ovali-cylindricus tubum aequans intus coloratus et tuberculatus, lobi retroflexi limbo bis longiores. Petala utrinque tuberculata cum staminibus basi limbi inserta. Genitalia limbo inclusa.

Folia uniuscujusque paris aequalia 13–21^{cm} longa 10–15^{cm} lata coriacea praetermisso utroque nervulo marginali trinervia, nervis in caudam oblongam 9^{mm} longam excurrentibus, venis transversis 3–4^{mm} inter se distantibus, petiolis robustis 4–6^{cm} longis. Pedunculi 3–6-fasciculati crassi 6–10^{mm} longi. Flores diametro 6.5^{cm}, bracteis crassis opacis, exterioribus late orbicularibus 2^{cm} longis uninerviis siccitate retroflexis et margine involutis, interioribus 1.5^{cm} longis margine crispato-plicatis. Calycis tubus campanulatus glaber, limbus 1^{cm} altus 12^{mm} latus carnosulus extus strigillosus in alabastro petala usque ad duas partes includens, lobi oblongo-ovati herbacei nervosi supra furfuracei subtus strigillosi jam ante anthesin e basi arcte retroflexi. Petala glabra oblongo-obovata 2.5–3$^{\mathrm{cm}}$ longa late unguiculata carnosula rosea. Stamina in sicco rubescentia, antheris pendulis dolabriformibus acute calcaratis 8$^{\mathrm{mm}}$ longis filamenta subaequantibus. Ovarium diametro 9$^{\mathrm{mm}}$, centro in rostrum oblongo-conicum 5$^{\mathrm{mm}}$ longum apice denticulatum producto, stylo gracili 1$^{\mathrm{cm}}$ longo, stigmate punctiformi. Baccae non suppetunt.—*B. grandiflorae* Hemsl. proxima.

Limbus propter exsiccationis pressionem diruptus limbum in herbario 6-fissum lobis appendiculatum simulat.

✓Ad pascuorum margines prope La Palma, Prov. San José, Costa Rica, alt. 1550$^{\mathrm{m}}$, Aug. 1898, *Tonduz*, n. 7363 Pl. Guat., &c., qu. ed. Donn. Sm. (n. 12435 herb. nat. Cost.)

Anguria ovata Donn. Sm.—Tota glaberrima. Folia omnia simplicia integra membranacea concoloria ovata cuspidato-acuminata dimidio longiora quam latiora ad basin rotundam leviter retusa, nervis basilaribus 5, lateralibus utrinque 3. Flores masculini pauci subcapitati. Calyx lineari-cylindricus. Petala utrinque dense furfuracea. Antherae rectae lineares, appendice glabra.

Caulis gracilis striatus. Folia 8.5–9$^{\mathrm{cm}}$ longa viridia, venulis reticulatis diaphanis, petiolis 3–5$^{\mathrm{cm}}$ longis. Cirrhi tenues striati. Pedunculi masculini striati 12–15$^{\mathrm{cm}}$ longi apice brevissime racemosi et 8–12-flori, pedicellis 1–2$^{\mathrm{mm}}$ longis. Calyx basi rotundus apice haud constrictus 14$^{\mathrm{mm}}$ longus 3$^{\mathrm{mm}}$ latus, dentibus obtuse ovatis 1$^{\mathrm{mm}}$ longis. Petala suborbicularia 6$^{\mathrm{mm}}$ longa 4–5$^{\mathrm{mm}}$ lata exunguiculata enervia lateritia. Antherae 10$^{\mathrm{mm}}$ longae 1.5$^{\mathrm{mm}}$ latae, appendice 0.5$^{\mathrm{mm}}$ longa. Flores feminini fructusque desunt.—*A. longipedunculatae* Cogn. proxima.

✓In dumetis ad Las Vueltas, Tucurrique, Costa Rica, alt. 635$^{\mathrm{m}}$, Feb. 1899, *Tonduz*, n. 13006 herb. nat. Cost.

Gurania Tonduziana Donn. Sm. (§ F. 1. Cogn. in DC. Monogr. Phan. **3**: 694.)—Folia circumscriptione cordiformia paulo longiora quam latiora 5-nervia profundissime 7-partita, segmentis 5 interioribus oblanceolato-linearibus, exteriore utroque oblongo et aurito. Pedunculi masculini foliis superati, floribus brevissime spicatis. Calycis pubescentis segmenta linearia tubo 2–3-plo longiora. Antherae oblongae, appendice minuta deltoidea.

Caulis robustus striatus cum petiolis cirrhis pedunculis pubescens. Folia 24^{cm} longa, pagina superiore scabriuscula, inferiore pallidiore pubescente conspicue reticulato-nervosa, margine subundulata remote minuteque spinuloso-denticulata, nervo basilari utroque exteriore imum sinum marginante, segmentis acuminatis, terminali 21^{cm} longo ultra medium 5^{cm} lato basi 13^{mm} lato ceteris interioribus paulo majore, utroque exteriore inequilaterali 6.5^{cm} longo 3^{cm} lato, sinibus inter segmenta rotundis a sinu basilari 2–3^{cm} distantibus, hoc sub-rectangulari 3^{cm} profundo 5^{cm} lato. Pedunculi 17^{cm} longi, spica 8^{mm} longa. Calycis tubus ovalis 1^{cm} longus 6^{mm} latus, segmenta parce pubescentia 22–25^{mm} longa basi 1^{mm} lata enervia miniata. Petala conniventia lineari-lanceolata 9–10^{mm} longa 2^{mm} lata enervia extus dense glandulari-papillosa intus furfuracea. Antherae 7^{mm} longae 2^{mm} latae tertia parte replicatae, connectivo loculis angustiore, appendice vix 0.5^{mm} longa. Flores feminini fructusque ignoti.—Ad *G. Makoyanam* Cogn. florum indole accedens foliis insigniter recedit.

In sylvis ad Shirores, Talamanca, Costa Rica, alt. 100^{m}, Feb. 1895, *Tonduz*, n. 9332 herb. nat. Cost.

Sciadophyllum systylum Donn. Sm.— Ferrugineo-pubescens. Foliola 7–9 elongato-oblonga longe acutissimeque caudato-acuminata basi obtusa subcoriacea praeter costam tandem glabrescentia, nervis patulis. Umbellae in racemum simplicem cylindricum dispositae. Styli in columnam quam bacca tertia parte breviorem omnino coaliti, stigmatibus 5–6, seminibus abortu paucioribus.

Totum pube detergibili stellata interdum tomentulosa vestitum. Stipulae coriaceae lineares 5–7.5^{cm} longae. Petiolus teres 16–27^{cm} longus, petiolulis canaliculatis, foliolo intimo maximo 14–25^{cm} longo 4–7^{cm} lato, cauda 2.5–3.5^{cm} longa, petiolulo 4–7^{cm} longo, foliolis lateralibus cum petiolulis sensim decrescentibus, infimo utroque 6–14.5^{cm} longo, petiolulo 2–2.5^{cm} longo, nervis lateralibus utrinque 12–18 prope marginem arcuate conjunctis. Racemi 20–35^{cm} longi, ramis satis approximatis 1.5–4.5^{cm} longis, pedicellis circa 10 et 5–8^{mm} longis. Baccae ovali-globosae 3–4^{mm} longae 5–6-angulares, juniores pube stellata punctatae, stylis 2–2.5^{mm} longis, stigmatibus vix 0.5^{mm} longis radiantibus, seminibus 3^{mm} longis, 1–3 saepius abortivis. Flores ignoti.—Species stylis longis totis coalitis insignis.

In sylvis ad El Alto de La Palma, Costa Rica, alt. 1542^{m}, Aug. 1898, *Tonduz*, n. 7395 Pl. Guat. &c., qu. ed. Donn. Sm. (n. 12488 herb. nat. Cost.).

Oreopanax pycnocarpum Donn. Sm.—Stellato-pubescens. Folia simplicia integra crassa pube punctulata mox glabrescentia nitidaque ovalia utrinque rotundata triplinervia longe petiolata. Capitula fructifera spiciformia oblongo-globosa pedicellis longiora inter maxima in racemos 3-nos abbreviatos pauciramos disposita, baccis compactis stylis liberis 6–7, seminibus abortu saepius paucioribus, albumine aequabili.

Folia 16–20^{cm} longa 8–11^{cm} lata, nervis subangulo angusto ascendentibus, basili utroque exteriore 8^{mm} a basi distante, lateralibus utrinque 3 ultra medium ortis, venis transversis inter marginem et nervum utrumque basilarem subtus conspicuis circa 10, petiolis pubescentibus 10–12^{cm} longis. Racemi pubescentes 7–9^{cm} longi, ramis crassis 8–11^{mm} longis, inferioribus alternis, supremis 4-nis, capitulis 2.5–3.2^{cm} longis 1.8–2.2^{cm} latis, rhachi 1–1.5^{cm} longa, bracteolis cuspidato-ovatis ciliatis. Baccae subglobosae pressione mutua angulatae, nitidae in sicc. pallide flavescentes numerosissimae 8^{mm} longae 6^{mm} latae, stylis stellatim recurvatis 1.5^{mm} longis, seminibus oblongis 3-gonis 5^{mm} longis 2^{mm} crassis. Flores deficiunt.—Ad *O. capitatum* Decne. et Planch. foliis ad *O. macrocephalum* Seem. capitulis accedit.

✓In sylvis ad Copey, Prov. Cartago, Costa Rica, alt. 1800^{m}, Febr. 1898, *Tonduz*, n. 11933 herb. nat. Cost.

Chomelia microloba Donn. Sm.—Inermis. Folia oblongo-ovata aut-elliptica obtuse acuminata basi acuta aut obtusa coriacea praeter nervorum axillas subtus barbatas glaberrima. Pedunculi terminales bini gracillimi, cymis bifidis multifloris, floribus ebracteolatis. Calyx glaber, ore subintegro. Corollae extus pubescentis tubus infundibuliformis calyce triplo longior, lobis induplicato-valvatis.

Ramuli recentiores cum stipulis cuspidato-triangularibus 3–4^{mm} longis persistentibus et petiolis 4–6^{mm} longis pubescentes. Folia 5.5–10^{cm} longa 3–4.5^{cm} lata, juniora e basi rotunda magis ovata, nervis lateralibus utrinque 4–5. Pedunculi glabri 2.5–3.5^{cm} longi, cymis glabris 3.5^{cm} latis circa 19–25-floris, floribus sessilibus. Calyx cylindricus 3^{mm} longus 1.5^{mm} latus, denticulis vix 0.3^{mm} longis obtusis. Corollae intus glabrae tubus 8–10^{mm} longus, lobi obtuse ovati 3^{mm} longi. Antherae semiexsertae lineares 2^{mm} longae ad tertiam partem longitudinis affixae. Ovarium calycis duas partes aequans, stigmatibus 1^{mm} longis, ovulis linearibus 1^{mm} longis. Drupa in speciminibus suppetentibus deficit.—Ab omnibus congeneribus calyce subtruncato differt.

✓In sylvis litoralibus ad Santo Domingo de Golfo Dulce, Costa Rica, Febr. 1896, *Tonduz*, n. 7048 Pl. Guat., &c., qu. ed. Donn. Sm. (n. 9874 herb. nat. Cost.

Faramea trinervia K. Sch. et Donn. Sm.—Folia nitida obovato-oblonga vel oblonga contracto-acuminata auriculata subsessilia, nervo utroque basilari percurrente, lateralibus angulo subrecto a costa divergentibus. Cyma foliaceo-bibracteata trichotomo-decomposita, floribus ebracteolatis. Calycis limbus denticulatus discum aequans.

Glaberrima. Folia pergamenea diaphana laete viridia 20–25^{cm} longa medio 6–9.5^{cm} basi 1.5–3^{cm} lata, suprema lineari-oblonga 11^{cm} longa 3^{cm} lata, costa utrinque prominente, nervo a basi utrinque prodeunte conspicuo apicem attingente a margine 5–10^{mm} distante, nervis lateralibus primariis utrinque circa 14, nervum percurrentem attingentibus, petiolis 2–3^{mm} longis. Stipulae 6–8^{mm} longae in vaginam semiconnatae parte libera rotundatae aristatae. Pedunculi singuli ramulos terminantes 4–6.5^{cm} longi apice bracteis ante anthesin caducis instructi. Cyma 4.5–6.5^{cm} alta, ramis late patulis complanatis, iis infimis 4–5.5^{cm} longis, pedicellis accrescentibus 5–11^{mm} longis. Calycis limbus ovarium aequans usque ad medium acute denticulatus. Ovarium post anthesin pedicello paulo crassius cum disco aequilongo truncato adjecto 1.5^{mm} longum. Corolla et fructus desunt.—A ceteris speciebus haec nervatione insigniter differt.

In sylvis ad Boca Zhorquin, Talamanca, Costa Rica, Mart. 1894, *Tonduz*, n. 8571 herb. nat. Cost.; in sylvis Tsakianis, Talamanca, alt. 200^{m}, Apr. 1895, *Tonduz*, n. 9583 herb. nat. Cost.

FARAMEA TRINERVIA **Suerrensis** Donn. Sm.— Folia obovato- vel oblongo-elliptica in caudam gracilem contracta infra medium in petiolum angustata, suprema lanceolata.

Frutex 3–4^{m} altus, ramosus. Foliorum cauda 1.4–2^{cm} longa, petioli 1–1.5^{cm} longi. Bracteae lanceolatae tenuissime elongatae 6^{cm} longae 12^{mm} latae. Florum nondum satis evolutorum pedicelli 2–5^{mm} longi, calycis limbus 1^{mm} altus, dentibus triangularibus, corolla intense cyanea in sicc. nigrescens 6^{mm} longa tubulosa usque ad mediam paene lobata, filamenta longiuscula prope basin corollae inserta, antheris 3^{mm} longis exsertis, ovarium obovatum cum disco conico adjecto 2^{mm} longum. Fructus cyaneus transversim depresso-ovalis 15^{mm} longus 11^{mm} crassus, semine conformi 11^{mm} longo 8^{mm} crasso subtus usque ad medium transversim bipartito, testa pallide scariosa.

In sylvis profundis ad fundum Suerre dictum, Llanuras de Santa Clara, Comarca de Limón, Costa Rica, alt. 300^{m}, Febr. 1896, *Donn. Sm.*, n. 6589, Pl. Guat., &c., qu. ed. Donn. Sm.

Parathesis glabra Donn. Sm.—Omnibus in partibus maculata et praeter corollam glabra. Folia oblongo-elliptica acuminata in petiolum attenuata integerrima subdiaphana utrinque dense maculata, nervis crebris patulis. Paniculae axillares foliis breviores, pedunculo filiformi, pedicellis ad apicem ramorum primariorum subumbellatis. Calycis segmenta elongato-triangularia. Corollae segmenta linearia. Antherae filamentis bis longiores prope basin affixae per totam longitudinem dehiscentes.

Folia 8–14$^{\mathrm{cm}}$ longa 3.5–7$^{\mathrm{cm}}$ lata maculis punctata et striatula, nervis inter se 4–6$^{\mathrm{mm}}$ distantibus, petiolis canaliculatis 0.8–1.5$^{\mathrm{cm}}$ longis. Paniculae cum pedunculo 2.5–4$^{\mathrm{cm}}$ longo adjecto 5–7.5$^{\mathrm{cm}}$ longae, ramis solitariis 7–15$^{\mathrm{mm}}$ longis, pedicellis 3–6-fasiculatis 5–7$^{\mathrm{mm}}$ longis, bracteis bracteolisque lanceolato-linearibus parvis, alabastris lanceolato-conicis. Calycis segmenta 1$^{\mathrm{mm}}$ longa. Corollae tubus 1$^{\mathrm{mm}}$ altus, segmenta e basi 1$^{\mathrm{mm}}$ lata attenuata usque ad 7$^{\mathrm{mm}}$ longa staminibus bis longiora revoluta intus praesertim marginibus sordide pubescentia. Ovarium conicum calyce brevius parce maculatum, stylo 4.5$^{\mathrm{mm}}$ longo. Fructus desideratur.—*Ardisiam ramifloram* Oerst. habitu simulans.

√In sylvis ad Copey, Prov. Cartago, Costa Rica, alt. 1800$^{\mathrm{m}}$, Febr. 1898, *Tonduz*, n. 11714 herb. nat. Cost.

MACROSCEPIS CONGESTIFLORA Donn. Sm., BOT. GAZ. **25**: 149. 1898.—Sub hoc nomine eandem plantam atque eodem numero indicatam incaute descripsi, quam typicam *M. pleistanthae l. c.* **20**: 543. 1895, jam edideram.

Markea leucantha Donn. Sm.—Praeter filamenta omnibus in partibus glaberrima. Folia coriacea nitida obovato-oblonga apice rotundata a medio in petiolum attenuata. Flores apice ramorum annotinorum aggregati pauci. Calyx parvus teres coriaceus, lobis oblongo-ovatis brevissime cuspidatis. Corolla calyce 5-plo longior, tubo extra calycem sensim ampliato late infundibulari. Genitalia exserta.

Frutex epiphyticus 2–3$^{\mathrm{m}}$ longus verrucosus, ramulis hornotinis quadrangularibus sub apice ramorum plerumque ortis. Folia plerumque geminatim aut ternatim approximatis 7–15$^{\mathrm{cm}}$ longa 2.5–5.5$^{\mathrm{cm}}$ lata, recentiora magis oblanceolata et acutiuscula, nervis lateralibus utrinque 5–8 subtus tantum conspicuis, petiolis crassis 4–12$^{\mathrm{mm}}$ longis. Pedicelli brevissime racemosi in speciminibus suppetentibus 3–8 circa 10$^{\mathrm{mm}}$ longi, bracteis subulatis 3$^{\mathrm{mm}}$ longis deciduis. Calyx intus nervosus 11–13$^{\mathrm{mm}}$ longus usque ad medium fissus. Corolla alba (Cooper in schedula) 5-nervia reticulata 5.3–6.3$^{\mathrm{cm}}$ longa, tubo

3.8–4.6^{cm} longo quam faucium latitudo bis longiore, lobis semiorbicularibus. Stamina ad 8^{mm} supra basin corollae inserta 4–4.8^{cm} longa, filamentis ad basin versus incano-barbatis, antheris paulo infra mediam affixis 6^{mm} longis 2.5^{mm} latis. Ovarium ovoideum 4^{mm} altum atque latum, stylo 4.3–5^{mm} longo, stigmatis obconoidei lamellis semiorbicularibus. Bacca desideratur.—Species calyce parvo insignis.

✓Estrella, Prov. Cartago, Costa Rica, alt. 1800^{m}, Jun. 1887, *Cooper*, n. 5887 Pl. Guat. &c., qu. ed. Donn. Sm.; Prope Juan Viñas, Prov. Cartago, alt. 1140^{m}, Maj. 1890, *Tonduz*, n. 1845 herb. nat. Cost.

Alloplectus macranthus Donn. Sm.—Omnibus in partibus strigilloso-pubescens. Folia maxima oblongo- vel obovato-elliptica apice acuminata in petiolum attenuata et decurrentia inaequilatera subintegra. Pedicelli racemosi bracteis breviores calycem subaequantes, floribus maximis numerosissimis coarctatis. Calycis segmenta breviter connata subaequalia oblonga obtusa integra. Corolla calyce bis longior erecta late infundibularis, limbo obliquo, lobis inaequalibus rotundatis denticulatis.

Caulis pollicis crassitudine in arborum truncis scandens. Folia 23–45^{cm} longa 10–19^{cm} lata, nervis lateralibus utrinque 7–8, petiolis crassis rugosis canaliculatis 4–7^{cm} longis. Racemi aetate provectiore recurvi 2–4^{cm} longi. Bracteae herbaceae ovales aut oblongo-ellipticae 3–4, 5^{cm} longae. Pedicelli 2.5–3^{cm} longi, demum subsecundi. Calyx herbaceus, segmentis circa 2.5^{cm} longis 8–10^{mm} latis. Corolla puberula ex schedula Tuerckheimiana extus candida intus maculato-aurantiaca 6^{cm} longa, tubo 4.2^{cm} longo a basi saccata 6^{mm} lata in fauces 2^{cm} latas sensim ampliato, lobis posticis 1^{cm} anticis 7^{mm} longis. Filamenta in vaginam brevem dilatata, antheris liberis oblongis 6^{mm} longis. Disci glandula solitaria. Ovarium dense pubescens oblongo-ovatum 6^{mm} longum, stylo 1.6^{cm} longo, stigmate concavo. Fructus calyce aucto cinctus ovalis 1.7^{cm} longus 1^{cm} crassus, placentis rubris, seminibus oblongo-ellipticis 1^{mm} longis.—Ab *A. circinnato* Mart. foliis et inflorescentia proximo recedit praecipue corolla infundibulari altero tanto longiore.

✓In fundo Cubilquitz vocato, Depart. Alta Verapaz, Guatemala, alt. 350^{m}, Jul. 1900, *H. von Tuerckheim*, n. 7642 Pl. Guat. &c., qu. ed. Donn. Sm.—Huic probabiliter referenda sunt specimina a *Tonduz* in Costa Rica lecta et sub n. 13042 distributa. Haec pedicellos densissime aggregatos brevissime racemosos bracteas calycesque erubescentes praebent, corollis tamen carent.

Columnea sulfurea Donn. Sm. (§ EUCOLUMNEA Benth. et Hook.)—Pilis aspersa. Folia disparia subtus vinosa elongato-elliptica utrinque acuminata inaequilatera basi valde obliqua.

Pedunculi solitarii aut bini petiolo longiores calyce breviores. Calycis segmenta vinosa attenuato-linearia tubi corollini duas partes aequantia. Corolla flava infundibulari-tubulosa leviter arcuata, limbo postico quam tubus breviore quam anticus porrectus altero tanto paene longiore, galea truncata. Ovarium dense pilosum.

Epiphytica, caule crasso parum ramoso erubescente, internodiis 1.5–3.5$^{\mathrm{cm}}$ longis, superioribus et petiolis pedunculis calycibus densius rubro-pilosis. Folia discoloria utrinque sparsim bulboso-pilosa ad basin latere altero obtusa altero valde exciso acuta, uniuscujusque paris folio florali 7.5–11.5$^{\mathrm{cm}}$ longo 2.5–4$^{\mathrm{cm}}$ lato, minore conformi 3–4$^{\mathrm{cm}}$ longo, petiolis 3–7$^{\mathrm{mm}}$ longis. Pedunculi plerumque singuli 9–15$^{\mathrm{mm}}$ longi. Calycis segmenta sublibera 2.5$^{\mathrm{cm}}$ longa. Corolla ex sched. Tuerckheimiana sulfurea sparsim pilosa 6.8$^{\mathrm{cm}}$ longa basi 3$^{\mathrm{mm}}$ faucibus 7$^{\mathrm{mm}}$ lata, tubo basi gibbo, limbo postico 3$^{\mathrm{cm}}$ longo, galea 1.5$^{\mathrm{cm}}$ longa atque lata integra, lobis lateralibus angulo recto subtriangularibus 1$^{\mathrm{cm}}$ longis obtusis, limbo antico lineari-oblongo 1.5$^{\mathrm{cm}}$ longo. Stamina 5.8$^{\mathrm{cm}}$ longa, antheris oblongis 3$^{\mathrm{mm}}$ longis, staminodio 4$^{\mathrm{mm}}$ longo. Disci glandula solitaria crassa bidentata. Ovarium ovoideum 2$^{\mathrm{mm}}$ altum, stylo rubro 6.5$^{\mathrm{cm}}$ longo ad apicem versus pubescente, stigmate bilamellato. Fructus ignotus.

Cubilquitz, Depart. Alta Verapaz, Guatemala, alt. 350$^{\mathrm{m}}$, Febr. 1900, *H. von Tuerckheim*, n. 7646 Pl. Guat. &c., qu. ed. Donn. Sm.

COLUMNEA MICROCALYX **macrophylla** Donn. Sm.— Folia membranacea pubescentia oblongo-elliptica vix acuminata basi cordata inaequilatera, uniusque paris majus usque ad 5$^{\mathrm{cm}}$ longum et 2$^{\mathrm{cm}}$ latum, alterum triente minus. Calyx virescens corollae 6.7$^{\mathrm{cm}}$ longae quintam partem aequans.

In sylvis prope Las Vueltas, Tucurrique, Costa Rica, alt. 650–700$^{\mathrm{m}}$, Dec. 1898, *Tonduz*, n. 12932 herb. nat. Cost.

Napeanthus repens Donn. Sm.— Herba repens acaulis strigilloso-pubescens. Folia opposita subrosulata petiolata tenuimembranacea oblongo-elliptica utrinque acuminata dentata. Pedicelli fasciculati filiformes. Calycis segmenta sublibera 3-nervia. Corolla rotata, tubo brevissimo, faucibus explanatis, limbo alte fisso subbilabiato. Stamina 4, loculis ovoideis divergentibus distinctis. Ovarium corollae tubum aequans. Capsula membranacea sphaerica.

Folia 4–9$^{\rm cm}$ longa 2–3.5$^{\rm cm}$ lata plerumque inaequilatera supra densius pubescentia subtus pallidiora et purpureo-reticulata, dentibus magnis crebrisque. Pedicelli complures 2–3.5$^{\rm cm}$ longi inferne marginati. Calycis segmenta lineari-lanceolata 2$^{\rm mm}$ longa dense pubescentia exreticulata. Corolla alba parce pubescens diametro circa 1$^{\rm cm}$, faucibus 3$^{\rm mm}$ latis, segmentis parum aequalibus ovalibus 3–4$^{\rm mm}$ longis. Stamina glabra, filamentis 1$^{\rm mm}$ longis inferne marginatis, antheris reniformibus supra medium affixis reversis 0.5$^{\rm mm}$ latis ante anthesin leviter cohaerentibus, loculis poro laterali subrotundo dehiscentibus. Ovarium pubescens, stylo 3.5$^{\rm mm}$ longo, stigmate parum bifido. Capsula diametro 1.5$^{\rm mm}$ calyce immutato inclusa.

In rupibus praeruptis humidissimis, Cubilquitz, Depart. Alta Verapaz, Guatemala, alt. 350$^{\rm m}$, Jun. 1900, *von Tuerckheim*, n. 7647 Pl. Guat. &c., qu. ed. Donn. Sm.

Amphilophium oxylophium Donn. Sm.—Pilis singulis dense molliterque ochraceo-tomentosum. Stipulae foliaceae. Folia conjugata cirrho carentia, foliolis breviter petiolulatis ovato-cordiformibus contracto-acuminatis infra indumentum supra tuberculatis subtus lepidotis. Calycis limbus tubum aequans lobos 2 interiores plus quam duplo superans, lobis exterioribus triangularibus induplicatis reflexis. Corolla glabra ultra mediam labiata, labio inferiore fisso. Ovarium lepidotum glabrum.

Caulis cum petiolis thyrsoque robustus et floccoso-tomentosus. Stipulae 10–12$^{\rm mm}$ longae deciduae. Petioli 2–2.5$^{\rm cm}$ petioluli 8–12$^{\rm mm}$ metientes. Foliola 7–12$^{\rm cm}$ longa 5–75$^{\rm cm}$ lata supra pilis simplicibus adpressis vestita subtus pilis ramosis densius tomentosa et pallidiora. Thyrsus contracto-cylindricus in speciminibus suppetentibus vix evolutus 1$^{\rm dm}$ longus, bracteis bracteolisque lineari-lanceolatis 1–1.5$^{\rm cm}$ longis. Calycis totius lepidoti tubus subglobosus 8$^{\rm mm}$ longus dense pilosus, limbus utrinque parce pilosus, lobis 5 exterioribus 5–6$^{\rm mm}$ longis, interioribus lati-rotundatis 3$^{\rm mm}$ longis extus parce pilosis. Corolla 2.5$^{\rm cm}$ longa ad apicem versus minutissime lepidota intus prope insertionem staminum linea lepidota incrassata, tubo 1$^{\rm cm}$ longo, labii inferioris laciniis 13$^{\rm mm}$ longis. Stamina majora 13$^{\rm mm}$ minora 10$^{\rm mm}$ metientia, thecis 2.5$^{\rm mm}$ longis, staminodio 3$^{\rm mm}$ longo. Discus pulvinaris cum stylo 1.5$^{\rm cm}$ longo glaber, stigmatibus semiorbicularibus. Capsula ignota.

Tucurrique, Costa Rica, alt. 630$^{\rm m}$, Jan. 1899, *Tonduz*, n. 13045 herb. nat. Cost.

Lophostachys Guatemalensis Donn. Sm.—Folia nascentia incano-pubescentia aetate provectiore praeter petiolum nervosque glabrescentia disparia lanceolato-elliptica longe falcato-acuminata triente inferiore in petiolum arcuatim attenuata subtus pallidiora. Spicae terminales subsessiles solitariae, bracteis lanceolato-linearibus 5-nerviis, bracteolis spathulato-linearibus abrupte cuspidatis 2-nerviis. Calycis segmenta exteriora aequalia spathulato-oblonga cuspidato-acuminata, postico basi 7-nervio medio 5-nervio, antici usque ad medium fissi laciniis 3-nerviis. Stamina omnia perfecta.

Fruticulus decumbens dichotomo-ramosus, ramulis quadrangularibus. Folia 5–8$^{\mathrm{cm}}$ longa 1.5–3.5$^{\mathrm{cm}}$ lata supra saepe minutissime lineolata subtus ad costam nervosque pubescentia, petiolis pubescentibus 1–1.5$^{\mathrm{cm}}$ longis, axillis saepius folia duo minuta producentibus. Spicae foliis reductis suffultae 3–4$^{\mathrm{cm}}$ longae, bracteis 9–10$^{\mathrm{mm}}$ longis 2.5–3$^{\mathrm{mm}}$ latis triente superiore falcato-acuminatis et ciliatis ad nervos pubescentibus, bracteolis 9$^{\mathrm{mm}}$ longis inaequilateralibus ciliatis, altera angustiore. Calyx 1.5$^{\mathrm{cm}}$ longus sicut bracteolae erubescens et pulchre reticulatus ciliatus ad basin versus utrinque incano-pubescens ceterum minute puberulus, segmentis lateralibus subulatis 8$^{\mathrm{mm}}$ longis, postico 5$^{\mathrm{mm}}$ lato. Corolla purpurea (ut videtur), pubescens 3.3$^{\mathrm{cm}}$ longa, labio postico truncato-ovato 8–9$^{\mathrm{mm}}$ longo bidentato, antici 10–11$^{\mathrm{mm}}$ longi segmentis ovalibus 6$^{\mathrm{mm}}$ longis. Stamina medio tubo affixa, antica 17$^{\mathrm{mm}}$ longa, posticorum 13$^{\mathrm{mm}}$ longorum antheris unilocularibus polleniferis. Discus 1$^{\mathrm{mm}}$ altus, ovario oblongo-ovoideo 4$^{\mathrm{mm}}$ longo, stylo capillari 2.7$^{\mathrm{cm}}$ longo, ovulis ovalibus 1$^{\mathrm{m}}$ longis. Capsula non adest.— Ceteris speciebus adhuc descriptis, omnibus Brasiliensibus aut Peruvianis, haec bracteis bracteolis calycibus praecipue discrepat.

Casillas, Depart. Santa Rosa, Guatemala, alt. 1300$^{\mathrm{m}}$, Jan. 1893, *Heyde* et *Lux*, n. 4382 Pl. Guat. &c., qu. ed. Donn. Sm.

Hernandia didymantha Donn. Sm.— Ramuli cum foliis petiolisque glaberrimi. Folia oblongo-ovata a medio linea arcuata sursum angustata basi obtusa aut rotundata penninervia. Paniculae folia superantes praeter involucella totae incanae, ramis secundariis bifloris, bracteis 4 oblongis. Flos masculinus solitarius 3-merus, pedicello filiformi. Flos femininus 4-merus, involucello truncato pyramidali subclauso, fructifero sphaerico drupam subaequimagnam arcte includente, semine globoso.

Arbor 15$^{\mathrm{m}}$ alta, trunco excelso, ramis inferioribus reflexis, superioribus erecto-patentibus, floribus porraceis (ex schedula et icone photographica Pitterianis). Folia 12–18$^{\mathrm{cm}}$ longa 4.5–7$^{\mathrm{cm}}$ lata tenuiter coriacea, nervis lateralibus utrinque 7–8, petiolis glabris canaliculatis 3–6$^{\rm cm}$ longis. Paniculae circa 5 terminales et ex axillis foliorum superiorum decrescentium prodeuntes cum pedunculo 9–11$^{\rm cm}$ longo adjecto 19–23$^{\rm cm}$ longae corymbiformes densiflorae, ramis secundariis arcuatim adscendentibus, inferioribus 2–3$^{\rm cm}$ longis. Bracteae jam ante anthesin reflexae 8$^{\rm mm}$ longae 3.5$^{\rm mm}$ latae apice rotundatae. Floris masculini pedicellus filiformis 7$^{\rm mm}$ longus, altero anantho brevi rarissime exstante, segmenta 6 oblongo-elliptica 5$^{\rm mm}$ longa obtusa, glandulae 6 liberae subsessiles, antherae oblongae 1.5$^{\rm mm}$ longae filamenta aequantes. Floris feminini pedicellus 1$^{\rm mm}$ longus, involucellum coriaceum parce pubescens siccitate nigrescens 3$^{\rm mm}$ altum atque latum, ore integro 1$^{\rm mm}$ lato, segmenta 8 uti glandulae 4 masculinis similia, stylus sursum incrassatus et quadrangularis 4$^{\rm mm}$ longus, stigma obliquum subintegrum nudum. Involucellum fructiferum crasse coriaceum 2.2$^{\rm cm}$-diametrale, drupa 1.9$^{\rm cm}$-diametralis ecostata (ut videtur).

H. Guianensi Aubl. proxima recedit praesertim foliis penninerviis, flore masculino singulo graciliter pedicellato, involucello jam sub anthesi paene clauso, drupa minore.

Ad litora Atlantica prope Punta Mona, Costa Rica, Sept. 1898, *Pittier*, n. 12682 herb. nat. Cost.

Brosimum heteroclitum Donn. Sm.—Scandens. Folia membranacea glabrescentia oblongo-elliptica cuspidato-acuminata basi obtusa aut acutiuscula crenulato-serrulata, stipulis bracteisque a basi lata filiformibus. Receptacula in axillis duabus supremis approximatis solitaria sessilia maxima, masculinorum loculis 1–3, ovulis abortivis in quoque loculo pluribus.

Suffrutex in arborum truncis scandens et radicans, ramis virgatis 30–40$^{\rm cm}$ longis glabris. Folia nascentia pubescentia, vetustiora supra punctis minutis albidis scabriuscula costa nervisque pubescentia 10–16$^{\rm cm}$ longa 4.5–6.5$^{\rm cm}$ lata, nervis lateralibus utrinque 6–8, venis transversis subparallelis, petiolis 1–3$^{\rm cm}$ longis sicut stipulae bracteaeque 6$^{\rm mm}$ longae pubescentibus. Receptacula masculina globosa 1–1.3$^{\rm cm}$-diametralia demum ovalia et usque ad 2$^{\rm cm}$ longa crasse corticata ore bracteolis crassis ovatis munita, ovulis abortivis lateraliter affixis. Cetera desunt. Species habitu scandente et ovulis rudimentariis compluribus valde anomala. Receptacula vetustiora staminibus derasis tantum suppetunt.

Jiménez, Llanuras de Santa Clara, Costa Rica, alt. 250$^{\rm m}$, Mart. 1896, *Donn. Sm.*, n. 5117, Pl. Guat., &c., qu. ed. Donn. Sm.

Pilea ptericlada Donn. Sm.—Dioica. Glabra. Folia oblongo-elliptica utrinque acuminata in petiolum brevem cuneato-attenuata supra trientem inferiorem grosse crenato-serrata, nervis basilaribus trientem superiorem attingentibus et costa subtus explanatis fuscis, stipulis quam petiolis paulo brevioribus. Pedunculi feminini foliis breviores et cymarum axes alati.

Herbacea. Caulis e basi lignosa radicante assurgens in exemplis obviis 6–15^{cm} altus, nodis approximatis. Cujusve paris folia aequalia aequilatera triplinervia 5–11^{cm} longa 3–5^{cm} lata summa apice obtusiuscula supra cystolithis fusiformibus et punctiformibus farcta subtus plerumque nuda, foliis inferioribus minoribus, serraturis obtusis, costa nervisque supra immersis, stipulis orbiculari-ovatis 5–8^{mm} longis binerviis, petiolis 6–10^{mm} longis. Pedunculi 2–6^{cm} longi 2–3^{mm} lati, cymis pyramidatis 2–3^{cm} altis 2.5–3.5^{cm} latis, ramis ramulisque patulis circa 1^{mm} latis sicut pedunculi cystolithis obsitis. Perianthium sessile fructifer bracteolam cystolithis lineatam subaequans, segmentis parum inaequilongis, achenia ventricoso-ovata 2^{mm} longa perianthium dimidio superante rubro-punctulata et marginata. Planta masculina ignota. Secundum methodum Weddellianam juxta *P. elegantem* Wedd. locari debetur.

✓ In sylvis udis Atirrensibus, Prov. Cartago, Costa Rica, alt. 600^{m}, Apr. 1896, *Donn. Sm.* n. 6779 Pl. Guat., &c., qu. ed. Donn. Sm.; Suerre, Llanuras de Santa Clara, Costa Rica, alt. 300^{m}, Apr. 1896, *Donn. Sm.* n. 6780 Pl. Guat., etc., qu. ed. Donn. Sm.—Eadem planta, ut videtur, sub nn. 172 et 199 *Endres* in herb. Kew. exstat.

Costus sanguineus Donn. Sm.— Pallide ferrugineo-villosus. Folia discoloria supra bulboso-pilosa oblanceolato-oblonga acutissime acuminata basi minute rotundata subsessilia. Strobilus lanceolato-ovoideus, bracteis pilosis oblongo-ovatis superne infra apicem carinatis, infimis apice foliaceis. Calyx prima tertia parte acute lobatus. Corolla sanguinea, labello pubescente oblongo apice angustata truncata 5-lobulato, ceteris segmentis anguste lanceolato-oblongis, connectivo triangulari labellum paulo superante. Ovarium pilosum.

Ochreae laciniis scariosis usque ad 2^{cm} longis marginatae saepius reticulato-striatae cum vagina extus villosae et intus glanduloso-punctulatae. Folia subtus sericea et ad costam longe villosa 14–22^{cm} longa supra medium 4.5–6.5^{cm} lata basi 8–10^{mm} lata, nervis omnibus a basi prodeuntibus. Strobilus 7–10^{cm} longus circa 3^{cm} crassus, bracteis coriaceis sanguineis circa 4^{cm} longis 20–23^{mm} latis, bracteola 1 pubescente lineari-oblonga 18^{mm} longa 6^{mm} lata acuminata, floribus sub quaque bractea singulis. Calyx campanulatus 8–9^{mm} altus pilosus striatus. Corolla purpureo-coccinea (von Tuerckheim in sched.) 5.5–6^{cm} longa, labello 3.3^{cm} longo 1.5^{cm} lato a triente superiore deorsum paulo angustato, lobulis oblongis 3^{mm} longis rotundatis, ceteris segmentis $26-28^{mm}$ longis $7-9^{mm}$ latis, filamento $9-10^{mm}$ lato, connectivo 7^{mm} longo in caudiculam marginibus revolutam producto, anthera 8^{mm} longa, loculis 1^{mm} inter se distantibus. Ovarium breviter oblongum 5^{mm} longum, stigmate semilunari 3^{mm} lato ciliolato, appendice dorsali ovali apice retusa. Capsula ignota.— *C. spicato* Sw. proximus differt praecipue indumento et florum indole atque colore.

Cubilquitz, Depart. Alta Verapaz, Guatemala, alt. 350^{m}, Maj. 1900, *von Tuerckheim*, n. 7686 Pl. Guat. &c., qu. ed. Donn. Sm.

ISCHNOSIPHON MORLAE (Eggers, Bot. Centralbl. **53**: 307. *pl.* *2*) **leiostachya** Donn. Sm.—Spicae glabrae, bracteis magis elongatis.—Ceteroquin exempla Centrali-Americana cum specimine typico Ecuadoriensi in herb. Kew. asservato prorsus congruunt.

San Pedro Sula, Depart. Santa Barbara, Honduras, alt. 300^{m}, Sept. 1888, *C. Thieme*, n. 5519 Pl. Guat. &c., qu. ed. Donn. Sm.; Las Vueltas, Tucurrique, Prov. Cartago, Costa Rica, alt., 635^{m}, Dec. 1898, *Tonduz*, n. 12884 herb. nat. Cost.

Calathea dasycarpa Donn. Sm. (§ EUCALATHEA Koern.)—Folia glabra oblonga 3–4-plo longiora quam latiora in cuspidem gracilem acuminata basi rotundata in articulum cuneato-producta, folio inflorescentiam suffulciente caulinis simili longe petiolato. Pedunculus petiolo brevior bifidus. Spicae pro ratione parvae oblongae interdum basi furcatae, bracteis distichis vix ac ne vix imbricatis dimidiato-ovatis cymbiformibus coriaceis ad margines barbatis, floribus paucis binis. Corollae tubus sepalis 3-plo longior intus villosissimus. Ovarium pilosum. Fructus monospermus.

Folia $60-80^{cm}$ longa prope medium $18-19^{cm}$ lata ad costam subtus pubescentia, cuspide lineari $1.5-2.5^{cm}$ longa, petiolis cum articulo glabro $5-6^{cm}$ longa adjecto 43^{cm} longis pilosiusculis. Pedunculus 21^{cm} longus basi bractea 10^{cm} longa apice bractea 3.5^{cm} longa suffultus, ramis $3-5^{cm}$ longis. Spicae $6-9^{cm}$ longae, rachis internodiis inferoribus $10-18^{mm}$ longis, bracteis 10–12 demum late patulis circa 2^{cm} longis 9^{mm} latis, bracteolis 2 late oblongis 10 14^{mm} longis, exteriore bicarinata et dentibus rotundatis 3-lobulata, interiore minore unicostata integra, floribus plerumque 4 minute pedicellatis. Sepala lanceolata $7-9^{mm}$ longa. Corollae pallide luteae (Pittier in sched.) tubus 28^{mm} longus intus valde pluri-costatus. Ovarium obovatum 3^{mm} longum dense longeque adpresso-pilosum, ovulo abortu unico triquetro. Fructus ovalis 10^{mm} longus 5^{mm} latus pilosus, pericarpio membranaceo nervoso, semine atro-purpureo oblongo 4.5^{mm} longo corrugato. Corolla cum androecio marcida tantum suppetit.

✓In sylvis ad oras Rio Hondo prope Madre de Dios, Comarca de Limón, Costa Rica, alt. 200^{m}, Nov. 1896, *Pittier*, n. 10350 herb. nat. Cost.; Agua Buena, Cañas Gordas, Comarca de Limón, Costa Rica, alt. 1100^{m}, Feb. 1897, *Pittier*, n. 11136 herb. nat. Cost.

Calathea lasiostachya Donn. Sm. (§ EUCALATHEA Koern.)—Folia glabra elongato-ovata apice acuminata inferne rotundata ima basi cuneata, folio inflorescentiam suffulciente conformi dimidio minore petiolis usque ad articulum vaginatis bis longiore. Pedunculi 3-ni petiolum subaequantes. Spicae elongato-oblongae sordide villosae, bracteis stricte distichis late patentibus conduplicatis membranaceis. Ovarium glabrum. Fructus dispermus.

Caulis robustus elatus. Articuli cum vaginis pedunculisque pilosiusculi. Folia 86^{cm} longa 23^{cm} lata a triente inferiore sursum angustata, articulis 9^{cm} longis, petiolis longissimis, vaginis scabriusculis. Folium sub inflorescentia 40^{cm} longum 15^{cm} latum, petiolo cum articulo 3^{cm} longo adjecto 21^{cm} longo. Pedunculi $15–22^{cm}$ longi ad apicem versus villosi. Spicae $11.5–17^{cm}$ longae $5.5–6^{cm}$ latae, lateribus subparallelis. Bracteae 22–32 sublaxe imbricatae dimidiato-ellipticae subfalcatae 3.5^{cm} longae 1.5^{cm} latae intus sericeae, omnes conformes, bracteolis lineari lanceolatis et linearibus circa 2^{cm} longis. Ovarium nitido-atrum oblongum 6^{mm} longum 4^{mm} latum 3-loculare abortu 2-ovulatum. Fructus laevis pallidus ellipticus 12^{mm} longus 6^{mm} crassus, pericarpio pergameneo intus valde reticulato, valvis 3 inaequilatis, minoribus latere septatis, seminibus atris 8^{mm} longis arillosis. Perianthium deficit.

✓In sylvis ad oras Rio Hondo prope Madre de Dios, Costa Rica, alt. 200^{m}, Nov. 1896, *Pittier*, n. 10344 herb. nat. Cost.

Calathea Verapax Donn. Sm. (§ MONOSTICHE Koern.)—Glabra. Acaulis. Folia inaequilatera elliptica vel ovato-elliptica acuminata ima basi in articulum brevem producta petiolis subaequilonga. Scapus nudus petiolum superans usque ad medium bractea radicali inclusus basi petiolo et bracteis cinctus. Spica obovato-elliptica, bracteis membranaceis coloratis numerosissimis lanceolatis filiformi-attenuatis subaequilongis. Corollae tubus sepalis linearibus dimidio longior, lobi lanceolati.

Rhizoma bracteas $7–20^{cm}$ longas apice denticulata petiolos 2 scapumque involventes emittens, petiolo altero toto fere vaginato alterum nudum includente. Folia 20–30^{cm} longa 9.5–14^{cm} lata, petiolis cum articulo 1–2^{cm} longo adjecto 29–33^{cm} longis. Scapus 35–55^{cm} longus. Spica 8–12^{cm} longa circa 4^{cm} lata, rhachi 5^{cm} longa, bracteis in sicco rubescentibus erecto-patentibus, infimis 6.5^{cm} longis 1.8^{cm} latis, supremis 6^{cm} longis 9^{mm} latis, bracteolis 3 late oblongis 1.7^{cm} longis, exteriore valde bicarinata, floribus 2–4-nis. Sepala 2.1^{cm} longa 2.5^{mm} lata. Corollae coccineae (ut videtur), tubus 3^{cm} longus, lobi 1.5^{cm} longi 5^{mm} lati acuti. Androecii labellum 1^{cm} longum 7^{mm} latum, lobus cucullatus appendice filiformi 4^{mm} longa instructus, staminifer anthera 2.5^{mm} longa superatus. Stylus incurvus, stigmate valde inflexo. Ovarium glabrum oblongo-obovatum 3-loculare. Fructus non adest.—Ad *C. Petersenii* Eggers habitu accedens spica et florum fabrica recedit.

Rubelcruz, Depart. Alta Verapaz, Guatemala, alt. 1000^{m}, Maj. 1887, *von Tuerckheim*, n. 1269 Pl. Guat. &c., qu. ed. Donn. Sm.; Sacolal, Depart. Alta Verapaz, alt. 1000^{m}, Apr. 1889, *Donn. Sm.*, n. 1779, Pl. Guat. &c., qu. ed. Donn. Sm.

Callisia grandiflora Donn. Sm.—Folia a basi rotundata sessili elliptico-lanceolata. Cyma elongata cincinnalis, pedicellis compluribus, floribus 3-meris maximis. Stamina fertilia 3, filamentis sursum barbatis, loculis divergentibus connectivo amplissimo brevioribus. Stamina sterilia 3 nuda. Capsula 3-valvis, loculis monospermis.

Praeter ocreas ciliatas glabra. Folia 6–12^{cm} longa 1.5–2.5^{cm} lata acutissima. Cyma paniculiformis 6–11^{cm} longa, rhachi flexuosa, axibus primariis 1.5–2.5^{cm} longis, lateralibus 7–20^{mm} longis, bracteis inferioribus foliaceis 1–5^{cm} longis, superioribus depauperatis sicut bracteolae minimae subspathaceis, pedicellis circa 5–9-fasciculatis 7–10^{mm} longis. Sepala herbacea albopunctata oblongo-elliptica 6.5^{mm} longa 2.5^{mm} lata sub anthesi reflexa. Petala ex schedula Tuerckheimiana alba in sicc. pallide flavescentia oblongo-elliptica 9^{mm} longa 4^{mm} lata obtusa. Stamina fertilia 6–7^{mm} longa, pilis aureis longissimis densissimis, antheris cinnabarinis transversim ovalibus 1.5^{mm} latis utrinque praesertim apice bifidis, loculis oblongis 0.5^{mm} longis subdivaricatis. Stamina imperfecta 2–3^{mm} longa, loculis connectivo parvulo subdiscretis. Ovarium ovale 1^{mm} longum stylum aequans, stigmate capitellato papilloso. Capsula ovalis 5–6^{mm} longa abortu saepius bisperma, seminibus erubescentibus rugulosis elongato-oblongis 4^{mm} longis.—Species staminibus et perfectis et rudimentariis abnormalis ad Tradescantiae sect. Descantariam accedens.

In dumetis et frutectis prope Cubilquitz, Depart. Alta Verapaz, Guatemala, alt. 350^{m}, Mart. 1900, *H. von Tuerckheim*, n. 7684 Pl. Guat. &c., qu. ed. Donn. Sm.

BALTIMORE, MD.

BRIEFER ARTICLES.

NITRATES AS A SOURCE OF NITROGEN FOR SAPROPHYTIC FUNGI.

The readiness with which different classes of plants make use of nitrogenous inorganic material has been variously demonstrated. It is well understood that salts of nitric acid, and to a less extent ammonia, serve as nutrient material for the higher plants, and that free nitrogen and salts of nitrous acid are worked upon by certain bacteria in such a way as to make them available as a nitrogen food supply. But Pfeffer[1] states that phanerogams and saprophytic fungi are unable to assimilate nitrites.

With a view of testing this latter point certain fungi were grown in culture solutions containing ammonium chlorid, potassium nitrate, potassium nitrite, hexamethylenetetramine, and peptone. The culture was prepared with 200^{cc} chemically pure water obtained by redistilling from a solution of potassium permanganate until free from every trace of ammonia, 10^{gr} cane sugar, 0.5^{gr} magnesium sulphate, 0.1^{gr} acid potassium phosphate, and a trace of ferric chlorid. To 10^{cc} of the sterilized solution was added 0.1^{gr} of one of the nitrogen containing substances. One drop of this preparation placed on a cover glass was inoculated with the fungus and the cover glass inverted over the cell and placed in the thermostat for cultivation at 28° C. The fungi used for inoculation were *Aspergillus flavus* and *Botrytis vulgaris.* Throughout the experiment care was taken to have the solutions and apparatus thoroughly sterilized, and all of the salts used were chemically pure.

Duplicates of each were prepared, also checks using the solution without the nitrogen containing compound. The cultures were examined at intervals for from one to three days. At the expiration of the time unquestionable results were obtained. In potassium nitrate and potassium nitrite the fungi grew with apparently equal vigor, Aspergillus developing well formed fruit bodies. Hexamethylenetetramine showed itself an excellent source of food, since both fungi grew and

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[1] Physiology of Plants, translated by Ewart, 406. 1899.

fruited in it. In peptone the fungi grew rapidly and luxuriantly, proving it to be a favorable source of nitrogen.—MARY H. SMITH, *Botanical Department, Cornell University.*

NON-SEXUAL PROPAGATION IN OPUNTIA. II.

A VERY interesting Opuntia which has recently come to my notice in studying the various propagative methods of the Cactaceae is *O. arbuscula* Engelm., a small, more or less arborescent form, densely branched, and reaching a height of about 15^{dm}. This plant sets an abundance of fruit which appears to mature well, but which upon examination is found to contain very few good seeds. So laden is the plant with its fruit that its branches, as a rule, bend over so as almost, if not quite, to touch the ground. In this position there takes place a process analogous to "layering," new shoots of an apparently primitive character arising from the decumbent branches, which also give off roots into the soil. The same formation of primitive shoots occurs in joints detached from the parent plant. This is also true of fruits, from the sides of which both stems and roots may often be found forming, so often, in fact, that this must be regarded as the rule rather than the exception. We have here the case of a structure, modified primarily for sexual purposes, turned finally to use in a non-sexual way, to accomplish, broadly speaking, the same end.

Still another method of propagation, perhaps not very common, yet apparently not infrequent with this species, is by the formation of adventitious shoots on the roots. The roots are, in this form as in the majority of the Cactaceae, divided into two systems, as already described.[1] On the absorptive roots, which run just below the surface, there arise, at some distance from the main plant, adventitious shoots of a character far more primitive than those formed on fruits or fallen joints. The leaves of these shoots are in some cases over 10^{mm} long, green, and succulent. By the time these shoots reach the height of about 2^{dm}, the root connecting them with the parent plant dies, thus leaving them independent at an early stage.

The distribution of this species is very well defined. It occurs almost exclusively in those slight depressions in the plain, which in time of hard rains are washed by broad and shallow streams of surface

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[1] BOT. GAZ. **30**: 348 *seq.* 1900.

water. Here it grows in colonies, following the lines of the depressions. The soil in such places is much finer and less pebbly than that on the slight elevations near by, but experiments in transplanting have demonstrated that this distribution is not due to soil characters. It seems probable that the fruits and joints are washed down by the stream, and settle at various places along the course. From the single plants so started colonies soon are formed, through the agency in part, it may be supposed, of root propagation and "layering."—CARLETON E. PRESTON, *Harvard University.*

CURRENT LITERATURE.

BOOK REVIEWS.

A new school botany.[1]

AT least three things must be considered in making an estimate of a text-book, namely, its style, its reliability, and its pedagogical standpoint. Professor Bailey's style is too well known to need description or commendation. He is one of our clearest and most forceful writers. The general facts of botany are fairly well established and are common property, so that the preparation of an elementary text involves merely selection from a great mass of well-known material. In the book before us, therefore, there is no occasion to discuss style or reliability, although in the latter feature Professor Bailey is as great a sinner as the rest of us. In regard to the pedagogical standpoint, however, he has raised a distinct issue and this deserves statement and some discussion. The author has had an extensive experience with teachers and schools, and his verdict is that "the schools and the teachers are not ready for the text-book which presents the subject from the view-point of botanical science." To discover the explanation of this statement by means of his book, it becomes evident that the author does not believe in the organization of botanical material so that some conception of the science as a whole may be developed. From his point of view the study need not develop the idea of relationships, or need not be used to illustrate principles. The selection of material is to be made from forms and phenomena which are familiar, and which are related to the experiences of the daily life. All of this means that in the judgment of the author the average recent botanical text is not adapted to the majority of teachers and of schools as they are, but overshoots them.

At least two objections to this view have doubtless had weight with those botanists who have prepared texts from a different standpoint, namely, the conviction that pupils of secondary-school age are ready for some organization of a science, and the further conviction that teaching can only be improved when some pressure is brought to bear upon teachers to become properly trained. It should be said that the author distinctly disclaims any criticism of existing text-books, but recognizes the need of one adapted to actual rather than to ideal conditions.

An illustration of the result of not keeping hold of some little thread of continuity may be found in Professor Bailey's chapter XXV, entitled

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[1] BAILEY, L. H.: Botany, an elementary text for schools. 8vo. pp. xiv+356. New York: The Macmillan Company. 1900. $1.10.

"Studies in cryptogams." In our judgment this chapter will be unintelligible or misleading to those who have had no other preparation for it than that obtained from the preceding chapters. This is no criticism of the chapter as to its contents, but as to its pedagogical soundness.

Another position taken by the author deserves attention. He says: "There are other ideals than those of mere accuracy. In other words, it is more important that the teacher be a good teacher than a good botanist. One may be so exact that his words mean nothing." The writer sympathizes with the thought in Professor Bailey's mind, for he has encountered these oppressively accurate and insistent teachers, whose mania for precision kills inspiration; but he doubts whether teachers in the secondary schools need any encouragement to be inaccurate. It would seem evident that reasonable accuracy, as opposed to pedantic accuracy, and inspiration should coexist in the teacher. If there is anything for which science stands, and in which it should train even the very young, it is a reasonable accuracy.

The four general subjects presented in the book are the nature of the plant itself; the relation of the plant to its surroundings; histological studies; and determination of the kinds of plants. From the pedagogical standpoint the author regards the third as the least important. The book is full of suggestive material for the teacher, and the illustrations are very attractive. The experiment suggested by Professor Bailey is worth the trial, and no teacher should be so confident of his own methods as not to await the outcome with keen interest.—J. M. C.

The Umbelliferae.

JUST TWELVE YEARS after the appearance of their first *Revision* of North American Umbelliferae, Drs. Coulter and Rose have brought out a new monograph of the same group, which appears to be a model of what such work should be.[2]

From the time of Linnaeus to the treatment of our Umbelliferae by Torrey and Gray, eighty-seven years, thirty authors wrote on the group, producing forty-one books and papers, which contained 195 new species or names. In the next forty-seven years, up to the appearance of the *Revision* of Coulter and Rose, twenty-seven writers, in fifty-seven contributions, introduced 258 new names or species in the group. And in the last twelve years nineteen persons, contributing forty-three papers, have added 108 new species and names. The *Monograph* now issued (as it chances, on the last day of the century) describes and places 332 native species and 39 which are considered as introduced, or a total of 371, in contrast with 233 included in their earlier *Revision*. No comment is needed on this as an indication of the rapidity with which the understood components of our flora are changing.

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[2] COULTER, JOHN M., and ROSE, J. N.: Monograph of the North American Umbelliferae. Contr. U. S. National Herbarium **7**: 1–256. *pls. 1–9. figs. 1–65.* 1900.

In addition to what appear to be serviceable keys to the genera and species, that which is now believed to be their necessary bibliography and synonomy, adequate descriptions, and a full citation of material examined, the work contains a large amount of tabular and statistical matter, which if not of interest to the ordinary seeker after the name of a plant, at least shows the painstaking care that has been bestowed on the study. An interesting feature is a table of data concerning the specimens which have served for illustration, and as all of the sixty-two native and sixteen introduced genera are figured, both as to the appearance of their fruit and its cross section, this information is of no little importance for those who in future may have to familiarize themselves with what these genera now stand for.

That all but four of some 800 references have been verified not only shows the industry of the authors but ensures the trustworthiness of their statements in this, a feature which is too often lamentably misleading to the men who compile from unverified citations.

The most conspicuous changes are as follows: *Coloptera* C. & R. is found to represent true *Cymopterus*, and the Cymopterus aggregate of the former *Revision* is distributed under four genera, two of them new (*Aulospermum* and *Rhysopterus*), and two of them Nuttallian (*Phellopterus* and *Pteryxia*); *Peucedanum* L. is found to have no indigenous species in North America, and this greatest of our umbelliferous genera becomes known as *Lomatium* Raf., certain groups of species heretofore included being recognized as genera, as *Cynomarathrum* Nutt. and *Euryptera* Nutt.; *Centella* L. is recognized as distinct from *Hydrocotyle; Deweya* T. & G. is restricted to its type species, and a new genus, *Drudeophytum*, established to include the other species variously described under Deweya, Velaea, and Arracacia; and *Sphenosciadium* Gray is taken out of *Selinum*. As a result of these and other changes, the following generic names disappear from our flora: *Coloptera* C. & R., *Crantzia* Nutt., *Cryptotaenia* DC., *Discopleura* DC., *Leptocaulis* Nutt., *Osmorhiza* Raf., *Peucedanum* L., *Phellopterus* Benth., *Selinum* L., *Tiedemannia* DC., and *Velaea* DC.

All-in-all, though changes are not unlikely to occur that may relatively soon cause us to look upon this as merely work of the last century, it appears to be of such a character that the twenty-first century will still see it at the elbow of every advanced and attentive student of the Umbelliferae of our country.—WILLIAM TRELEASE.

MINOR NOTICES.

THE THIRD FASCICLE of the second volume of Pittier's *Flora of Costa Rica*[3] has appeared. The first fascicle contained the Polypetalae (excepting

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[3] PITTIER, H.—Primitiae Florae Costaricensis. Vol. II, pp. 219–294. Piperaceæ, by Casimir de Condelle. San José de Costa Rica. 1899. $1.

Polygalaceae, Sapindaceae, Meliaceae, Leguminosae, and Melastomaceae), by John Donnell Smith. The second fascicle included the Gamepetalae (excepting Rubiaceae, Compositae, Solanaceae, Convolvulaceae, Acanthaceae, and Labiatae), by the same author. The present fascicle presents the Piperaceæ, by Casimir de Candolle, who calls attention to the close affinity of the flora to that of South America. The two genera are Piper and Peperomia; the former containing eighty-three species, fifty-one of which are described as new; the latter forty-three species, twenty-one of which are new.—J. M. C.

PROFESSOR KARL SCHUMAN has begun the publication of *Blühende Kakteen* (*Iconographia Cactacearum*), with the assistance of the Deutsches Kakteen-Gesellschaft. Each part is to contain four colored plates, with descriptive text, and is sold for four marks. It is expected that about three parts will be issued each year. The first part contains *Echinocactus microspermus* Web., *Echinopsis cinnabarina* Lab., *Echinocereus subinermis* Salm-Dyck, and *Echinocactus Anisitsii* K. Sch., the last being a new species from Paraguay. The plates are beautifully colored illustrations of the plants in bloom, made from nature by Frau Dr. T. Gürke. The text, by Professor Schuman, needs no comment. The publisher is J. Neumann, Neudamm, Brandenburg, Germany.—J. M. C.

DR. A. J. GROUT'S *Mosses with a hand lens*[4] describes in nontechnical language 100 of the mosses of the northeastern United States which can be recognized with some degree of certainty by the use of a simple lens. The identification in many cases must be limited to the genus, the specific differences being too recondite for observation in this way. Miss Thayer's excellent drawings will be quite as helpful to the student as Dr. Grout's text. A key based upon the more apparent structural characters, and one based upon habitat, would need to be tested before pronouncing judgment upon them, but they are here and there unavoidably somewhat vague, which always detracts from the value of a key. The only danger from the use of such a book will be that beginners will not heed sufficiently the author's cautions, and will be too sure of their determinations. But if properly used the book will stimulate interest in the mosses and lead on to more exact study.

The glossary has concise and accurate definitions, elucidated by admirable illustrations. It would have been more serviceable had it been arranged in one alphabetic sequence instead of being divided into several. One must first know to what his strange word is applicable before he can tell in what group to look for it.— C. R. B.

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[4] GROUT, A. J.: Mosses with a hand lens. A nontechnical handbook of the more common and more easily recognized mosses of the northeastern United States. Illustreated by Mary V. Thayer. 8vo. pp. xii+74. *pls. 8. figs. 90.* New York: The Author, 360 Lenox Road, Flatbush. 1900.

NOTES FOR STUDENTS.

In two papers[5] Dr. Bessey states that some recent observations of his have lead him to think that the greater portion of the state of Nebraska is capable of supporting a tree vegetation. He claims that the absence of trees is due to the prairie fires, and that now wherever given a chance the tree area of the state is spreading.— H. N. Whitford.

According to Miyake[6] the majority of the leaves of Japan evergreens are found to contain more or less starch in winter, only one third of the species being devoid of it altogether. The starch content in winter, however, is considerably decreased; this decrease begins in November, the minimum of starch is found in January, and the amount increases again in February. The author also shows that starch is actually manufactured in winter, though much less than in summer.—H. C. Cowles.

Nemec asserts[7] that in certain plant parts, *e. g.*, the root, where transmission of a stimulus occurs, there are embedded in a special plasma fibrils, the clusters of which, by proper staining, may be made easily visible with moderate magnification. These fascicles correspond on opposite sides of the partition walls and presumably are continuous or at least in contact through it. Experiment has shown that conduction of a stimulus is more rapid in the direction of these fibrils than across them, and that after their degeneration this difference in rate disappears. The perceptive region of the root, he declares, lies mostly in a special group of cells in the root cap. These are characterized by a very fluid plasma, and permanent starch grains which easily sink through it to rest on the ectoplasm. Fibrils extend from these cells to the region of curvature. In some roots this group of cells becomes a special organ, which may be compared in principle with the organs of equilibrium (vesicles with statoliths) in certain lower animals. (Cf. Noll, rev. in Bot. Gaz. **30**: 134. 1900.)—C. R. B.

Mr. James A. Terras, of Edinburgh, has examined the conditions under which the winter buds of *Hydrocharis Morsus-ranæ* germinate. This plant propagates itself by buds, formed at the extremities of the subaqueous runners, in which is stored an abundant supply of reserve proteid, apparently a fluid albumin. The autumnal buds separate as soon as mature and sink to the bottom, where they rest till the following spring, or longer if covered by mud to the depth of two or three centimeters. It seems that this cover is effective merely because it cuts off the light, any other opaque screen likewise preventing germination. Indeed if merely much shaded the buds do

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[5] The forest and forest trees of Nebraska. Reprint from Report of Nebraska Board of Agriculture, pp. 79–102. 1899.

The natural spreading of timber areas. Forester **6**: 240–243. 1900.

[6] Bot. Mag. **14**: 44–49. 1900.

[7] Biologisches Centralblatt **20**: 369. 1900.

not develop. Experiments with colored liquid screens show that yellow and orange rays are most efficient, as Heald found in studying the germination of moss and fern spores. Heat apart from light is incapable of inciting to development; and no supply of food, either carbohydrate or nitrogenous, awakens to activity. No zymogen was found in resting buds, and Terras concludes that the primary effect of light is to stimulate the protoplasts to activity, leading to the development of a zymogen, which in its turn is converted under the influence of the light into a zymase by which the utilization of the stored food becomes possible.—C. R. B.

IN HER RECENT WORK on Lavatera,[8] Miss Byxbee describes a process of spindle development as follows: In the young pollen mother cells the cytoplasm consists of a fibrous network and a granular substance. As division approaches, the network surrounding the nucleus pulls out parallel to the membrane, forming a felt of fibers, and at the same time the granular substance of the cytoplasm collects in a wide dense zone about the nucleus. The nuclear wall now breaks down, and the fibers outside begin to grow into the nuclear cavity and mingle with the linin threads, which appear to have increased in quantity. This central mass of fibers now grows out into several projections, which become the cones of the multipolar spindle. Two of these cones become more prominent than the others, which they finally absorb, and the result is a bipolar spindle. Just how this absorption of the smaller cones is brought about is not made clear either in the description or in the figures.

The work is well illustrated by four beautiful lithographic plates. While the results differ in certain minor details from previous work on the subject, it confirms the more important points that have already been worked out in such forms as Equisetum, Cobaea, Passiflora, Gladiolus, etc. The paper is an addition to the very interesting series of contributions on spindle formation recently issued from the Botanical Laboratory of the University of California.

Flemming's strong solution, with an excess of acetic acid, palladium chlorid, and iridium chlorid, to which a small quantity of glacial acetic acid was added, were used for fixing; saffranin, gentian violet, and orange G were used for staining.—A. A. LAWSON.

THE GEOLOGICAL SURVEY of New Jersey has just issued a publication[9] which contains some valuable information concerning the forests of that state. In this C. C. Vermeule discusses the physical conditions of the forests of the state, and gives some field notes on forest conditions. Gifford Pinchot

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[8] BYXBEE, EDITH SUMNER: The development of the karyokinetic spindle in the pollen mother cells of Lavatera. Cal. Acad. Sci. III. Bot. **2**: 63–81. *pls. 10–13.* 1900.

[9] Annual Report of the State Geologist for 1899. Report on forests. Geol. Surv. of New Jersey, pp. ix+327, *pls. 21*, with *maps*. 1900.

writes on the effects of fire on forest production, and on the plains, and adds some silvicultural notes on the white cedar. The last two topics are incorporated in the present volume from former reports of the survey.

By far the most useful part of the report from an ecologic standpoint is a paper discussing the relation between forestry and geology, by Dr. Hollick. This is a revision of a paper of the same title published in the January and February (1899) numbers of the *American Naturalist.* It contains a discussion of the existing conditions of the forests and their historic development. The state is divided into coniferous, deciduous, and tension zones. The coniferous zone lies to the south, which has for the most part barren soil conditions. In better soil conditions in the north is the deciduous zone, and the tension zone lies between these. Dr. Hollick draws the conclusion that "the coniferous zone is destined to be ultimately obliterated, or only to exist over limited areas, often for the negative reason that in such areas the conditions may not be favorable for other types of vegetation."

In part three of the report John B. Smith treats of the rôle of insects in the forest; and part four contains an article by John Gifford on the forestal conditions and silvicultural prospects of the coastal plain of the state, with remarks in reference to other regions. Other valuable features of the report are a large number of half-tone reproductions from photographs, and maps showing geological formations, distribution of rainfall, and distribution of forest areas.— H. N. Whitford.

Items of taxonomic interest are as follows: C. H. Bissell (Rhodora 2: 225. 1900) has described a new variety of *Zizia aurea* from Connecticut.—Two new genera of Hymenogasters have been described recently: *Arcangeliella*, by F. Cavara (Nouvo Giorn. Bot. Ital. 7: 117–128. *pl. 7,* 1900), from the coniferous forests of Vallombrosa, Etruria; and *Martellia.* by O. Mattirolo (Malpighia 14: 39–110. *pl. 1.* 1900), from Sicily.— L. Petri (Malpighia 14: 111–139. *pls. 2–4.* 1900) has described a new genus of Gasteromycetes from Borneo, *Clathrogaster* by name.—H. T. A. Hus (Zoe 5: 61–70. 1900) has published a preliminary synopsis of the west coast species of *Porphyra*, recognizing thirteen species and varieties, four of which are described as new.— S. B. Parish (*idem,* 71–76) has begun a series of papers entitled "Contributions to Southern California Botany," the first containing new species or varieties under *Sphaeralcea, Gilia, Galium, Eupatorium,* and *Bidens.*—T. S. Brandegee (*idem,* 78–79) has described a new species of *Tapirira* from Lower California.— Miss Alice Eastwood (*idem,* 80–90) has described new Californian species under *Salix, Chrysopsis, Helianthella, Sphacele, Mimulus, Aphyllon, Asclepias, Cleomella, Peucedanum,* and *Navarretia.*—C. L. Pollard (Proc. Biol. Soc. Washington 13: 184. 1900) has described a new Helianthus (*H. agrestis*) from Florida.— Scribner and Merrill (Division of Agrostology, Circular 27, Dec. 4, 1900) have described two new species of *Eatonia* from the southern states.— RUDOLPH SCHLECHTER (Mém. de l'Herb. Boiss. 21: 1–78. 15 N. 1900) has published a monograph of the *Podochilinae* (a group of orchids including four genera), much enlarging the borders of *Podochilus*, recognizing forty-seven species in it, and describing five as new; describing a new genus, *Lobogyne;* and recognizing six species in *Thelasis*, and two in *Oxyanthera*.—J. M. C.

MESSRS. D. H. SCOTT and T. G. HILL have published[10] an account of the structure of *Isoetes Hystrix*, a terrestrial species, dealing entirely with the vegetative organs. Some of the results are as follows:

Stem.— There is some evidence of a single apical cell; the stele is not composed of united leaf traces, but is cauline, as in the simpler lycopods; two cambiums are developed, in some cases the outer, in other cases the inner first; well-differentiated phloem is always present in the intracambial zone, being continuous with the leaf traces.

Leaf.— The vascular bundle in the lamina has exarch structure, the protoxylem lying next the phloem; the phloem contains true sieve tubes with transverse and lateral sieve plates, on both of which callus is formed; growth is intercalary, except at first; the labium and velum are derived from tissue above the sporangium, and not from sterilized sporogenous tissue.

Root.— The stele has a monarch structure throughout, the differentiation of the xylem beginning with the development of a single tracheid; the apex is distinctly layered, the initial groups giving rise to plerome, and to inner and outer cortex.

In the conclusion of the paper the authors discuss the systematic position of the genus, presenting strong arguments in favor of its affinity with the Lycopodiales, in which group it seems to have some real affinity with Selaginella, but not close enough to include the two in the same family. "The relationship of Isoetes to the Lepidodendreæ is probably a nearer one." The authors regard the genus as one reduced from a much more complex type, and in no sense a primitive form of the leafy sporophyte. They would regard it "as a group that has long hovered on the limit of terrestrial and aquatic life, some of the forms becoming wholly submerged, while a few have definitely betaken themselves to dry land, a large proportion leading a more or less amphibious existence." — J. M. C.

ONE OF THE greatest ecological investigations of the day has been delayed if not permanently checked by the untimely death of the brilliant young Scotch botanist, Robert Smith, of Dundee. Inspired largely by Flahault, he attempted to do for Scotland what the latter is doing for southern France, viz., make a detailed ecological survey of the country. Since 1896 Smith has worked unceasingly at his task, and had published but the

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[10] Annals of Botany **14**: 413–454. *pls. 23, 24.* 1900.

first two installments[11] when death put an end to his labors. In 1894 Flahault conceived the idea of making an ecological map of France,[12] especially with regard to the forests and agricultural areas. In 1897 the first sheet, corresponding in a way to the topographic sheets of our national geological survey, was published.[13] The maps are made on the scale of 1 : 200,000, and each plant association is represented by a given color. Flahault has adopted twenty-two conventional color tones, which also in a general way show the topographic relief, lowlands having light and highlands dark colors. Contour lines are used as on ordinary topographic sheets. Smith studied with Flahault at Montpellier and then turned his enthusiastic attention to his native country.

In 1899 Robert Smith published an interesting paper on the study of plant associations,[14] in which was given a historical summary of plant society studies from Humboldt down to Warming and Flahault, together with suggestions for use in field work. The two sheets which the author published give evidence of the most careful work, and cause us to regret that we shall not soon see any more. The Edinburgh sheet deals largely with lowlands and hence with cultivated areas. The littoral vegetation consists of marsh, dune, and rock plants, all of which the author regards as halophytic. The dominating forest trees are oaks on the plains and hills, pines and birches on the mountains, and alders in the swamps, though but little natural forest remains. In the higher areas are many dry, medium, and wet heath associations. The North Perthshire sheet has to do with a mountainous district. The maps are finely executed in colors that show strong contrasts. In America no comprehensive work like that of Smith or Flahault has yet been done, though the excellent mapping of our forest reserves under Gannett's supervision, published in the nineteenth and twentieth annual reports of the director of the United States Geological survey, does a similar grade of work for the forests. Professor Geddes[15] has given a very appreciative sketch of Robert Smith, which shows how his loss was felt at home.—H. C. COWLES.

THE CURIOUS PARASITIC Balanophoraceæ have always excited interest, but especially so since the appearance of the papers of Treub (1898) and Lotsy (1899) describing the strange ovulate organ and apogamous embryo of species of Balanophora. Our knowledge of the group has now been extended by a paper just published by Dr. Lotsy,[16] in which he describes a species of

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[11] SMITH, ROBERT: Botanical Survey of Scotland. I. Edinburgh District. II North Perthshire District. Scot. Geog. Mag. **16**: 385–416, 441–467. 1900.

[12] Bull. Soc. Bot. France **41**: 56–94. 1894. [13] Annales de Geographie. 1897.

[14] Nat. Sci. **14**: 109–120. 1899. [15] Scot. Geog. Mag. **16**: 597–599. 1900.

[16] LOTSY, J. P.: *Rhopalocnemis phalloides* Jungh., a morphological-systematical study. **Ann. Jard. Bot. Buitenzorg II. 2**: 73–101. *pls. 3–14.* 1900.

Rhopalocnemis. The plant body is tuber-like, frequently as large as a man's head, is entirely devoid of even a trace of foliar organs, and is parasitic upon the roots of various trees. It seems to pass several years underground and comes to the surface but a short time before the development of flowers. The thick spicate flower clusters burst through the outer layers of the tuberous body, the individual flowers being well protected by peculiar peltate scales.

The carpellate flower consists of a syncarpous pistil, made up of two to five carpels, and inclosing a structure which Lotsy calls a free central placenta, and once, presumably by inadvertence, a nucellus. In any event, the structure is the enlarged tip of the axis of the flower, which soon completely fills the cavity of the ovary. At this stage one or more hypodermal cells of this axis tip enlarge, and without division are transformed into embryo sacs, one of which germinates in the usual way and passes through the ordinary ante-fertilization stages. The author regards this axial structure with its embryo sacs as a placenta without ovules; but, even aside from the fact that a placenta is nothing morphologically, the reviewer sees no reason for regarding the structure other than a terminal cauline ovule without integuments. A very large primary endosperm nucleus is formed in the usual way, but the author never observed a pollen tube, nor could he by repeated artificial pollination induce pollen tubes to develop. Under these circumstances Balanophora has learned to develop an embryo apogamously from the micropylar polar nucleus, but Rhopalocnemis is unable to do so, and hence has become practically a seedless plant. In just one case was Lotsy able to secure a few seeds, and even in them few stages of developing embryos were discovered, but enough to assure him that they had come from the egg, and probably a fertilized egg.

The staminate flowers are no less singular, each one consisting of a single structure which by courtesy may be called a stamen, but is probably a transformed axial structure. In its enlarged extremity numerous imbedded sporangia are developed, centrally as well as peripherally. These sporangia do not organize definite wall layers as in ordinary angiosperms, and have no method of dehiscence other than the breaking down of the superficial tissues. It would seem to be the rarest chance, therefore, if a pollen grain should ever reach a stigma, which in fact has usually lost all power of retaining pollen grains. The pollen grains are completely organized, and the two male cells appear, both of them finally assuming, along with the tube nucleus, an elongated, vermiform appearance, which according to Lotsy is merely preparatory to disorganization.

The twelve elaborate and handsomely colored plates present every detail observed, as well as the condition of the preparations. It is unfortunate that Dr. Lotsy writes in English, as his unfamiliarity with the language makes his meaning a matter of inference rather than statement. While the well-informed English reader finally comes at his meaning, the paper must be baffling to the foreigner who is compelled to translate.—J. M. C.

Professor Harper has given us a detailed description of the sexual reproduction of Pyronema.[17] The account is of especial interest, for it presents another instance of the fusion of multinucleate gametes, and is an important corroboration of Stevens' studies on *Albugo bliti* with respect to the behavior of cytoplasm and nuclei under such conditions.

The oogonium of Pyronema, as is well known, puts forth a conjugation tube (trichogyne) whose tip fuses with the antheridium. The tube is separated from the oogonium by a cross wall before its fusion, and this septum is later absorbed, when the protoplasm from the antheridium passes into oogonium and fertilizes the latter structure.

The oogonium and antheridium are multinucleate from the start. The conjugation tube likewise contains many nuclei, but these break down before fertilization. The number of nuclei in the oogonium is variable but there may be an many as two hundred. These gather in the central region of the structure, forming a closely packed collection at the time of fertilization. A great many sperm nuclei enter the oogonium through the conjugation tube, but they are hardly likely to equal the female nuclei in number. The sperm nuclei are attracted to the central mass of female nuclei, and shortly afterwards are found fusing in pairs with these elements. Some nuclei are always left over unmated, and these may be recognized for a long time by their smaller size. There is evidence that they finally break down.

The ascogenous hyphae spring directly from the fertilized oogonium, and as they develop the oogonium becomes rapidly emptied of its protoplasm and is finally left as a hollow cyst. The development of the asci is not essentially different from Peziza, Ascobolus, Erysiphe, and other types. The young ascus is the second cell of a curved branch. It contains two nuclei that fuse, and these are not sister nuclei. The fusion nucleus gives rise by successive mitoses to eight nuclei accompanied by the beautiful asters that Harper has described for several other forms, and the ascospores are cut out of the cytoplasm by these asters in the characteristic manner.

The ascocarp of Pyronema is a compound structure involving several systems of ascogenous hyphae from as many fertilized oogonia. The elements become so mixed that it is impossible to separate them. However, the ascogenous hyphae may be readily distinguished from the vegetative mycelium that forms the envelop of the ascocarp and the paraphyses in the hymenium. Harper points out that the characters most distinctive of the ascogenous hyphae are large nuclei, many times larger than those of the vegetative mycelium.

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[17] Harper, R. A.: Sexual reproduction in *Pyronema confluens* and the morphology of the ascocarp. Ann. of Bot. **14**: 321. *pls. 19–21.* 1900.

This study of Pyronema has important bearings in various directions and these are discussed at length. Along the lines of Harper's previous studies they serve to clinch more strongly his argument, supporting the views of De Bary, that the Ascomycetes have sexual organs. Indeed the opinions of Van Tieghem, Brefeld, and Dangeard seem to have passed below the horizon of the present day outlook, so conclusive is the evidence presented from work in various fields, among the lichens, the Laboulbeniales, the Perisporiales, and the Pezizales.

Pyronema is of especial interest because it presents characters somewhat intermediate between the simple fusion of the antheridium and oogoniun in Sphaerotheca, and the complex apparatus with the trichogyne found in the lichens and Laboulbeniales. Still it is very remarkable that such diverse conditions should appear in a single group, and the question seems very fair whether or not the Ascomycetes are a phylogenetic unit. However, the trend of investigation indicates complexities in life histories as well as structures among the fungi far greater than were at first imagined, and it is quite possible that widely different results may have quickly arisen under the pressure of peculiar life conditions.

The study of multinucleate gametes has opened an interesting line of investigation, and promises results that may materially modify our views of the evolution and differentiation of sexual organs among the Phycomycetes, and perhaps the Ascomycetes.— B. M. DAVIS.

IN A RECENT PAPER Wager gives an interesting account of his observations on *Euglena viridis* as they bear on the functions and relations of the eye spot and flagellum. After a brief résumé of the general morphology of the cell he takes up the vacuole system and gullet. He states definitely that, contrary to previous observations, the principal vacuole opens directly into the gullet, and therefore is an excretory reservoir. Just at this point Wager takes issue with the zoologists' claim of holozoic nutrition. Using powdered carmine in the culture medium he failed to find a single grain entering the gullet. He also brings forward tentatively Kawkine's explanation that the gullet is an absorptive region because paramylum grains are smallest in close proximity to it. Wager's views on the structure of the eye spot antagonize some older ideas and support others. In brief, the eye spot is composed of granules, bright red in color, imbedded in plasmatic network. The granules are in a single layer and with no regular arrangement. On treatment with alcohol, a reaction similar to that of disintegrating chlorophyll grains is obtained; hence the eye spot coloration is a derivative from chlorophyll. The origin of the spot *de novo* is in doubt. The flagellum and its close physical connection with the eye spot takes up the next paragraph. Nothing is known of its mechanism, however. Its structure is simple; a single filament with bifurcate base, bearing a swelling on one of the bifurcations. The base is attached to the posterior side of the excretory reservoir. The swelling mentioned lies against and below the concave side of the eye spot. This fact leads to a consideration of the effect of light on Euglena. As is the case in all motile cells, strong light repels and a moderate light attracts. A bright light will cause the active cells to round up and encyst, if the stimulation be continued for several days. In darkness the cells round up, lose flagella, and divide. In spectrum rays, over seventy per cent. are drawn into the green-blue field. These blue rays are those absorbed by the red eye spot. As to the function of the eye spot, Wager makes two suggestions. First, that the absorbed blue rays stimulate the eye spot, which in turn stimulates the swelling on the flagellum; second, that by cutting off certain rays, the eye spot produces a definitely unequal illumination of the enlargement, and as a result, an attempt at orientation. Both hypotheses, however, he puts forward tentatively, subject to further and more careful investigation.—PHILIP G. WRIGHTSON.

R. A. ROBERTSON (Trans. and Proc. Bot. Soc. Edinburgh **21**: 290–298. *pls. 3*. 1900) has recorded and illustrated some interesting observations on variations in *Lycopodium clavatum*. A luxuriant patch of this plant growing in a wood became exposed by a great storm which removed nearly every tree, and upon 20 to 30 per cent. of the erect axes the observed variations were found. Of this varying material 87 per cent. had extra branching of the strobilus-bearing axes, 66 per cent. showed branching of the strobili, and in 9 per cent. the strobili were completely metamorphosed into leafy shoots. The author suggests that these variations are of interest in reference to the phylogeny of the Lycopodiales, the branching of the strobilus and the sterilization of sporogenous tissue being supposed to have played a part in the evolution of the group.—J. M. C.

THE LITERATURE of lenticels has been further supplemented by James A. Terras (Trans. and Proc. Bot. Soc. Edinburgh **21**: 341–352. *pls. 2*. 1900), who has written upon the relation between the lenticels and adventitious roots of *Solanum Dulcamara*. He concludes that these roots do not arise below or grow out through lenticels, as is apparently the case in the majority of plants, but that their origin is entirely independent of the formation of lenticels. Furthermore, he states that the protuberances on the surface of the stem are not lenticels, but result from the formation of a mass of secondary tissue which originates in the reaction of the phellogen to the pressure set up by the elongating root below it. The lenticels only appear after the protuberances are fully formed.—J. M. C.

NEWS.

THE *Fern Bulletin* for January contains an excellent portrait of Professor L. M. Underwood.

WE REGRET to learn of the death of Dr. S. J. Korshinsky, of St. Petersburg, at the age of 40. He had done some excellent work, especially in problems concerned with the vegetation of the steppes.

DR. M. RACIBORSKI, formerly professor of botany at the University of Cracow, and lately of Buitenzorg, has been appointed professor of botany and director of the botanical garden in the Dublany Agricultural Academy at Lemberg.

ONE GARDEN scholarship is to be awarded by Director Wm. Trelease, of the Missouri Botanical Garden, before April 1 next. Applications must be in his hands before March 1, and examinations will be held at the garden on March 5.

THE FRENCH ACADEMY OF SCIENCES has awarded the Desmazières prize to Abbé Hue for his "Mémoire sur une Classification des lichens fondée sur leur anatomie," and the Montaigne prize to M. J. Heribaud for his "Les Muscinées d'Auvergne."

THE VIENNA Academy of Sciences intends to send an expedition in 1901 to study the flora of Brazil. Professor Dr. Richard von Wettstein, director of the botanical garden of the University, and Dr. Victor Schiffner of Prague, will accompany the party.

THE BOTANICAL DEPARTMENT of the British Museum has purchased the Bescherelle herbarium of mosses and liverworts, the collection containing 14,800 specimens of the former, and 3500 of the latter. The herbarium is very rich in types and authentic specimens.

THROUGH the liberality of T. M. Baird, Jr., Esq., of Victoria, B. C., a tract of land on the coast of Vancouver island, opposite Cape Flattery, has been presented for a seaside botanical station of the University of Minnesota. The erection of a group of log buildings has been begun and a party of thirty or more botanists has been organized to open the work of the station next June.

AT A MEETING of the Botanical Section of the Philadelphia Academy of Natural Sciences, held December 10, 1900, the following officers were elected for the ensuing year: *Director*, THOMAS MEEHAN; *Vice director*, GEORGE M. BERINGER; *Treasurer* and *Conservator*, STEWARDSON BROWN; *Recorder*, JOHN W. HARSHBERGER; *Executive Committee,* GEORGE M. BERINGER, THOMAS MEEHAN, STEWARDSON BROWN, JAMES D. CRAWFORD, IDA A. KELLER.

THE REPORT of the committee of the Society for Plant Morphology and Physiology on securing better reviews of botanical literature was presented at the recent meeting of the society at Baltimore. The results secured are of the greatest interest to all botanists. After correspondence with the editor and publisher of the *Botanisches Centralblatt,* a modification of this journal will be effected with the first number of the present year, and these changes are officially announced in the last number for 1900. Hereafter the *Centralblatt* proper will contain only reviews and the list of new literature, while the *Beihefte* will contain only original articles, and will appear as heretofore at irregular intervals. These may be subscribed for separately; the price and size of the former will remain as at present, *M* 28 per year. A committee of three from the society, Drs. Farlow, MacDougal, and Ganong, together with one botanist from the central states and one from the Pacific coast, to be named later, will be asked to nominate American editors, who will cooperate with the German editors, Drs. Uhlworm and Kohl. Inasmuch as the editors of the *Centralblatt* have shown themselves so willing to take up the suggestions made by this committee it should now be a matter of pride, and it certainly is a matter of self-interest as well, for American botanists to give the fullest support, financial and scientific, to this bibliographic journal. It should remain unique and become as perfect in its notices of literature as it is possible to make it. Separates, not titles merely, should still be sent to Dr. Uhlworm, Cassel.

THE following action was taken by the employés of the Department of Agriculture in reference to the death of Mr. Thomas A. Williams: It is with feelings of profound sorrow and regret that we, the employés of the Department of Agriculture, learn that death has removed from among us our beloved companion and coworker, Thomas A. Williams, a classmate and intimate associate of many of our number. His broad knowledge of scientific matters, his keen appreciation of nature, his kind and forbearing disposition have endeared him to all. He was known to his associates as an indefatigable worker and investigator.

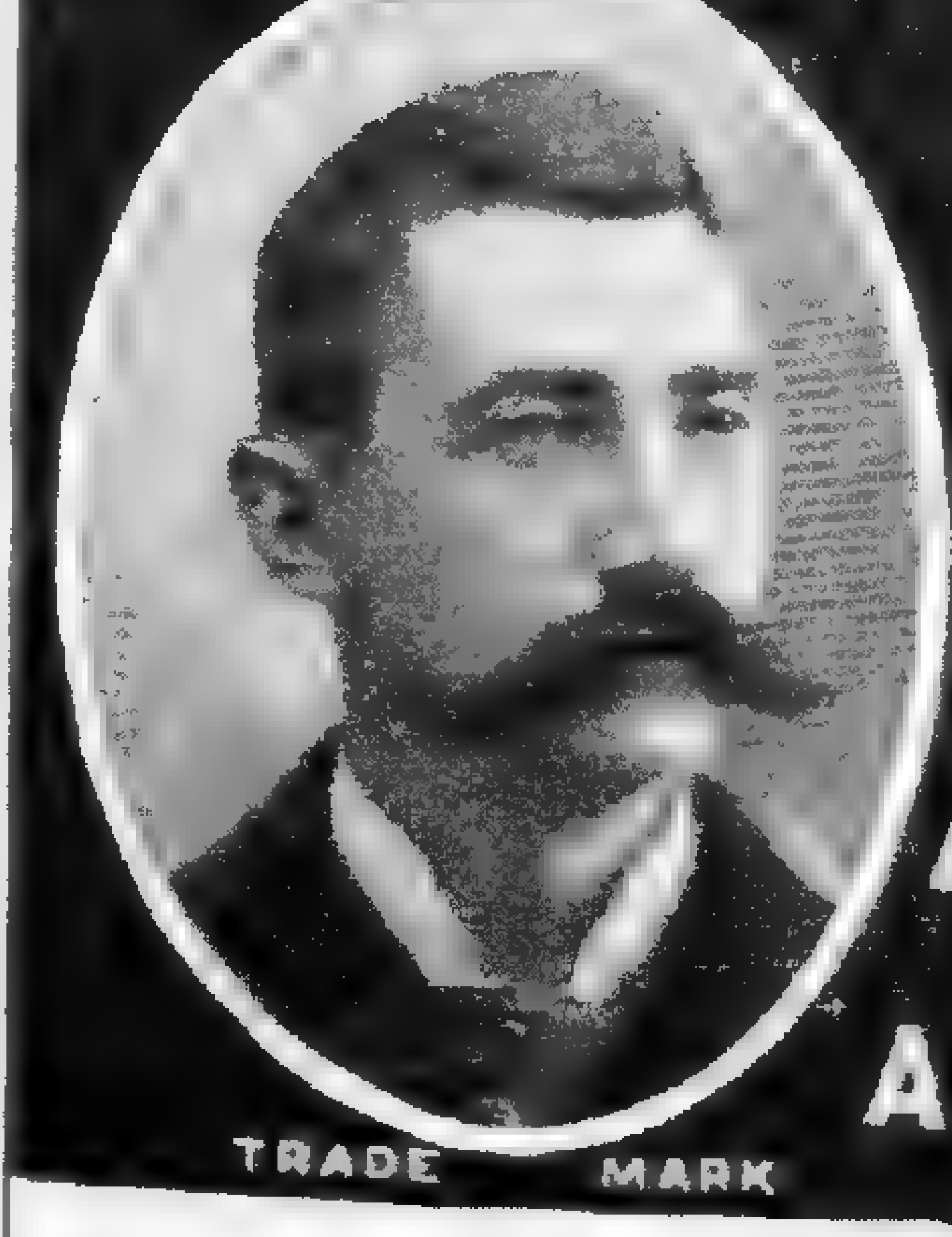
Resolved, That in the death of Professor Thomas A. Williams, science and agriculture have suffered a great loss, and we, his associates, a dear friend, whose self-forgetfulness in his kindly consideration for the feelings of others and uniform cheerfulness, often under conditions of severe physical suffering, revealed a lovable character of the highest Christian type. The loss to the Division of Agrostology is irreparable. In the performance of his official duties he had proved himself an excellent executive and an organizer of unusual merit, and his relations with his associates in office were always such as to command the highest esteem and respect. He never shirked a duty, and however difficult the undertaking the work performed by him was done most creditably. His loss will be felt most keenly by his associates in the division, and his memory will remain with them as one whose exemplary life and steadfastness of purpose they should strive to emulate.

Resolved, Further, that we tender to his bereaved family our heartfelt sympathy in their great loss and invoke for them the blessing of the Heavenly Father, who alone can heal the broken heart and give lasting comfort.

Resolved, That copies of these resolutions be sent to the family of the deceased and to the various daily and scientific journals.—Committee on Resolutions for the Department of Agriculture.

FROM ADVANCE sheets of the twelfth annual report of the director of the Missouri Botanical Garden we make the following extracts:

The garden has been maintained through the past year on about the same lines as for some years past. Though the revenue has not yet been increased through sales of real estate, the power to make such sales now makes it possible to spend on the garden the entire current revenue, which adds annually ten or fifteen thousand dollars to the available funds. The extensions which have been contemplated for some years past have now been begun. The improvements made this year consist in the grading of some twenty acres of land, and in planting the border about this tract. Two rather large ponds, connected by a meandering brook, were made, and the ground was given an easy fall from the streets to these bodies of water. All of the material used in this border plantation is representative of North American plants, and it is proposed to plant on this tract a collection of 181 arborescent, 269 fruticose, and some 1400 herbaceous species, representative of the North American flora, and arranged essentially in the familiar sequence of families of the "Genera Plantarum" of Bentham and Hooker. The garden now contains 9194 species and varieties of plants, of which 5547 are annuals or hardy perennials, and 3647 are cultivated under glass. A further extension of the plant houses has been made by the erection of a tower at the northwestern corner of the system, in which small but representative collections of succulents and of acacias and acacia-like plants have been planted out in a natural manner. The material incorporated in the herbarium during the year comprises 8415 sheets of specimens. The additions to the library in 1900 include 573 books and 31 pamphlets purchased, and 311 books and 456 pamphlets presented or sent in exchange for garden publications. Of serial publications the garden now receives 1117, all but 66 by exchange. The garden has materially assisted the botanical work in the public schools by supplying material. Several pieces of research work are about ready for publication.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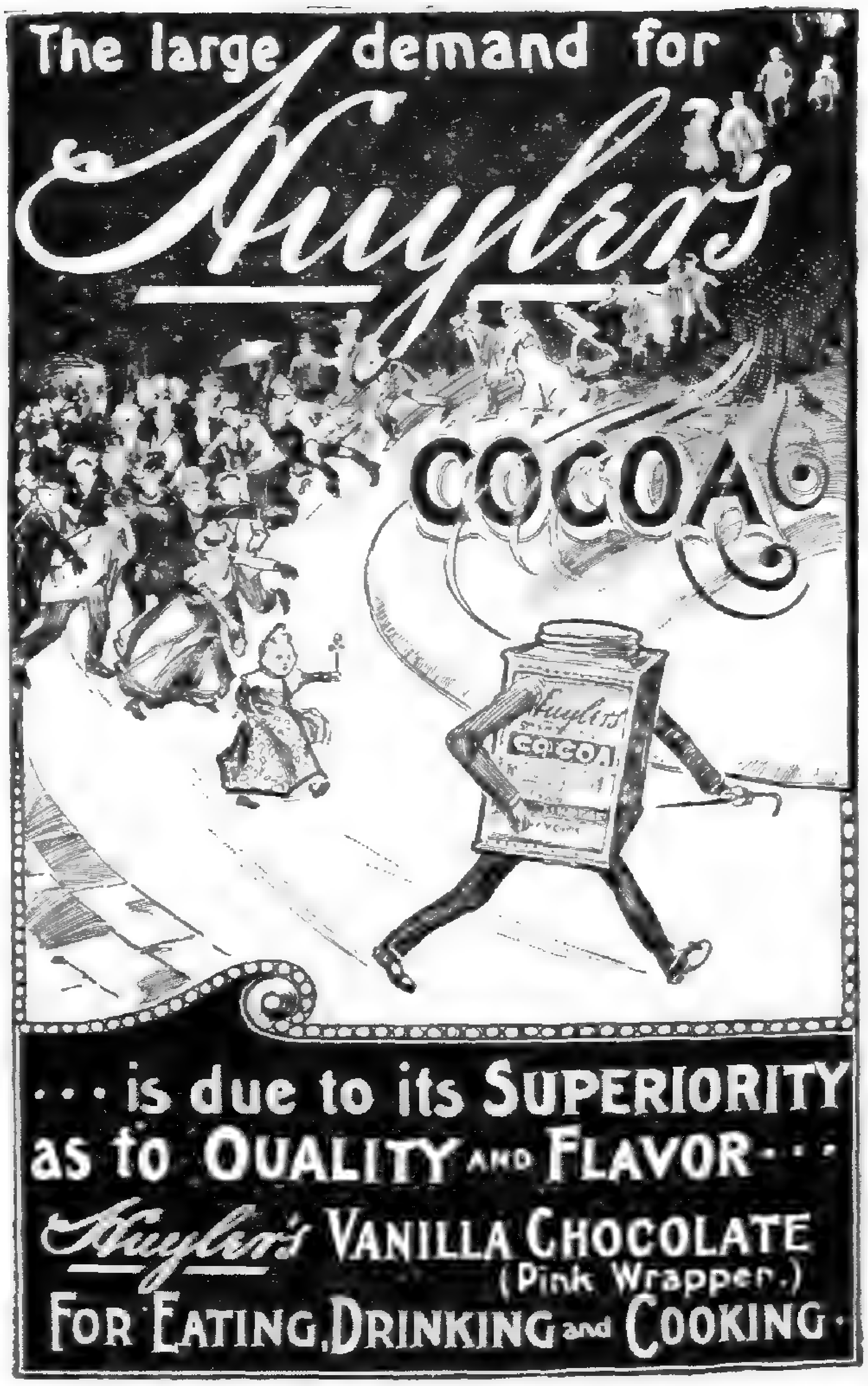

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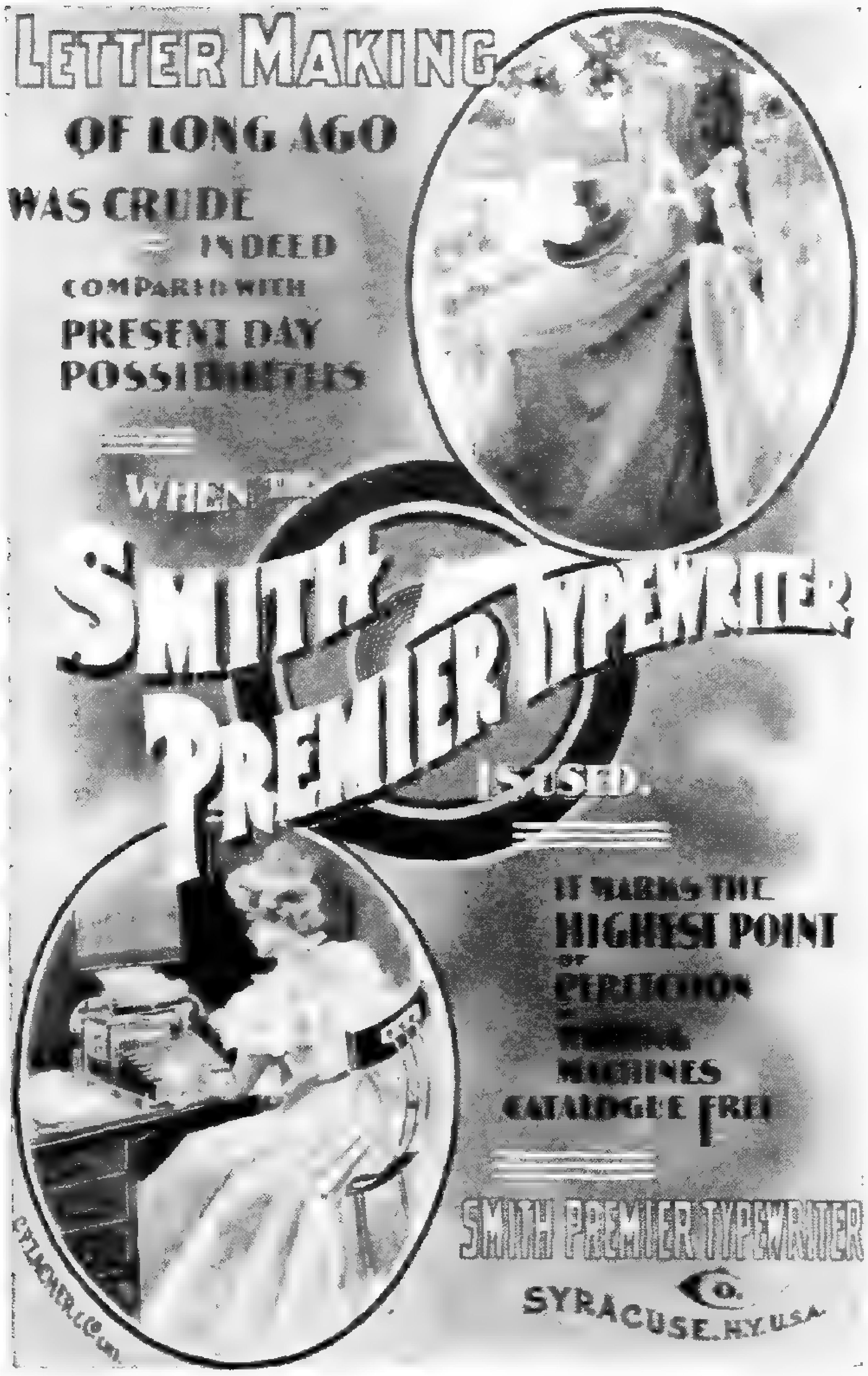
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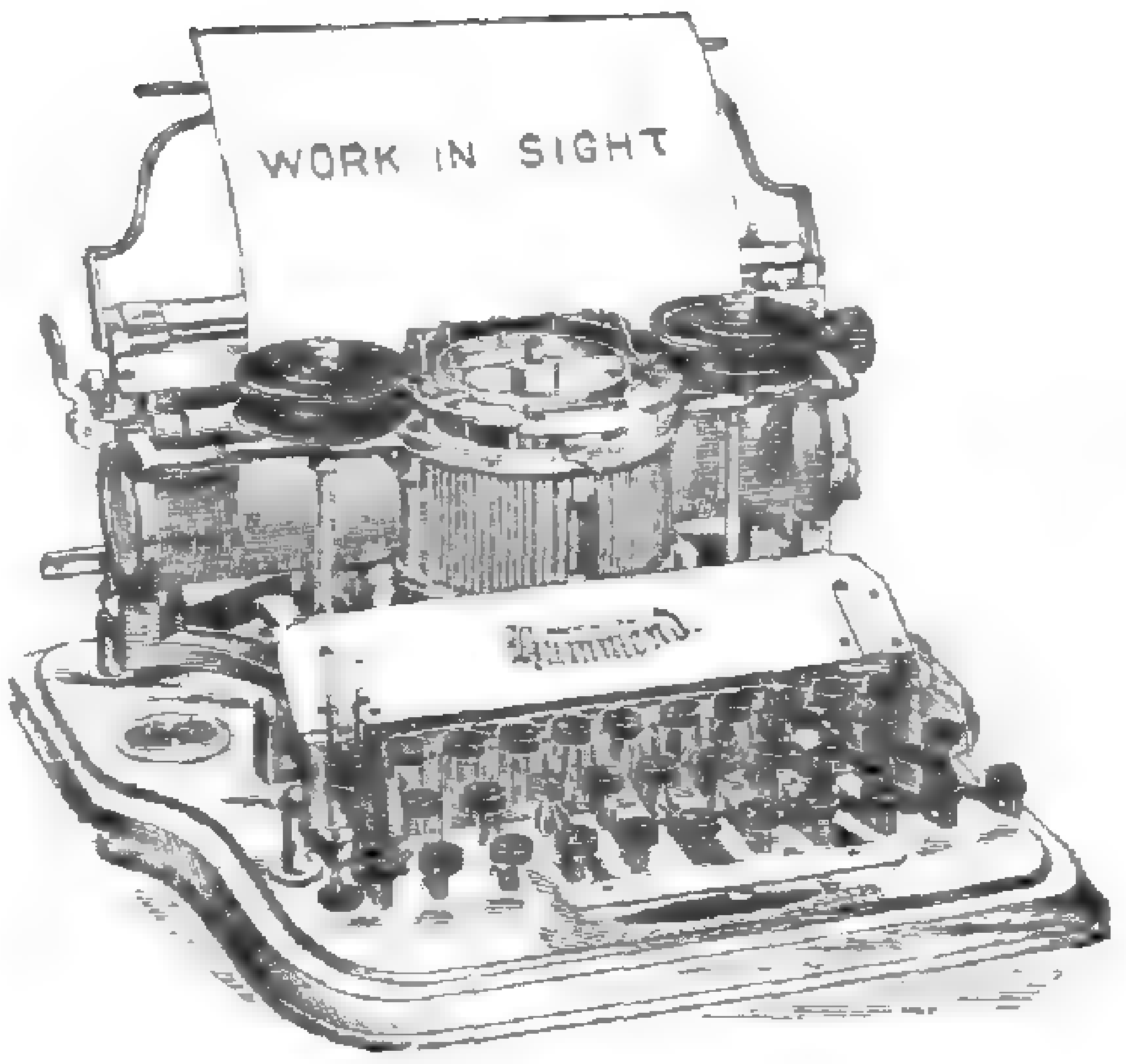
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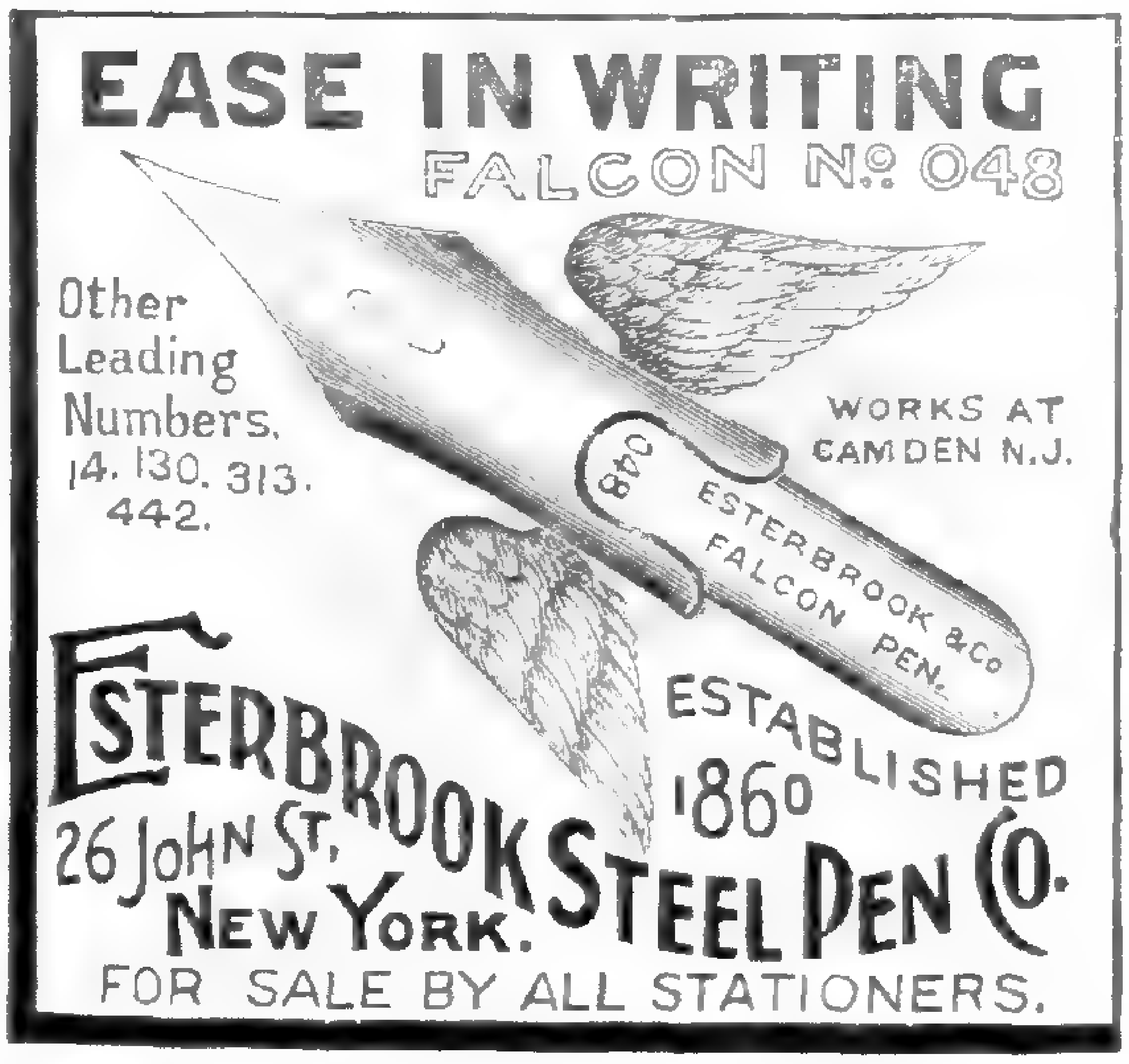

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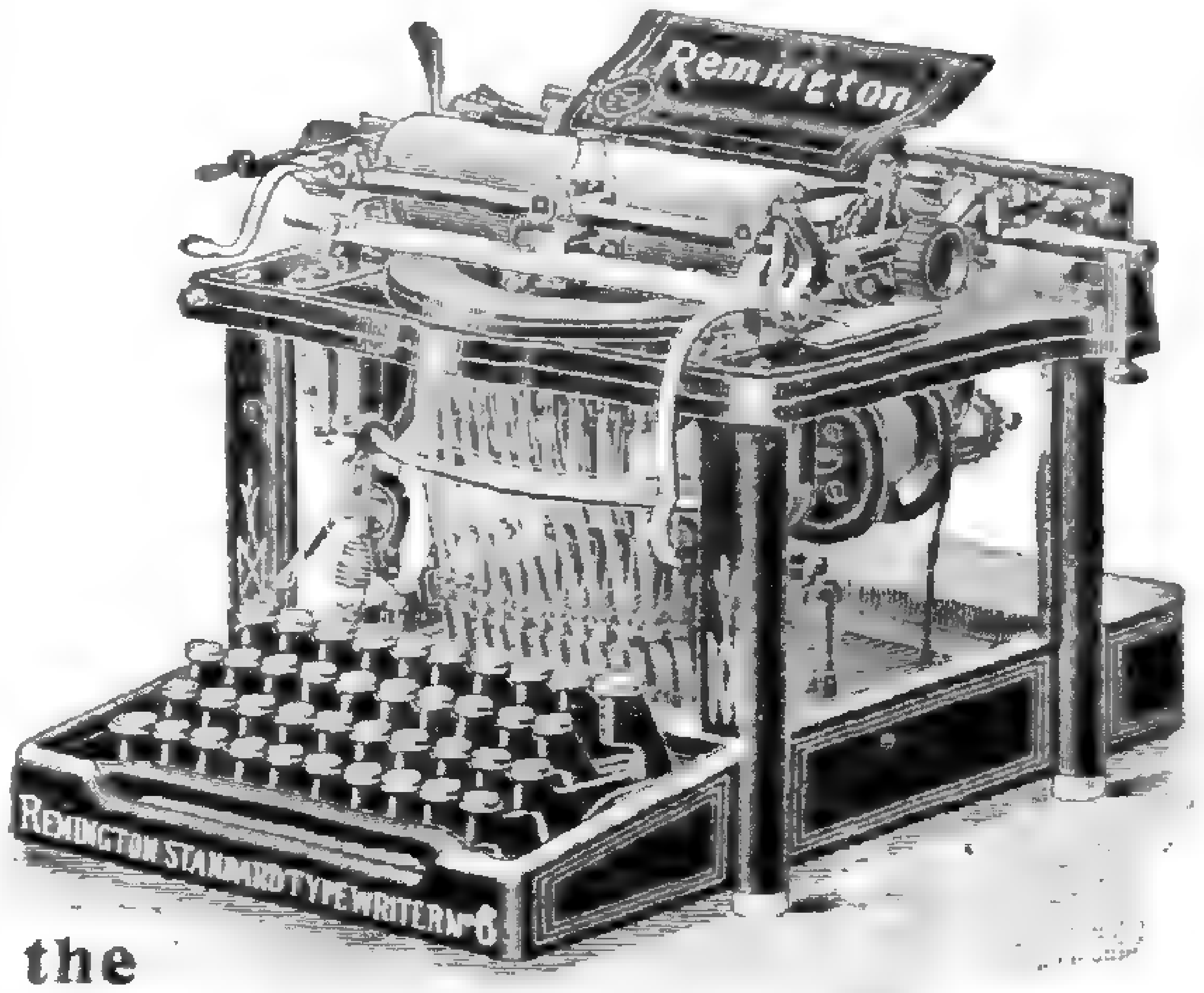

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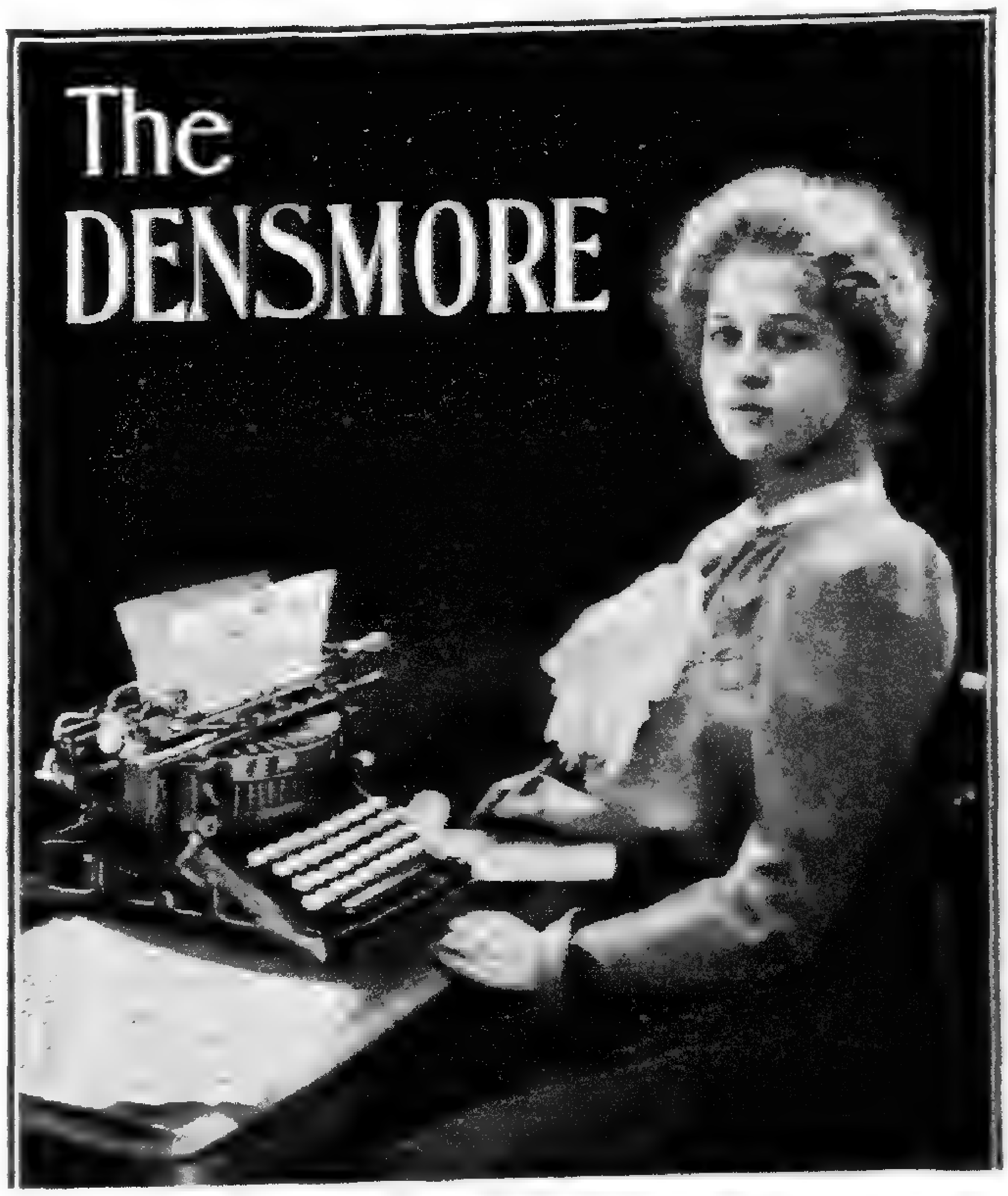


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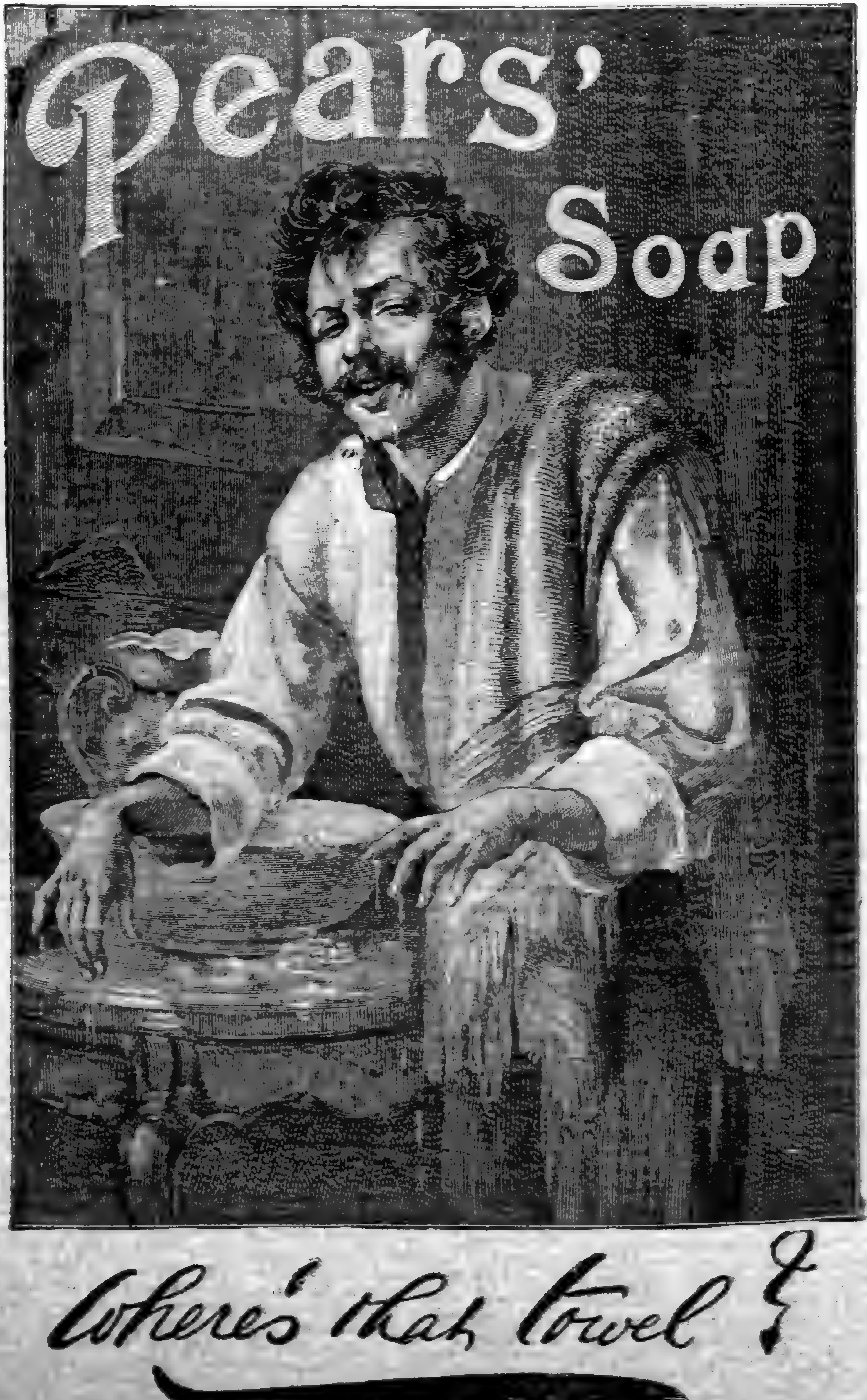
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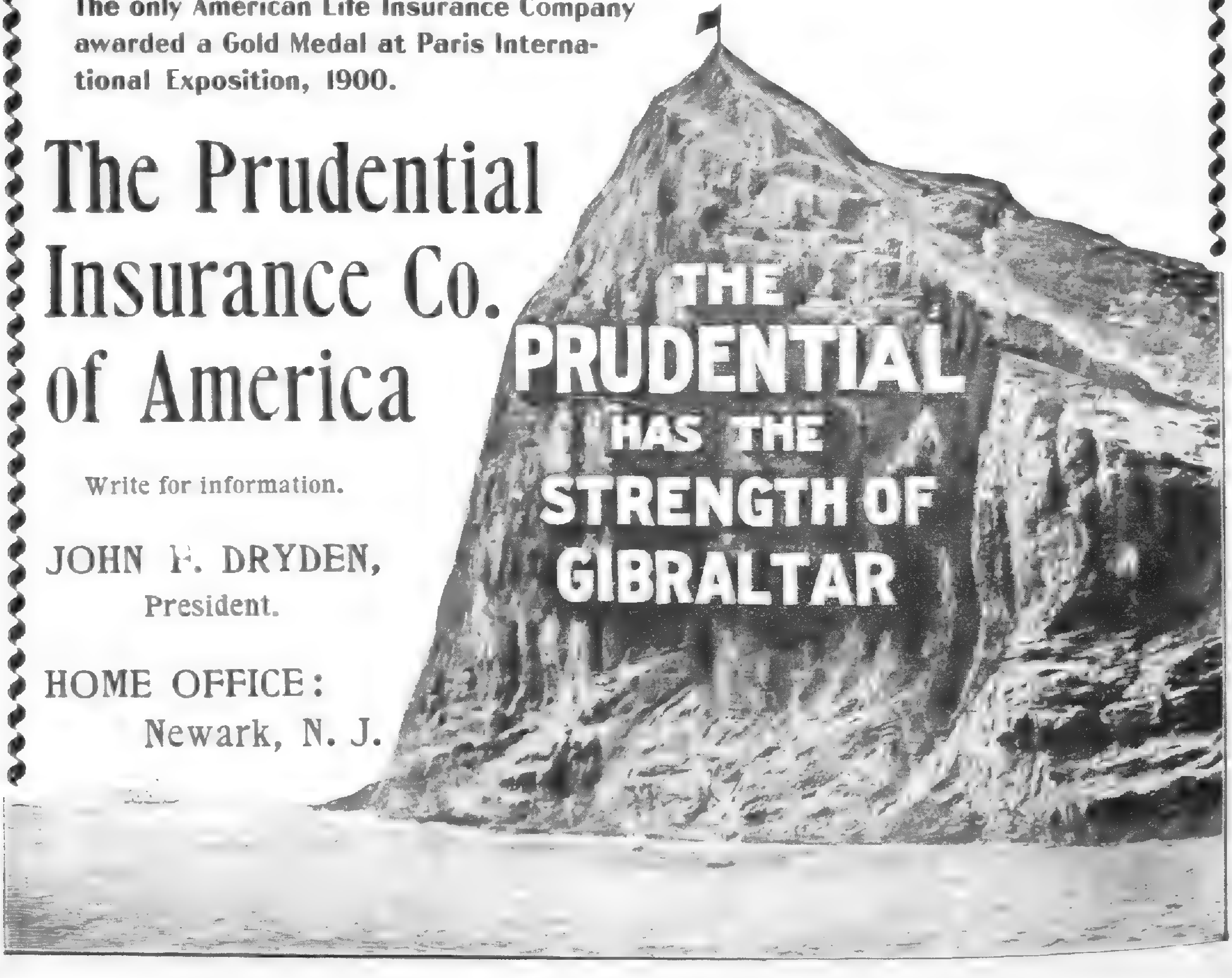
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THE PHYSIOGRAPHIC ECOLOGY OF CHICAGO AND VICINITY; A STUDY OF THE ORIGIN, DEVELOPMENT, AND CLASSIFICATION OF PLANT SOCIETIES.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY XXIV.

HENRY CHANDLER COWLES.

[*Concluded from p. 108.*]

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A. *The pond.*—There are all gradations between rapid streams and completely undrained ponds, and corresponding with these various gradations are characteristic plant species. It will be convenient to subdivide the series under discussion into two parts, the first dealing with undrained ponds and swamps, the second with half-drained ponds and swamps.

No two floras can be more unlike in species or in adaptations than are the typical brookside and swamp floras. Though each type may be called hydrophytic, so far as the water is concerned, the vegetation is really hydrophilous in the first case but pronouncedly xerophilous in the second. Peat bogs which may be taken as the type of undrained swamps have a remarkable assemblage of xerophytic adaptations, such as leathery or hairy leaves, and special structures for water absorption. Schimper[23] believes

---

[23] SCHIMPER: Pflanzengeographie, p. 18.

that these structures are due to the difficult absorption in peaty soil, the humus acids and the lack of oxygen being detrimental to normal root activities. For similar reasons the normal soil activities of bacteria and fungi are lessened, and as a result of this relative lack of decay great quantities of peat accumulate. All of these peculiarities of peat bogs may be referred to the lack of drainage, since the stagnant conditions prevent oxidation and the removal of the humus acids. The lack of drainage is of course due to topographic conditions. Peat bogs and undrained lakes, therefore, are features of a young topography, since several agencies combine to cause their rapid destruction. Rivers may work back and tap the undrained lakes or inlets may fill them up. Probably the most important agent in the death of undrained lakes, however, is the vegetation, as will be seen later. The great abundance of lakes and ponds in the young glaciated regions as compared with older regions to the south is a striking proof of their short life.

In the immediate neighborhood of Çhicago typical peat bogs are scarce. They find their best development in the depressions of the dune region, where they may be called abundant. Wherever a sag between two dunes is low enough to retain moisture for the greater part of the season, the conditions favor the development of an undrained swamp flora. If the depression is so low that the water level outcrops throughout the year, then there is an undrained pond or lake. The first flora in this latter case consists of plants that are able to exist with little or no change in the water of the pond except through rain and evaporation. Among these plants the alga Chara takes a prominent place. The water lilies (Nymphaea and Nuphar) are an exceedingly important constituent of this first vegetation, as is also Utricularia, which is represented by several species. The above species, together with others, play a great part in filling up lakes, since their remains accumulate with almost no decay. Chara in particular is a soil former of great importance. The rapidity with which these filling processes are carried on is striking; in pools of known age among the rubbish heaps of

Jackson park the author has noticed accumulations of Chara peat amounting to one or two inches per year.

B. *The undrained swamp.*—It is obvious that the processes outlined in the preceding paragraph must eventuate in the death of the lake or pond involved and its replacement by a marsh, entirely apart from ordinary erosive activities. Indeed, as has been stated, these activities are relatively unimportant here; this fact is shown by the absence of ordinary sediments from most peat beds. As the aquatics make the pond shallower and shallower they make it more and more unfit for themselves and fit for their successors, viz., those plants which grow along pond margins. Among the first plants of this type are various sedges (Carex), also the bulrush (*Scirpus lacustris*), though this latter species is more characteristic of the half-drained margins than of those under discussion here. Other marginal plants of our peat bogs are *Menyanthes trifoliata* and *Potentilla palustris*.

Spring
Vs.
Pond

The vegetation that follows may be called typical of peat bogs. The dominant plants are usually shrubs, especially the leather leaf (*Cassandra calyculata*); this plant may be so abundant as to give tone to the landscape. *Fig. 19* shows some Cassandra islands in a sedge swamp. It is clear that the islands represent places where in the original lake the water was shallow. The present remnant of the lake is shown at the left. Not only have the sedge zones advanced upon it from all sides, but centers of sedge growth appear also in shallow places in the lake itself. Just as the sedge zone encroaches upon the lake, when conditions become favorable, so the Cassandra zone advances on the sedges. Again a tree zone advances on the shrubs, as will be seen farther on. The zonal arrangement of plant societies that has just been seen is a feature of most peat bogs, and is due to the symmetry of lake and bog conditions. It will be observed that along the lake margin the zones advance toward a common center, while on the islands the advance is from a center. Eventually, of course, the marginal and island zones will merge.

Besides Cassandra many other plants are commonly found in the shrub zone. Other shrubs are the swamp blueberry (*Vaccinium corymbosum*), the cranberry (*Vaccinium macrocarpon*), the dwarf birch (*Betula pumila*), the alder (*Alnus incana*), the hoary willow (*Salix candida*), and the poison sumach (*Rhus venenata*). Characteristic herbs, especially in the open places, are the pitcher plant (*Sarracenia purpurea*), the sundew (*Drosera rotundifolia*), various orchids, as *Calopogon pulchellus*, Pogonia, and Cypripedium; sedges, as Eriophorum and Dulichium; *Woodwardia Virginica*, and *Elodes campanulata*. One of the most typical plants of these places is the peat moss, Sphagnum.

FIG. 19.—Typical peat bog in a depression between established dunes at Miller. Relict of the original pond at the left. Sedges (light-colored vegetation) are encroaching on the lake, while shrubs, mainly Cassandra, are encroaching on the sedges. Cassandra islands toward the right. Advance of conifers on Cassandra (seen in its beginnings on the islands) shown at the extreme right.

The flora just mentioned has many interesting features which are well known and may be passed over briefly. The highly xerophytic character of this plant society has already been noticed, and the reasons for it briefly given. The xerophytic structures are well illustrated in the leathery leaves of Cassandra and the absorption and storage adaptations of Sphagnum.

Many bogs of this type are very spongy and unstable, whence the name quaking bogs; this feature is due to the rapid growth of the vegetation and the absence of ordinary inorganic soils for a considerable depth. The similarity of the peat bog vegetation throughout the northern hemisphere is one of its most striking features. Not only the adaptations but the species themselves are similar over vast areas; the conditions are unique and the flora also. None of our plant societies, not even the lakeward dune slopes, have such a pronounced northern flora as do the peat bogs. No contrast could be more striking than that between the southern vegetation of the flood plains and the northern flora of the bogs.

FIG. 20.—Tamarack swamp in an undrained portion of the Calumet flood plain at Miller. Peat bog herbs and shrubs in the foreground.

Fig. 19 shows that a coniferous vegetation, now represented by but two or three small trees at the centers of the islands, is to follow the Cassandra. Such an advance of conifers on Cassandra is shown in the background at the right. The most typical conifer in such cases is the tamarack (*Larix Americana*); with this the arbor vitae (*Thuya occidentalis*) is sometimes found.

Larix and Thuya swamps reach but an imperfect development in our region and little need be said about them. The shade in these forest swamps is so dense that bare patches of soil are often seen. The vegetation consists largely of shade plants, among which may be mentioned Mnium and other similar mosses, *Coptis trifolia*, *Cornus Canadensis*, *Viola blanda*, and Impatiens. The tamaracks appear to be succeeded by the pines (*Pinus Strobus* or *P. Banksiana*), and they in turn by oaks, as the soil becomes drier and better drained, and thus more adapted to deciduous trees. *Fig. 20* shows a tamarack swamp near Miller, Ind.

Not all peat bogs have a history like the above. Just as some flood plains are forested and others not, so some peat bogs grow up to shrubs and trees, while others are dominated, for a long time at least, by herbs and grasses. *Fig. 21* shows a swamp of this character. Bulrushes are seen to be encroaching upon the water lily vegetation, while back of the bulrushes, instead of Cassandra, is a zone with sedges and grasses and scattered willows. Among the species, other than sedges and grasses in a plant society like this are *Viola sagittata* and *V. lanceolata*, *Potentilla Anserina*, *Fragaria Virginiana*, *Parnassia Caroliniana*, *Sabbatia angularis*, *Gentiana crinita*, *Gerardia purpurea*, *Castilleia coccinea*, *Aletris farinosa*, *Iris versicolor*, *Sisyrinchium angustifolium*, *Hypoxys erecta*, *Xyris flexuosa*, *Triglochin maritima*. The shrubs in such places are chiefly *Salix glaucophylla*, *Cornus stolonifera*, *Potentilla fruticosa*, *Hypericum Kalmianum*. The conditions that determine this type of bog, as contrasted with the Cassandra type, are not clear. The soil is hard, compact, shallow, and usually sandy; it may be that this type develops in shallow depressions, while the type with spongy, quaking ground develops in deeper depressions. This second type much more closely resembles the half-drained swamps in its flora than does the Cassandra type, although so far as drainage is concerned it agrees with the Cassandra bogs.

There is yet a third type of swamp which still more closely resembles the half-drained swamp in its flora. It is found along the edge of the Calumet valley near Dune park, also at West

Pullman. In this case the soil is rather deep and rich, in which respects there is agreement with the first type rather than the second. Grasses and sedges, but of a more luxuriant type, dominate here also, and with them are found such plants as *Cephalanthus occidentalis*, *Aspidium Thelypteris*, *Onoclea sensibilis*, *Saxifraga Pennsylvanica*, *Caltha palustris*, *Viola blanda*, *Polygala sanguinea*.

FIG. 21.— Shallow, undrained swamp (peat bog) at Dune park. In the foreground the relict of the original pond, with water lilies; then in order, encroaching zones of bulrushes, sedges, willows, and pines. The oaks in the background are on an established dune, and are not encroaching on the swampy soil.

Sphagnum occasionally occurs here, as it never does in the second type. Here again there is doubt as to the determining conditions, but it may be that things can be explained by the difference in the drainage. The ultimate fate of the second and third swamp types is not known. The relative absence of trees and shrubs is certainly natural and in no wise due to man.

Possibly local prairies will be the final type, or it may be that the forest will come in. *Fig. 21*, which shows pines encroaching upon the grassy areas, favors the latter view. So do some of the facts seen in the Calumet valley.

All of the peat bog types have a characteristic marginal flora, *i. e.*, the vegetation at the margin of the original lake is essentially alike in all cases. These plants, as well as those of Cassandra bogs, are the same over wide areas. The most common members of the bog margin flora are the sour gum (*Nyssa sylvatica*), the aspen (*Populus tremuloides*), *Ilex verticillata*, *Pyrus arbutifolia* (including var. *melanocarpa*), *Spiraea salicifolia* and *S. tomentosa*, *Rubus hispidus*, *Gaultheria procumbens*, *Osmunda cinnamomea*, *O. Claytoniana*, *O. regalis*, *Betula papyrifera*, and *Polytrichum commune*. This vegetation originates outside the swamp, and may be regarded as xerophytic; however, it often encroaches upon the swamp as the latter develops. At Thornton there is a dead swamp which is now almost entirely occupied by this xerophytic bog margin flora, only a few of the original swamp plants now remaining. Near Morgan park is a

FIG. 22.—Encroachment of bulrushes on Calumet lake, showing how plants may destroy lakes.

bog margin flora without a bog; a shallow trench has been dug and in this trench there have appeared various peat bog plants, *e. g.*, Sphagnum. These considerations show that bog margin floras, though associated with most bogs, are not necessarily genetically connected with them.

A word may be said about undrained swamps among the active dunes. The conditions here, of course, are far more severe than in ordinary peat bogs and only a few species are able to endure in such a habitat. The most typical herb is *Juncus Balticus littoralis*. Seedlings of the cottonwood, as well as the long-leaved and glaucous willows, germinate in these wet depressions. Reference will be made to these plants in connection with the dunes.

FIG. 23.—Pond at Waukegan almost destroyed by bulrushes.

In the morainic portions of our territory there are few if any peat bogs as described above, although they are usually more typical of moraines than of other topographic areas. On account of the clay soil which characterizes the morainic uplands there are many patches of swampy woods throughout the district. Shallow depressions of this type in sandy soil would not have a swamp developed. Morainic forest swamps are characterized by several trees, viz.: the bur oak, swamp white oak, and scarlet oak (*Quercus macrocarpa*, *Q. bicolor*, and *Q. coccinea*), the red maple (*Acer rubrum*), the elm (*Ulmus Americana*), and the ash (*Fraxinus Americana*). Other species are *Cephalanthus occidentalis*, *Salix discolor*, *Ribes floridum*, *Cardamine rhomboidea purpurea*, *Ranunculus septentrionalis*. This vegetation is ultimately supplanted by the mesophytic forest. A vegetation allied with that of swamps is the amphibious ditch flora with such plants as *Nasturtium palustre*, *Penthorum sedoides*, *Proserpinaca palustris*, *Ludwigia palustris*, *Polygonum Hydropiper*, etc.

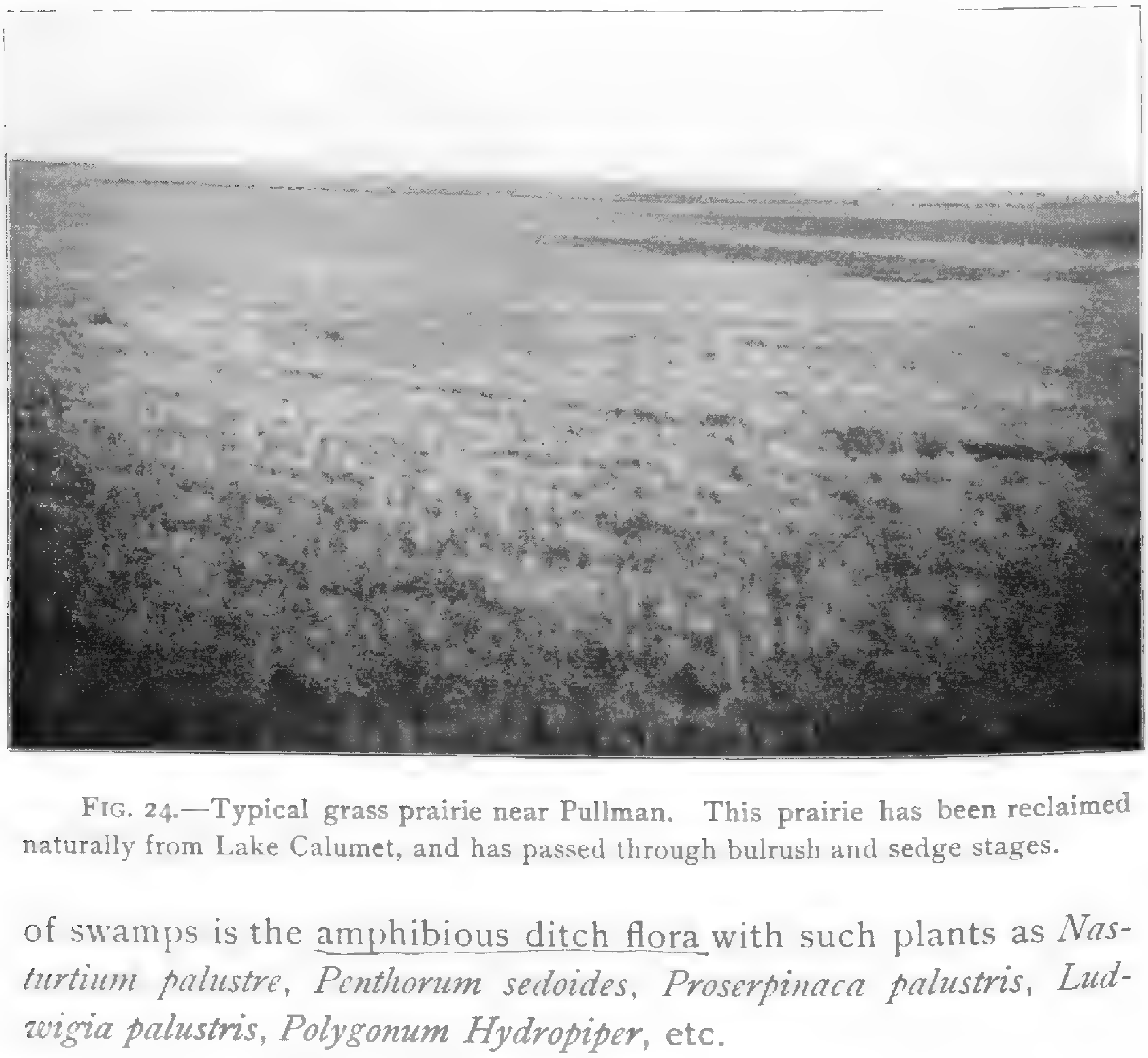

FIG. 24.—Typical grass prairie near Pullman. This prairie has been reclaimed naturally from Lake Calumet, and has passed through bulrush and sedge stages.

Calumet lake and Grand Calumet river may be taken as types of half-drained waters. We have here conditions that are midway between those of peat bogs and those of ordinary rivers. The vegetation is subject neither to the currents of the rivers nor to the stagnant conditions of the peaty lakes, and hence the luxuriance of the flora is far greater than in either of the other instances. The aquatic vegetation is rich both in species and individuals. Here is to be found a great wealth of alga vegetation, including such forms as Cladophora, Spirogyra, Oedogonium, Hydrodictyon. Among the floating plants are Riccia, Ricciocarpus, Spirodela, Lemna, and Wolffia. There are also a large number of attached plants, including many species of Potamogeton, *Ranunculus aquatilis*, Brasenia, Nelumbo, Myriophyllum, Ceratophyllum, Elodea, Vallisneria, and Naias. This rank growth of vegetation fills the lake up rapidly, since the currents are not sufficient to carry off the plant remains. There is a rapid advance of marginal plants upon the lake, a phenomenon that is shown in *fig. 22*, where the scattered bulrushes (*Scirpus lacustris*) are seen to be soon followed by a dense bulrush society. With or soon after the bulrushes are a number of marginal plants, especially *Typha latifolia*, *Pontederia cordata*, *Sparganium eurycarpum*, *Sagittaria variabilis* and *S. heterophylla*, *Zizania aquatica*, *Phragmites communis*, *Acorus Calamus*, and *Eriophorum cyperinum*. *Fig. 23* shows a stage in which a lake has been all but destroyed by a rank bulrush vegetation.

C. *The prairie.*—Sedges encroach rapidly upon the bulrushes as the new soil becomes raised more and more above the lake, and grasses in turn encroach upon the sedges, forming a prairie. *Fig. 24* shows an expanse of grassy prairie which has developed through these successive stages from Calumet lake. Skokie marsh and Hog marsh are undergoing transformations of this character also. Sometimes with the prairie grasses are a number of coarse xerophytic herbs, largely composites (*Silphium laciniatum*, *S. terebinthinaceum*, *S. integrifolium*, Lepachys, *Solidago rigida*, Aster, Liatris), with some legumes (*Amorpha canescens*, Petalostemon, Melilotus, Baptisia), Eryngium, Dodecatheon, Phlox, *Allium cernuum*. A Silphium (compass plant) prairie is shown in *fig. 25*. The prairies of our area are in the basin of the glacial Lake Chicago, and hence all may be referred to a lake or swamp origin, exactly as prairies are developing from Calumet lake today. This explanation of the prairie, an undoubted explanation for the cases in hand, must not be applied to the great climatic prairies farther west. Whether the Chicago prairies will ever become forested is a question not easily answered. There are signs of it in some places, as at Stony island, but this topic needs more detailed treatment than can be given here.

The processes outlined in this section are rapid. The mesophytic prairie or forest develops from the lake or marsh, while the region as a whole still retains a young topography. Thus this mesophytic assemblage, like that of the ravine slope, is bound to pass away, though its life tenure is much longer. Sooner or later river action will enter; there will be developed ravines, xerophytic bluffs, and ultimately flood plains, again with a mesophytic flora. A broad survey then shows a rapid development to a somewhat prolonged temporary climax, and finally after ravine and bluff vicissitudes there appears the true and more enduring climax of the mesophytic flood plain.

FIG. 25.—Prairie at Pullman in which the compass plant (Silphium) grows with the grasses. This prairie is much older and drier than that shown in *fig. 24*.

3. THE UPLAND SERIES.

A. *The rock hill.*—While all of a land area is eventually worked over by stream activities and can thus be referred to the river series, other activities are at work in a young topography. The swamp series which has just been discussed is one illustration. So also there are hills which are not due to erosive processes, but to other causes, notably in our region morainic hills and sand hills. There are rock hills also which are not connected with the present erosion cycle. All of these hill types have their peculiar vegetation features and must be discussed apart from river activities, since they have an interesting history before they are attacked by stream erosion.

FIG. 26.—Slope of limestone ledge at Stony island, showing mosses and higher plants establishing themselves in the crevices.

We may speak first of rock hills, which in the vicinity of

Chicago are quite rare and consist entirely of dolomitic Niagara (Silurian) limestone. Not only are hills of this limestone quite rare, but surface outcrops of any kind are uncommon because of the heavy drift. Hence the rock vegetation of the Chicago area is not very important. Perhaps the most interesting outcrop is at Stony island, where it is quite easy to trace the various stages in the development of the vegetation. This rock, like most limestone, is subject to chemical as well as mechanical erosion, but is much more resistant than most limestones on account of its strongly dolomitic character. The first vegetation that gets a foothold is composed of lichens, but the lichen flora appears to be rather sparse, perhaps because of the chemical nature of the rock, since lichens are commonly supposed to shun calcareous soils. The relative poverty of lichens may be due, however, to the easy solution of the surface rock layers and the consequent difficulty in retaining a foothold. The limestone is considerably jointed and fractured and there is in consequence a rich crevice vegetation, composed of several mosses, especially Ceratodon and Bryum, and also various grasses. *Fig. 26* shows a vegetation of this nature, and among the other crevice plants is an abundance of *Solidago nemoralis*. Other species growing in the crevices or on the first soil which is formed on the rock face are *Potentilla arguta, Verbascum Thapsus, Heuchera hispida, Poa compressa*, etc. At Thornton there is a rock outcrop which gradually recedes from the surface, and it is possible to tell by the vegetation where the rock surface dips considerably under the surface of the soil. Where the soil is shallow the dominant plant is *Poa compressa*, but as the soil layer deepens it becomes gradually replaced by *Poa pratensis*. Similarly at Stony island crevices can be distinguished in a covered horizontal rock surface by a sudden change from the xerophytic plants of the shallow soil, that hides most of the rock, to the mesophytic plants of the deeper soil which lies over the crevices.

Through rock decay and the accumulation of organic matter a considerable soil comes to be developed where there was at first an outcrop of bare rock. The opportunity for a shrubby vegetation eventually arrives, especially in the crevices. *Fig. 27* shows such a vegetation getting a foothold. Among the shrubs in such places are the chokecherry (*Prunus Virginiana*), ninebark (*Physocarpus opulifolius*), poison ivy (*Rhus Toxicodendron*), *Rosa humilis*, sumach (*Rhus typhina*), hop tree (*Ptelea trifoliata*), wild crab (*Pyrus coronaria*). Still later the way is open for a tree vegetation, at first xerophytic, but ultimately mesophytic, as the author has frequently observed in the Alleghanies. There can be no doubt but that a temporary mesophytic climax can be reached even on rock hills, though the probability of this

FIG. 27.—Limestone ledge at Stony island, showing vegetation farther advanced than in *fig. 26*. The crevice shrubs here are chokecherries (*Prunus Virginiana*).

is much greater where the hill is composed of limestone than in the case of sandstone or granite.

B. *The clay hill.*— Morainic hills are common in the Chicago region and almost without exception they are covered with a mesophytic forest, in which the dominant trees are usually the white oak (*Quercus alba*), the red oak (*Quercus rubra*), and the shell-bark hickory (*Carya alba*). This is easily the dominant forest type of the Chicago region, and is remarkably characteristic of morainic areas. The soil in all cases is a glacial clay or till, heterogeneous in composition, but rich in food salts. Of all our plant society life histories these are about the most difficult to unravel and it is due to the favorable conditions under which they have developed. After the continental glacier left this region for the last time, it was doubtless on these low

FIG. 28.—Typical upland clay (morainic) forest at Beverly hills. The dominant trees here are red oaks (*Quercus rubra*), though a white oak (*Q. alba*) is shown at the extreme right.

morainic hills that the first mesophytic forests were developed. And they have been developed for so long that almost no traces of their history are left behind; we have only the completed product, the mesophytic forest.

Where these mesophytic forests are disturbed we may perhaps get some notion of what took place in the first postglacial centuries. On the clay banks along the drainage canal and also on recent river bluffs, one may follow in rapid succession a series of plant societies leading to the forest. There is here no pronounced lichen or moss stage as on rock hills, but the first vegetation consists of xerophytic annuals and perennial herbs. Xerophytic shrubs, especially Salix and Populus, soon appear. It is not long before there is an extensive thicket formation with an herbaceous undergrowth. Humus accumulates with great rapidity and we soon have almost a mesophytic vegetation in which the dominant thicket species are likely to be the aspen (*Populus tremuloides*), wild crab (*Pyrus coronaria*), red haw (*Crataegus punctata, C. coccinea*, etc.). Such a thicket is the immediate forerunner of the oak-hickory type of mesophytic forest. When a forest of oak and hickory is cut down or destroyed by fire it returns after a comparatively short interval, but the first stages in the clearing are thicket stages much like those just described. Of course it takes much longer to develop a forest from naked clay soil than from a forest land that has been cleared. Whether the stages that led up to the first postglacial forests are such as have been described is very doubtful. It is much more likely that the first forests were of slow growth and were coniferous in character, such as are found farther north. *Fig. 28* shows a typical morainic hill forest of the above type. Here the dominant tree is the red oak; a white oak is seen at the right.

Among the shrubs of these morainic forests there may be mentioned, apart from the crabs and haws, the hazel (*Corylus Americana*), and various species of Viburnum. Many herbaceous plants are found, among which are Podophyllum, Claytonia, various species of Aster, Trillium, *Geranium maculatum, Viola* *pubescens*, *Anemone nemorosa*, etc. Sometimes the bur oak (*Quercus macrocarpa*) is the dominant tree in these morainic forests, though in such cases the habitat is usually more moist or else the drainage is less perfect. A bur oak forest is shown in *Fig. 29*. The transition from this type to the morainic swamp forests, already mentioned, is an easy one, and bur oaks are often found with the swamp white oak and other species characteristic of such places.

FIG. 29.—Typical forest of low morainic clay soil, made up chiefly of bur oak (*Quercus macrocarpa*).

In spite of the abundance of the type of morainic forest described above, it is scarcely probable that it is anything more than a very slowly passing forest stage. The fact that in all directions from Chicago the ultimate forest type on morainic uplands is not the oak-hickory but the maple-beech forest leads us to expect that here. This latter type seems to be of a higher order in all respects. It is found in richer soil where the humus content is very great. Seedlings of the beech or maple can easily grow in the relatively light oak forest, whereas oaks cannot grow in the denser shade of the maple or beech. Furthermore, oak forests have been seen with a pronounced undergrowth of beech. It would seem that one of the chief factors in determining the order of succession of forests is the light need of the various tree species, the members of the culminating forest type being those whose seedlings can grow in the densest forest shade. There are evidences that the oak forests about Chicago are being succeeded by the beech or maple. The best instance of this which the author has seen is on the low moraines along the Desplaines river west of Deerfield. The sugar maple (*Acer saccharinum*) has already been mentioned as a character plant of the temporary mesophytic forests of ravines. Here we see it in the more permanent forest of the morainic hills. The beech (*Fagus ferruginea*) is much rarer than the sugar maple, though it is a rather important constituent of the mesophytic forests about Chesterton. Why the beech-maple forest has lagged so far behind in the region about Chicago is a question not yet settled. If these forests elsewhere have had an oak stage it indicates that the development here is very slow.

Though the forests just described, whether of the oak-hickory or the maple-beech type, are of a high degree of permanence, it can be seen that this permanence is but relative. Sooner or later stream action will enter these districts and base leveling processes will begin on a more rapid scale. But for these activities the lowering of hills would be very slow indeed, so slow as hardly to interfere at any point with a luxuriant development of the vegetation. The destruction of these morainic forests by stream erosion is well shown near the shore north of Evanston and also along Thorn creek. *Fig. 18* shows a morainic island in a flood plain, the sole remnant of an extensive stretch of upland mesophytic forest. We must therefore regard upland forests as temporary also, though they endure for a much longer time than do the temporary mesophytic forests of the ravines.

C. *The sand hill.*—A third type of upland is found in the sand hills, but since most of these in our district are of dune origin, their treatment will be deferred until later.

B. The coastal group.

I. THE LAKE BLUFF SERIES.

The plant societies that have been discussed hitherto may be found in many if not in most inland districts. The societies that follow, on the other hand, are best worked out only in connection with the coasts of oceans or great lakes. Theoretically a bluff may be composed of any kind of rock or soil, but those of our area are composed of morainic clays, and the life histories that follow will not hold good in other conditions. It may be noted here that there is a short stretch of rocky shore with lithophytic algae at Cheltenham, but there is nothing that in any way approaches a rock cliff.

Wherever a sea or lake erodes rather than deposits, there is commonly developed a sea cliff of greater or less dimensions. The material which is thus gathered may be deposited elsewhere in the form of beaches and later the wind may take up the sands from the beach and form dunes. The Chicago area gives splendid examples of these two types of sea activity; to the north of the city is an eroding coast line with its bluffs, and to the south and southeast is a depositing coast with extensive areas of beach and dune.

The lake bluffs at Glencoe give an excellent opportunity for the study of the life history of a sea-cliff vegetation. There can be almost no other habitat in our climate which imposes such severe conditions upon vegetation as an eroding clay bluff. The only possible rival in this regard is a shifting dune, and even here the dune possesses some points of advantage so far as the establishment of vegetation is concerned. In the first place, the conditions as to exposure are almost identical with those of a dune: the heat of midday and of summer and the cold of night and winter are extremely pronounced; the intensity of the light and the exposure to wind make the conditions still more severe. In other words the only plants that can grow on these lake bluffs, at least in the earlier stages, are pronounced xerophytes. Again the character of the soil is unfavorable, for while the clay is wet in the autumn, winter, and spring, it dries out in the summer and becomes almost as hard as rock. In the heart of summer the conditions for vegetation are no better on the hard dry slopes of a clay bluff than on the hot, dry sands of a dune. Finally as to instability: it is doubtless the constant shifting of the sand which in the last analysis accounts for most of the poverty of the dune vegetation. It is similar on clay bluffs, for when the waves undermine the cliff at its base, the action of gravity causes great masses of material to fall down from the entire cliff face. Furthermore, when the clay is saturated with water, great portions of the cliff face slide down, entirely apart from the action of the sea or lake. At no time, then, is an eroding bluff any more stable than a naked dune.

FIG. 30.—Sea cliff along the eroding shore at Glencoe, exposing the morainic clay. Vegetation almost entirely absent. Projecting turf mats at the top show the tenacity with which the vegetation holds its ground in the face of the erosive forces

It becomes evident from a survey of the bluff conditions that all vegetation is impossible so long as active erosion by the lake continues. Not only this, but vegetation at the top of the bluff is soon destroyed. *Fig. 30* shows a naked cliff of this character; at the top there can be seen overhanging turf, giving evidence both of the destructive action of the lake and also of the tenacity with which a grass mat holds its place in the presence of adverse conditions. Near the center of *fig. 31* may be seen a white oak which was almost overthrown by the erosive activities, but which has been preserved through the cessation of erosion at this point. The gully shown near the center of *fig. 30* is seen in closer view in *fig. 1*; the absence of vegetation, save that which has slid down from above, is very striking.

If for any reason the lake activities at the base of the cliff are stopped, an opportunity is offered for the development of vegetation. At Glencoe the cliff erosion has been checked to some extent by artificial means, and one can see various phases of cliff life within a small area. When the erosion at the base of the bluff ceases, conditions become much more stable, though landslide action may still occur. In time the slope gradient becomes so low that the cliff soil is essentially stable; when this time arises vegetation develops with great rapidity in spite of the xerophytic conditions which are still as pronounced as before. It is very obvious, therefore, that it is the instability of the eroding cliff and not its xerophytic character which accounts for the absence of plant life.

The first vegetation is commonly made up of xerophytic herbs, both annual and perennial. Among these are the sweet clover (*Melilotus alba*), various annual weeds, various species of aster, especially *A. laevis*, *Equisetum hyemale*, various grasses, etc. Soon there develops a xerophytic thicket vegetation, such as is shown in *fig. 31*. This may be called the shrub stage of the captured cliff, and among the dominant species are the juniper and cedar (*Juniperus communis* and *J. Virginiana*), *Salix glaucophylla*, the osier dogwood (*Cornus stolonifera*), *Shepherdia Canadensis*, various sumachs (*Rhus typhina* and *R. glabra*). The following tree stage is dominated by various poplars (*Populus tremuloides*, *P. grandidentata*, *P. monilifera*), the hop hornbeam (*Ostrya Virginica*), the white pine (*Pinus Strobus*), the red cedar (*Juniperus Virginiana*), and some of the oaks (probably *Quercus* *rubra* and *Q. coccinea tinctoria*). *Fig. 32* shows a tree-clad cliff in which most of the above trees are to be found.

Whether a mesophytic forest would develop on a lake bluff is something of a question. It seems likely that semi-xerophytic trees will dominate there for a long time to come on account of the xerophytic atmospheric conditions. Particularly at the top of the bluff do the conditions remain severe, by reason of the great exposure and also the dryness of the soil. If the lake should recede for some distance, a mesophytic forest could certainly develop on the bluff before it is reduced to anything like the common level. This is shown on the ancient lake bluff at Beverly hills. Here there is an old cliff about forty

FIG. 31.—Sea cliff at Glencoe, at a place where lake erosion has ceased. Shrubs (largely cedars and willows) prominent as well as herbs. Absence of lake erosion also indicated by the gentle slope, as compared with *fig. 30*. The leaning oak at the top bears witness to former erosive forces.

feet above the country level, representing a lake bluff of the Glenwood stage of Lake Chicago.[24] This bluff has long had a mesophytic forest on its slopes, and yet it will be many centuries before the erosive forces remove all traces of this ancient sea cliff. A still more striking case is to be seen north of Waukegan, where an ancient lake bluff, higher than that at Beverly hills and only a mile back of the present lake shore is tenanted by a high grade type of mesophytic forest.

FIG. 32.—Sea cliff at Glencoe, where lake erosion has been absent for a long period. Xerophytic trees and shrubs, especially conifers, dominate, *e. g.*, white pine, red cedar, juniper.

It will be instructive to make a few comparisons between lake bluffs and other plant societies. Closest to the lake bluff in a

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[24] SALISBURY and ALDEN: The geography of Chicago and its environs. Chicago, 1899.

physiographic sense is the river bluff. When a stream has banks of clay the conditions seem decidedly similar and yet the flora is not the same. A comparison of the lake bluffs at Glencoe with the bluffs along Thorn creek shows that some species are common, notoriously Ostrya, Rhus, Quercus, Populus. Yet the differences are still more striking, for the bluffs along Thorn creek do not show *Salix glaucophylla* nor Shepherdia; most striking of all, however, is the entire absence of conifers. When we compare the lake bluffs with the rock bluffs of the Illinois river we find that the resemblances are greater than the differences, since the river bluffs have conifers, though even here some of the lake bluff forms are absent. When, however, we compare the Glencoe bluffs with the dunes, we find that all of the dominant shrubs and trees of the bluff are found also on the dunes ; not only this, the dominant bluff forms are dominant on the dunes also.

The facts of the preceding paragraph are pregnant with significance. One obvious corollary is that given similar soils but dissimilar conditions of atmospheric exposure, as at Glencoe and Thorn creek, the vegetation is unlike. Another and more striking corollary is that given the most dissimilar soils possible, viz., the Glencoe clay and the dune sand, we still have similar vegetation, because the atmospheric conditions are the same in the two cases. The evidence of the Illinois river bluffs is less clear; they are more xerophytic than the bluffs along Thorn creek, but whether this is chiefly due to rock as against clay or to greater exposure is not certain. At all events these facts show that it is not enough to know about chemical or physical conditions in the soil. We cannot divide plants into those of clay, rock, and sand, but must take into account that most plants have a wide range of life so far as soil is concerned, provided the atmospheric conditions are congenial. The chief exception to this statement seems to be found not in the original soils but in the superimposed humus. There are many plants that require humus for their occurrence in nature, but it makes no difference whether the subsoil is rock, sand, or clay, provided alone that the humus is present in sufficient quantity. It is by reason of this last fact that the mesophytic forest can appear in all conditions in this climate, since the mesophytic forest is associated to a high degree with humus.

2. THE BEACH-DUNE-SANDHILL SERIES.

A. *The beach.*—The author has previously discussed in considerable detail the dynamics of the dune societies,[25] and it will not be necessary to do more here than to summarize the chief conclusions, and add a few new data. Before long it is expected that a paper will appear giving the changes that have taken place since the first observations were made in 1896.

The beach in the Chicago area is xerophytic throughout. There is nothing analogous to the salt marshes of the Atlantic coast, nor to the hydrophytic shores farther north along Lake Michigan. The lower portion of the beach is exposed to alternate washing by the waves and desiccation in the sun, and is devoid of life. The middle beach, which is washed by winter waves, though not by those of summer, has in consequence a vegetation of xerophytic annuals, the most prominent of which is *Cakile Americana.* The upper beach is beyond present wave action, and is tenanted by biennials and perennials in addition to the annuals. *Fig. 33* shows a beach of this type, the lower beach being smooth and even, the middle beach covered with débris, while the upper beach has a scattered perennial vegetation.

The beach at the base of cliffs shows similar subdivisions, though the zones are much narrower as a rule. The vegetation, too, is much the same, though some forms, as Strophostyles, have not been seen as yet on the beaches of the dune district. At the foot of cliffs there often occur alluvial fans of sand, which have been deposited by the torrents during and following rain storms. These fans have a comparatively rich vegetation and species sometimes occur here that are not found elsewhere on the beach.

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[25] COWLES, H. C.: The ecological relations of the vegetation on the sand dunes of Lake Michigan. BOT. GAZ. **27**: 95–117, 167–202, 281–308, 361–391. 1899.

B. *The embryonic or stationary beach dunes.*—Wherever plants occur on a beach that is swept by sand-laden winds, deposition of sand must take place, since the plants offer obstacles to the progress of the wind. If these plants are extreme xerophytes and are able to endure covering or uncovering without injury, they may cause the formation of beach dunes. Among the dune-forming plants of this type are *Ammophila arundinacea*, *Salix glaucophylla* and *S. adenophylla*, *Prunus pumila*, and *Populus monilifera*. The shapes of these beach dunes vary with the characteristics of these dune-forming plants. Ammophila dunes are extensive but low, because of strong horizontal rhizome propagation. Prunus and Populus dunes are smaller but higher, because of the relative lack of horizontal propagation and the presence of great vertical growth capacity. Dunes are formed more slowly in protected places, and here the dune-forming species may be plants that are ill adapted to the severest beach conditions, such as the creeping juniper.

FIG. 33.—Beach at Dune park, showing the smooth and naked lower beach, the middle beach with its line of débris, the upper beach with scattered shrubs, and the dunes.

C. *The active or wandering dunes. The dune complex.*—The stationary embryonic dunes on the beach begin to wander as soon as the conditions become too severe for the dune-forming plants. The first result of this change is seen in the reshaping of the dune to correspond with the contour of a purely wind-made form. The rapidity of this process is largely determined by the success or failure of the dune-formers as dune-holders. The best dune-holders are Calamagrostis, Ammophila, and Prunus.

There are all gradations between a simple moving dune and a moving landscape; the latter may be called a dune-complex. The complex is a restless maze, advancing as a whole in one direction, but with individual portions advancing in all directions. It shows all stages of dune development and is forever changing. The windward slopes are gentle and are furrowed by the wind, as it sweeps along; the lee slopes are much steeper. The only plant that flourishes everywhere on the complex is the succulent annual, *Corispermum hyssopifolium*, although *Populus monilifera* is frequent. The scanty flora is not due to the lack of water in the soil, but to the instability of the soil and to the xerophytic air.

The influence of an encroaching dune upon a preexisting flora varies with the rate of advance, the height of the dune above the country on which it encroaches, and the nature of the vegetation. The burial of forests is a common phenomenon. The dominant forest trees in the path of advancing dunes are *Pinus Banksiana* and *Quercus coccinea tinctoria*. These trees are destroyed long before they are completely buried. The dead trees may be uncovered later, as the dune passes on beyond.

In the Dune park region there are a number of swamps upon which dunes are advancing. While most of the vegetation is destroyed at once, *Salix glaucophylla*, *S. adenophylla*, and *Cornus stolonifera* are able to adapt themselves to the new conditions, by elongating their stems and sending out roots from the buried portions. Thus hydrophytic shrubs are better able to meet the dune's advance successfully than any other plants. The water relations of these plants, however, are not rapidly altered in the new conditions. It may be, too, that these shrubs have adapted themselves to an essentially xerophytic life through living in undrained swamps. Again it may be true that inhabitants of undrained swamps are better able to withstand a partial burial than are other plants.

Vegetation appears to be unable to capture a rapidly moving dune. While many plants can grow even on rapidly advancing slopes, they do not succeed in stopping the dune. The movement of a dune is checked chiefly by a decrease in the available wind energy, due to increasing distance from the lake or to barriers. A slowly advancing slope is soon captured by plants, because they have a power of vertical growth greater than the vertical component of advance. Vegetation commonly gets its first foothold at the base of lee slopes about the outer margin of the complex, because of soil moisture and protection from the wind. The plants tend to creep up the slopes by vegetative propagation. Antecedent and subsequent vegetation work together toward the common end. Where there is no antecedent vegetation, Ammophila and other herbs first appear, and then a dense shrub growth of Cornus, Salix, *Vitis cordifolia*, and *Prunus Virginiana.* Capture may also begin within the complex, especially in protected depressions, where *Salix longifolia* is often abundant.

D. *The established dunes.*—No order of succession in this entire region is so hard to decipher as is that of the established dunes. There are at least three types of these dunes so far as the vegetation is concerned, and it is not yet possible to figure out their relationships. The continuation of the conditions as outlined in the preceding paragraph results in a forest society on the lee slope, in which is found the basswood, together with a most remarkable collection of mesophytic trees, shrubs, and climbers, which have developed xerophytic structures. These dunes are evidently but recently established, as is shown by the absence of a vegetation carpet; furthermore the slopes are almost always steep.

Again, there are forest societies in which the pines dominate, either *Pinus Banksiana* or *P. Strobus.* These arise from a heath, composed in the main of Arctostaphylos and Juniperus. The heath appears to originate on fossil beaches or on secondary embryonic dunes or other places where the danger of burial is not great. It will be noted that both the heath and the pine forest are dominated by evergreens. These societies commonly occur near the lake or on lakeward slopes, which are northern slopes as well. On these coniferous dune slopes there is to be found another notable collection of northern plants, resembling ecologically the peat bog plants already mentioned. Heaths and coniferous forests also occur on sterile barrens and in depressions where the conditions are unfavorable for deciduous forests. A slight change in the physical conditions may bring about the rejuvenation of the coniferous dunes, because of their exposed situation. This rejuvenation commonly begins by the formation of a wind sweep, and the vegetation on either hand is forced to succumb to sand-blast action and gravity.

A third type of established dune is that in which the oaks predominate, and especially *Quercus coccinea tinctoria*. The oak dunes are more common inland and on southern slopes. Probably the oaks follow the pines, but the evidence on which this is based is not voluminous. The pines certainly have a wider range of habitat than the oaks, occurring in wetter and in drier soil and also in more exposed situations. The mutual relations of the pines and oaks are certainly interesting and deserve some very careful study. Pine forests prevail on the north or lakeward slopes and oak forests on the south or inland slopes. With the pines are other northern evergreen forms, such as Arctostaphylos, while with the oaks are Opuntia, Euphorbia, and other more southern types. The density of the vegetation on the north side is also in contrast with the sparser and more open vegetation of the south side. The cause for this radical difference on the two slopes is doubtless complex, but it is obvious that the north slope has greater moisture, shade, and cold, and probably more wind. Which of these is the more important is not certain, but the presence of the northern species seems in favor of cold or wind as the chief factor.

There are a number of interesting sand hills and ridges at some distance from the lake. Some of these are fifteen miles from the present lake shore, while others are found at various intervals nearer and nearer the lake. It has been found that these can be grouped for the most part into three series, representing three beach lines of Lake Chicago, as the glacial extension of Lake Michigan has been called. The upper and oldest of these ridges has been termed the Glenwood beach, the intermediate ridge the Calumet beach, and the lower and younger ridge the Tolleston beach. The geographic relations of these beaches is well discussed by Leverett[26] and also by Salisbury and Alden,[27] and nothing need be said here except as to the vegetation. In general these ridges and hills have a xerophytic forest flora, dominated by the bur, black, and white oaks (*Quercus macrocarpa*, *Q. coccinea tinctoria*, *Q. alba*). The proportions between these trees varies strikingly, though the bur or

FIG. 34.— Portion of an ancient beach line (Calumet beach) at Summit, showing the characteristic oak vegetation, in this case chiefly bur oaks (*Quercus macrocarpa*).

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[26] *Op. cit.* 55-85.

[27] *Op. cit.* 31-51.

black oak is usually the chief character tree. No satisfactory reason can yet be given for these variations, though the bur oak appears to be more abundant on the lower and less drained ridges, while the black oak is more abundant on the higher ridges. The shrub undergrowth is commonly sparse, and the most frequent members of this stratum are the hazel (*Corylus Americana*), Rosa, the New Jersey tea (*Ceanothus Americanus*), *Salix humilis*, the low blueberry (*Vaccinium Pennsylvanicum*), and the huckleberry (*Gaylussacia resinosa*). Among the commoner herbs are *Silene stellata*, *Antennaria plantaginifolia*, *Heuchera hispida*, *Rumex Acetosella*, *Carex Pennsylvanica*, *Potentilla argentea*, *Poa compressa*, *Pteris aquilina*, *Ceratodon purpureus*. In open places there are often almost pure growths of Poa or Potentilla. *Figs. 34* and *35* show portions of these ancient beaches in which the oaks dominate; *fig. 34* shows, perhaps, the more common condition, *i. e.*, a rather low beach with a sparse tree growth.

FIG. 35.—Portion of an ancient beach (Glenwood beach) near Thornton. The trees here are chiefly black oaks (*Quercus coccinea tinctoria*); the beach is higher, and the trees more luxuriant than usual.

The future of the vegetation on the established dunes and beaches is somewhat problematical. From analogy with other plant societies in this region, and from established dunes in Michigan, we should expect a mesophytic forest, probably of the white oak-red oak-hickory type at first and then followed by a beech-maple forest. There are evidences that some such changes are now taking place. On many of the oak dunes, especially where protected from exposure, there is already a considerable accumulation of humus. Herbaceous ravine mesophytes like Hepatica, Arisaema, and Trillium are already present, and with them mesophytic shrubs and trees, including the sugar maple itself, though the beech has not been found on the dunes of our area, as it has in Michigan. One might expect that the flora of the older Glenwood beach would have advanced more toward the mesophytic stage than has the flora of the younger Tolleston beach. Such, indeed, seems to be the case, especially at Glenwood, where the white oaks are more numerous, and the black oaks much larger and more luxuriant. The humus is richer and most things look as if the age of this beach were notably greater than that of the Calumet or Tolleston beaches. This subject, however, needs much further investigation. In any event, one character of the sand hill stands out in bold relief, viz., its great resistance to physiographic change. Not only is its erosion slower than that of the clay hill, but the advance of its vegetation is vastly slower at all points along the line. The slowness of humus accumulation accounts for this, perhaps, more than all else.

III. Summary and conclusion.

In the present paper the author has endeavored to show the need for a classification of plant societies which shall form a logical and connected whole. Warming's classification, based on the water content of the soil, is doubtless the best possible classification, if but one factor is used. Graebner's classification, based on soil characteristics, includes the advantages of Warming's scheme, and adds desirable new features.

The physiographic theory here presented is the result of several years of field study devoted chiefly to testing the current theories and to developing new ones. The classification is based on the fundamental notion that a true theory must be genetic and dynamic; the plant societies must be grouped according to origins and relationships, and the idea of constant change must be strongly emphasized.

The laws that govern changes in plant societies are mainly physiographic; whether we have broad flood plains, xerophytic hills, or undrained swamps depends on the past and present of the ever-changing topography. Nor is topographic change haphazard. Modern physiography has made a logical classification of dynamic surface forces, and has found a progressive tendency toward a definite end. Denudation of the uplands and deposition in the lowlands results in an ultimate planation, known as the base level. Wherever hills are being eroded, or lakes filled, or coastal plains enlarged, it is obvious that there must be changing plant societies, in other words, a definite order of succession of plant groups. These changes, too, are cumulative; a topographic form will have plants that are relicts of an older stage, as well as those that are typical of the new conditions, showing that the supplanting of one plant society by another is slow and gradual. The full effect of a given environment may not be felt till that environment has gone.

Using ecological terms in place of those of physiography, soil conditions tend to become more mesophytic as the base level develops. A young topography is rich in xerophytic hills and in hydrophytic lakes and swamps. There may be local retrogressions toward xerophytic or even hydrophytic plant societies, forming eddies, as it were, but the great movement is ever progressive and toward the mesophytic condition. Though instances of vast planation are found in geological history, the ultimate mesophytic base level is seldom reached, since crustal movements interfere with physiographic processes. So far as plants are concerned, however, a physiographic terminology may still be used, since all possible crustal changes are either toward or away from the mesophytic, *i. e.*, progressive or retrogressive. Again, climatic changes doubtless occur; even here we may use the general terminology, since the new conditions either favor or retard the general mesophytic development. This leads to the general view that the climax type differs with the climate. While the general series of physiographic changes is much the same everywhere, the corresponding plant societies are vastly different. In a desert climate most of the societies, including the climax type itself, are xerophytic. Finally, there is at least one point where physiographic and ecological classifications must diverge. Changes in vegetation often take place where the topography remains the same; in other words, a cycle of vegetation may be shorter than a cycle of erosion. The following application of these principles applies only to the Chicago region.

The typical erosion series is based on the life history of rivers, and this series is the most instructive ecologically. An embryonic clay ravine is essentially a little desert, though this character is due more to the instability of the soil than to the ordinary xerophytic factors. Soon landslide action becomes much reduced, and a xerophytic flora may appear, though in a remarkably short time a rich mesophytic forest is developed. This forest is not permanent, but may be regarded as a temporary climax. Rock ravines, whether of limestone or sandstone, commonly have more vertical slopes and drip with moisture, favoring the growth of extreme shade plants. The stages in limestone and sandstone habitats are essentially the same in spite of great physical and chemical differences in the rock.

As a clay ravine widens, the exposure increases; xerophytic herbs appear at the top of the slope, and later farther down toward the stream bed. Xerophytic shrubs and finally xerophytic trees make their appearance, notoriously *Ostrya Virginica.* In the early stages of these xerophytic bluffs trees are often found that look back to the ravine for their origin, while under them are xerophytic herbs that are better suited to the new conditions. As the slopes of a mesophytic rock ravine pass to a xerophytic rock bluff, changes in the vegetation are most pronounced. A slope less xerophytic than that of clay becomes more xerophytic as it becomes a river bluff, and conifers are found as well as deciduous xerophytes. As the bluff slopes become more gentle through erosive action, a mesophytic flora may gradually replace the xerophytes.

Before the growing valley possesses a permanent stream there may be developed in the torrent bed a vegetation of amphibious shade plants, and when the water becomes more permanent one may find algae and other hydrophytes. Spring brooks are infrequent, but they have a characteristic vegetation, due doubtless to the presence of more light and water. The development of a flood plain vegetation is well shown on river islands. First a sand bar develops, then an annual flora, and later a perennial vegetation in which Salix dominates. The river constantly erodes above and deposits below, hence the islands migrate down the stream, showing the oldest plant societies at the upper end. Depositing streams gradually develop a flood plain which shows an interesting succession of societies. Beyond the true hydrophytes there is commonly seen a Salix zone, then a zone of Populus and other trees on the older flood plain, and finally there develops a luxuriant mesophytic flood-plain forest which as a whole is permanent, though local retrogressions may occur. In some of these flood-plain forests there are found interesting southern types of trees. Occasionally meadows occur on flood plains in place of forests. Retrogressive processes are active on flood plains, such as terrace formation, which is due to further erosion; terrace development tends to favor xerophytes. New channels are also cut off, leaving portions of the old river as oxbow lakes; here hydrophytes of undrained swamps come in, and one often sees trees of the old river margin together with shrubs and herbs of the undrained swamps. These latter phases, however, are ephemeral and the mesophytic flood plain as a whole increases constantly in area.

The vegetation of undrained areas has a remarkably xerophytic stamp; this is possibly due to the unfavorable opportunity for root activity in undrained soils. In any event, these areas are features of a young typography and they are soon filled up by accumulating peat. Algae and other hydrophytes characterize the lake or pond stages, and largely by their partial decay the water becomes shallow enough to support the vegetation of a marginal swamp, particularly rushes and sedges. After these forms there appear the most remarkable plant societies of the entire series, characterized chiefly by Cassandra and other ericads with xerophytic structures. Following the shrub stage there is the tree stage in which the tamarack often dominates, though pines appear later and ultimately mesophytes. In these swamps one finds the most perfect examples of the regular succession of plant societies, and hence of zonal arrangement. These peat bog societies contain a most striking collection of northern plants. There are various diverging types of undrained swamps, some with shallow soil and a vegetation without extreme xerophytic structures, others in which an imperfect drainage may account for the facts observed. The marginal vegetation is the same in all cases and is remarkably characteristic; this flora is sometimes seen after the lake and swamp floras have gone. Half-drained areas are characterized by luxuriance of the vegetation in the lake stage. The lake is followed in order by the bulrush, sedge, and grass stages, the latter being denominated the prairie stage. Whether this latter type passes into the forest is not certain; in any event, this mesophytic stage is not final, for the region must subsequently pass through the stages of the river series.

Uplands, as well as swamps, have an interesting history before they are attacked by stream erosion. Limestone hills and outcrops show first a lichen vegetation, followed by mosses and crevice herbs and later by shrubs and trees. The stages on clay hills pass far more rapidly, indeed early stages are hard to detect, and one almost uniformly finds a mesophytic forest of oaks and hickories in these habitats. Where the forest conditions are disturbed, there is a rapid return through a series of herb and shrub stages to the same tree types. It is somewhat probable that the oaks will be followed by sugar maples and beeches, and this change is now occurring in some places. The mesophytic stage here also is not permanent, though it may endure for a long period.

Clay bluffs along an eroding coast are subject to considerable change involving the rapid destruction of upland vegetations. The changes, too, are so rapid that practically no vegetation can develop on the bluff slopes. If the erosive activity of the lake ceases, there soon appears a vegetation of xerophytic herbs, followed by xerophytic shrubs and trees in which conifers play a large part. There is a notable resemblance between the flora of the clay bluff along the lake shores and the flora of the sand dunes, and also the flora of rock bluffs along rivers, while the resemblance is less close to the flora of clay bluffs along rivers, showing that soil conditions may often be less important than conditions of aerial exposure.

The dune vegetation, presented in detail elsewhere, is summarized in this present paper. Nothing need be said in the way of further summary except to remark that dunes, like all other topographic forms in our climate, may ultimately develop a mesophytic forest, though the stages are far slower than in most of the other series.

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SOME RECENT PUBLICATIONS AND THE NOMENCLATORIAL PRINCIPLES THEY REPRESENT.

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THE second edition of Mr. Heller's *Catalogue*[1] presents, as a piece of presswork, a great improvement over its predecessor. For thus materially improving the dress of his work the author is certainly to be commended. The book also contains a very large increase of species over the first edition; and for bringing together hundreds of recently published names, where they can be readily consulted, the compiler should have the gratitude of students of systematic botany. In a work of this sort, necessarily accomplished largely by compilation, monographic treatment of recent and doubtful species can not and should not be expected; but there can be no question that the compiler of a check list or catalogue owes to the public the product of the best light he has upon the species with which he deals. Mr. Heller's new *Catalogue*, especially, representing the so-called reform tendencies in American botany, should be judged primarily by the degree of adherence to or divergence from the principles which he has taken upon himself to exploit. This second edition, too, should be judged by the degree of readiness shown by its author to correct such obvious errors and inconsistencies in his preceding work as have been definitely called to his attention in print.

It is a question which is the point of greater significance to systematic botany—the hopeless tangle of nomenclatorial principles here exhibited, or the tendency, by no means new, to break through the traditional though necessarily vague barriers separating the minor categories to which plant-variations may be assigned, namely, the species, variety, and form. That the author of this *Catalogue*, and numerous other American botanists,

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[1] Catalogue of North American plants north of Mexico, exclusive of the lower cryptogams. By A. A. HELLER. Second edition. Issued November 10, 1900.

like Jordan and others in Europe, have essentially abandoned these finer discriminations in classification, has been made perfectly evident in their past work, and now we are informed that "there is also a growing tendency to discard the use of varietal names, and to call all plants species which have characters enough to justify the use of a distinctive name."[2] To the critical student, who is familiar with growing plants and the causes which so often control their variations, such action as this cannot appeal; and, though the author of the *Catalogue* is not alone in his standpoint, there are still many students whose conceptions of plants and their relationships can be expressed only by the retention of categories which are subordinate in rank to the species.

However, even if, by putting essentially all variations within the genus upon a common level, the author chooses to obscure the minor degrees of relationship in plants, there should be no question of personal choice or opinion in judging the method so often adopted by him in order to increase the number of so-called species. In the introduction to the new *Catalogue* (as well as in the original edition) many new combinations of names are made; but, finding that space would not permit the publication there of all the changes he desired to make, the author has ventured a new private journal,[3] the first issue of which is occupied by an appendix to the nomenclatorial changes begun in the *Catalogue*. It seems that the author has, or did have on November 10, 1900, some conception of the unsatisfactory methods he was employing, for in apologizing for so proceeding he says: "The bare citation without discussion in most cases is *undesirable*, but *lack of time* forbids a more extended treatment of the different species under *consideration* [italics ours]."[4] Does anyone suppose that by careful botanists such an apology can be accepted as a pledge of sincere desire to advance botanical science; or can it be that

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[2] HELLER, *l. c.* 3.

[3] Muhlenbergia, a Journal of Botany. Edited and Published by A. A. HELLER, Lancaster, Pa.

[4] HELLER, *l. c.* 1:1.

the author conceives that *his time*, the "lack" of which alone permits him to launch so many *unconsidered* species, is of far greater importance than that of the scores of other botanists who must now spend weary hours trying to unravel the snarls he has produced? An example or two may make our point more clear. The names *Prenanthes Serpentaria* and *Nabalus Serpentarius* have been essentially interchangeable in American floras,[5] and the name in either case has been made to cover until recently two very different species. In the *Illustrated Flora*, however, Dr. Britton has revived Cassini's *Nabalus trifoliolatus* for a well-marked northern plant, and has left the name *N. Serpentarius* to cover (as it should) the thick-leaved species of more southern range with the "involucre more or less bristly-hispid." Torrey and Gray described *Nabalus Fraseri*, var. *barbatus*, with the "involucre (12–15-flowered) hirsute when young with long purplish hairs," and in the *Synoptical Flora*, Dr. Gray, writing at a time when the name *Prenanthes Serpentaria* covered the northern plant with usually glabrous involucre, published *P. Serpentaria*, var. *barbata*, with the remark that "occasionally a few of these setose hairs are found on the involucre of ordinary *P. Serpentaria*, and in this variety [*barbata*] some heads are almost destitute of them." Now the original Torrey and Gray specimen of this variety is in no way different from the species, *Nabalus Serpentarius*, as correctly interpreted by Dr. Britton. Nevertheless, we have in *Muhlenbergia* (**1**:8) the new combination *Nabulus barbatus* (T. & G.) Heller, although in the *Catalogue* both *N. Serpentarius* and *N. trifoliolatus* are listed. Again, *Ilex verticillata*, forma *chrysocarpa*, noted by Dr. Robinson in Rhodora (**2**:106), appears in the new *Catalogue* as "[var.] *chrysocarpa* Robinson." The original specimen in the Gray Herbarium has never been borrowed by the author of the *Catalogue*, and it is perhaps elevated by him to varietal rank through carelessness; but now that it is listed as a variety it will be interesting to see how soon it will be erected to a species by one who believes in calling "all plants species which have

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[5] In this paper these names may be thus accepted without discussion as to their status.

characters enough to justify the use of a distinctive name," and who, like him, knows the plant only from the descriptive phrase "fruit bright yellow." These two cases are sufficient to show the character of work which can be done by one who believes in making all the new combinations possible, when he is handicapped by "lack of time" to consider his work, and who apparently holds it more important to launch a mass of ill-considered (and often to him unknown) species than to publish only the results of critical and scholarly consideration.

If in thus launching so many species (and occasional varieties) of which he can have little or no personal knowledge, the author were producing combinations consistent with the names in the remainder of his book, his reason would be obvious and to some extent justifiable. But only a slight examination of the names taken up is sufficient to show that he has had little conception of any clearly defined principle to govern his selection of names. Professedly the names in his work, like those in the Botanical Club *Check List* and in Britton and Brown's *Illustrated Flora*, are based upon the principle of strict priority; but the result, as shown here perhaps even more than in those works, gives us little assurance that the publications on such a basis are bringing us the uniformity which has been so loudly proclaimed and which every one would so gladly welcome.

In the first group of plants listed, for instance, the Pteridophyta, the names essentially as defined by Professor Underwood[6] are taken up. Professor Underwood is one of the few authors among the radical botanists who has squarely faced the strict priority question, and in his selection of generic types he has attempted to follow the logic of his course to the bitter end. Thus, as the type of the genus he takes the first species described under the generic name, so long as the same plant does not belong to some previously defined genus. In such a case he logically takes for the generic type the first species which is clear from all previous genera. However much one may differ from him as to the expediency of such a course, it is indeed a

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[6] Our Native Ferns and their Allies. Ed. 6. 1900.

satisfaction to know that at least one follower of the Rochester Code is ready to show us the actual task and the enormous upsetting of names consequent upon a conscientious and logical working out of the principle of strict priority.

In Mr. Heller's *Catalogue* many of the names accepted are not those which can be used consistently by authors who are committed to the Rochester Code. When that code was proposed it was professedly with the purpose of establishing uniformity in our nomenclature. As an outgrowth of its adoption by some American botanists the Botanical Club *Check List* was issued, a list which aimed to give us the names which our northeastern plants must henceforth bear according to the rulings of strict priority principles. That publication gave us the first tangible result upon which to base our estimate of the workings of the code; and though by some thoughtful and conservative students the book and the principles represented by it were carefully discussed, by other botanists the publication was hailed as "the sign that the day of 'authority' as such is ended, and the day of 'law' has begun,"[7] and we were informed that "even the most obscure botanist is nowadays entitled to know why an old plant comes out under a new name . . . . and that their [the compilers of the *Check List*] work is plain work, the plain and straightforward statement of facts."[8]

It is pertinent, then, for "the most obscure botanist" to ask about some of the names now (at least at the time of this writing) in vogue among those who champion the Rochester Code, and we may be permitted to inquire of those who have been instrumental in bringing about the present "uniformity" how they account for a few of the names in their pages. Reference has already been made to Professor Underwood's treatment of the ferns partially adopted by Mr. Heller in his *Catalogue*. In Britton and Brown's *Illustrated Flora*, published in 1896, 59 species of true ferns are recognized, and the names, we are told, are those authorized by the Rochester Code. But in Professor Underwood's latest treatment more than *25 per*

[7, 8] **Bessey, C. E.**: Am. Nat. **29**: 350.

cent.[9] of those very species appear under different names—still the names authorized by the Rochester Code. For the benefit of those not familiar with these works, but who have an interest in seeing the working of the same rule in the hands of one of its strong advocates, the fifteen northeastern species which have recently appeared under new names are here enumerated:

Names in Britton and Brown's *Illustrated Flora* (1896), based upon the Rochester Code.	Names in Underwood's *Our Native Ferns and their Allies* (1900), based upon the Rochester Code.
Onoclea Struthiopteris (L.) Hoffm.	*Matteuccia struthiopteris* (L.) Todaro.
Dicksonia punctilobula (Michx.) A. Gray.	*Dennstaedtia punctilobula* (Michx.) Bernh.
Cystopteris bulbifera (L.) Bernh.	*Filix bulbifera* (L.) Underwood.
" *fragilis* (L.) Bernh.	" *fragilis* (L.) Underwood.
" *montana* (Lam.) Bernh.	" *montana* (Lam.) Underwood.
Dryopteris Lonchitis (L.) Kuntze.	*Polystichum lonchitis* (L.) Roth.
" *acrostichoides* (Michx.) Kuntze.	" *acrostichoides* (Michx.) Schott.
" *Braunii* (Spenner) Underwood.	" *Braunii* (Spenner) Lawson.
Phegopteris Dryopteris Robertiana (Hoffm.) Davenp.	*Phegopteris Robertiana* (Hoffm.) Underwood.
Scolopendrium Scolopendrium (L.) Karst.	*Phyllitis scolopendrium* (L.) Newm.
Asplenium acrostichoides Sw.	*Asplenium thelypteroides* Michx.
Pteris aquilina L.	*Pteridium aquilinum* (L.) Kuhn.
Pellaea Stelleri (S. G. Gmel.) Watt.	*Cryptogramma Stelleri* (Gm.) Prantl.
Cheilanthes gracilis (Fée) Mett.	*Cheilanthes Feei* Moore.
Notholaena nivea dealbata (Pursh) Davenp.	*Notholaena dealbata* (Pursh) Kunze.

That the names recently used by Professor Underwood are more truly consistent with the strict priority principles than many names in other groups listed by Mr. Heller has been already emphasized. But why, we would ask, are there so many unexplained inconsistencies in this new *Catalogue*, especially when the attention of followers of the Rochester Code has

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[9] The true ferns alone are here considered, and the genus *Botrychium* is purposely omitted, since that genus has been subdivided by Professor Underwood to such an extent that comparative figures would have little definite significance.

been called to a number of such erroneous matters? A very typical example of the inconsistent method (or lack of method) employed in the *Catalogue* is shown in the treatment of the genera *Cheiranthus* (*Erysimum* of authors), *Erysimum* (*Sisymbrium* of authors), and *Sisymbrium* (*Nasturtium* and *Roripa*[10] of authors). Professor E. L. Greene[11] pointed out, in December 1896, the only logical and consistent course to be followed, according to strict priority principles, in the cases of *Cheiranthus* and *Erysimum.* Mr. Howell[12] has followed his lead, and in a recent article the same point[13] was further emphasized. There is, then, no reason why the authors of the second volume of the *Illustrated Flora*, published May 31, 1897, and of the *Appendix*, published June 20, 1898, should have been ignorant of Professor Greene's logical article. But why did they ignore his conclusions and use names in a sense absolutely inconsistent with the

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[10] The so-called reformers persist in writing *Roripa* instead of the original form, *Rorippa*, and they say *Bicuculla* instead of the original form, *Bikukulla*, although the matter has been freely discussed in the past, and by this time they should be aware of the facts in the case. But, on the other hand, after using the name *Koniga*, they now take up the original *Konig*. If in one case they adopt the original spelling, why not in the others? Is this what they consider a consistent method, and does it appeal to them as "the plain and straightforward statement of facts?" We should like to inquire also about the name which, in the publications of the reformers, has recently taken the place of *Mikania* Willd. In the Botanical Club *Check List* we have a name attributed to Necker and spelled *Willoughbya*, with the footnote remark "*Willoughbaeya* in original;" but in the *Illustrated Flora* the name is spelled *Willughbaea*, and we are informed that the plant was "probably named in honor of Francis Willoughby, 1635–1672, English naturalist, but the name spelled by Necker as above [*Willughbaea*]." This spelling is, therefore, faithfully followed in Mr. Heller's *Catalogue.* Otto Kuntze enumerates in his *Revisio Generum Plantarum* some "incorrect ways of writing the name" as follows: "*Willugbaeya, Willoughbeia, Willughbeia, Willoughbeja, Willugbeia, Willughbeja, Villughbeia.*" Poor Necker, himself, if he were living, would indeed be dazed, particularly as his name was unlike either of those definitely asserted by Dr. Britton to be correct, and since, on the contrary, the true and original form *Willugbaeya*, is the *first* form enumerated by Kuntze as "incorrect." From these facts it would seem that to some botanists whose work is controlled by "law" such divergence from the original spelling is of slight moment. If so, will they be good enough to make clear why *Mikania* is rejected for *Willugbaeya* and its variations (1790), when in 1789 Scopoli published *Willughbeja* (compare Otto Kuntze above), a genus of the *Apocynaceae?*

[11] Pittonia **3**: 128.

[12] Fl. N. W. Am. **1**: 38–56.

[13] ROBINSON, B. L.: BOT. GAZ. **25**: 439–442.

spirit and rulings of their own Rochester Code, especially when, as we were informed in 1895 by one of the *Check List* committee, "the committee . . . . . would still be grateful . . . . . for useful suggestions on these matters, and that all communications of this kind would receive fair hearing and sober judgment."[14] There is, furthermore, no possible reason why the author of the *Catalogue* which suggested this discussion, should have been, in 1900, uninformed of the publications on the subject. In fact, perhaps unconscious of the thoroughly inconsistent course he was taking, he has followed one third of the suggestions made and has adopted for the conventional *Erysimum* of authors the name *Cheiranthus*; but he still clings to the names *Sisymbrium* and *Roripa* for genera to which they cannot be applied by conscientious followers of strict priority principles dating from 1753.

Another point in regard to generic names pointed out in one of the articles cited[15] is in the case of *Cerastium* and *Stellaria*. It was there clearly shown that when the first part of the Linnaean *Stellaria* was transferred by the reformers to *Alsine* (a course not entirely free from question), one species was still left in *Stellaria*, namely, *S. cerastioides* L. This plant is treated by modern authors as a *Cerastium*, and in the Botanical Club *Check List*, the *Illustrated Flora* and in Mr. Heller's new *Catalogue* it appears as *C. cerastioides* (L.) Britton. But in the *Species Plantarum* of Linnaeus *Stellaria* preceded *Cerastium*, and therefore the portion of *Stellaria* (*S. cerastioides*) left when the remainder was transferred to *Alsine* should, according to the strict priority principle, become the type of *Stellaria*, and the succeeding genus *Cerastium* should be absorbed by it. Why, then, after this matter was clearly pointed out in June 1898, does the author of the *Catalogue*, who does not hesitate to launch a lot of new combinations based upon plants of whose status he is much less certain, still keep up the name *Cerastium* in its traditional sense?

The familiar vine known to most of us as *Wisteria* is listed in the

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[14] COVILLE, F. V.: BOT. GAZ. **20**: 164.

[15] ROBINSON, B. L.: BOT. GAZ. **25**: 444, 445.

Catalogue as *Kraunhia frutescens* (L.) Greene (though that name was first published by Rafinesque in 1808); but the recently described *Apios Priceana* Robinson is given without change of name. The author of the *Catalogue* must admit that he knew of the publication of the latter plant, else how could he include it in his *Catalogue*. But will he inform us how it happens that he has ignored the facts presented in the original discussion,[16] of that species? Was it not shown as clearly as could be desired by anyone that the names *Apios* Moench (1794) and *Kraunhia* Rafinesque (1808) were both antedated by *Bradlea* Adanson (1763)—a name applied to two Linnaean species of *Glycine*, *G. Apios* (*Apios tuberosa* Moench), and *G. frutescens* (*Wisteria frutescens* Poir.) now referred by the reformers to *Kraunhia?* And was it not made clear that by those who would follow the Rochester Code the name *Bradlea* must be taken up for *Apios?* How does the author of the *Catalogue*, who lists *Apios Priceana*, explain his failure to stand by the principles he claims to follow?

There are many other generic names accepted by the reform botanists and now adopted in this *Catalogue*, which, according to the rules to which they have committed themselves, have no better status than those pointed out. But the few cases already explained in the past and here again emphasized are sufficient to show him who cares to examine the original references that the member of the *Check List* Committee, who, in 1895, wrote that "all communications of this kind would receive fair hearing and sober judgment" could not have been speaking for all the members of the committee, nor indeed for many whose prolific writings have done more than anything else to stultify the rules of which they claim to be true advocates. That such absolute recklessness in the application of these rules is not satisfactory to all members of the *Check List* Committee is occasionally made apparent. Professor Underwood's position in regard to fern names has been remarked; and another of the committee has thus expressed himself: "Why are some of us so openly at war with our own rules? Certainly no rule relating to the

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[16] ROBINSON, B. L.: BOT. GAZ. **25**: 452.

observance of priority has been more generally recognized and deferred to than this, that a genus, as to its name at least, stands or falls with its type species; no rule is more indispensably necessary; and nothing but endless change and confusion can come of the neglect of it."[17]

Numerous inconsistencies as to the treatment of species as well as genera have been publicly pointed out; yet here, as in case of some other perfectly just and logical criticisms, the effort seems to have been wasted upon those who are bringing us "the day of 'law.'" In a review[18] of the first edition of the *Catalogue* attention was called to some of these specific names. *Anoda lavaterioides* Medic., for instance, as there intimated, has a Linnaean synonym in *Sida cristata*, while *Arenaria sajanensis* Willd. is the same as the Linnaean *Stellaria biflora* (*Arenaria biflora* (L.) Watson, which is the name accepted by Dr. Britton). Yet in spite of these very clear cases which have been emphasized in print, the second edition of the *Catalogue* follows the first in giving *Anoda lavateroides* [*lavaterioides*] and *Arenaria Sajanensis*. By what "law" are these names reconciled with the Rochester Code, and why is the public criticism of their use by the so-called reformers so openly ignored?

Another point emphasized by the same reviewer, whose words apparently bore too much of "authority" to influence the author of the book criticized, was the abundance of "perfect and confessed synonyms" in the *Catalogue*, thus swelling its bulk, but decreasing by inverse proportion the confidence we can feel in it as the product of careful work. Several cases were cited (*Silene Cucubalus* and *S. vulgaris*, for example); but, as we have now learned to expect, the same misleading and unjustified duplication of names occurs in the new edition. When, however, the same species appears under different genera, as in case of *Aster nemoralis* Ait., we must confess the least bit of surprise. Professor Greene, in splitting the genus *Aster*, revived for part of it the Nuttallian genius *Eucephalus*. Among other species which

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[17] GREENE, E. L: Pittonia **3**: 129.

[18] ROBINSON, B. L.: Am. Nat. **32**: 460.

he proposed was *Eucephalus nemoralis*, based upon *Aster nemoralis* Ait., though in *Aster* he left the closely related and often indistinguishable *A. acuminatus* Michx. In the new *Catalogue* we find under *Aster*, *A. nemoralis* Ait., listed and numbered, while under *Eucephalus* we have *E. nemoralis* Greene, treated in the same handsome manner. The troublesome *Aster nemoralis* var. *Blakei* Porter, however, a plant which so mingles the characters of *Eucephalus nemoralis* Greene and *Aster acuminatus* Michx. as to embarrass even its own author, is wisely left with *Aster nemoralis*. Why, then, if *Eucephalus nemoralis* is identical with *Aster nemoralis*, does the author of the *Catalogue* list the variety of the latter only under *Aster*, when the species is treated as belonging to both genera?

Many of us were brought up to speak of *Alisma Plantago* L. and *Veronica Anagallis* L., but during the past decade the followers of the Rochester Code have adopted the fad of calling these plants *Alisma Plantago-aquatica* and *Veronica Anagallis-aquatica*. The use of such names has indeed afforded an interesting diversion and has kept us constantly tingling with expectant excitement as we have waited to see what other familiar names would appear in new and fantastic garb; but it must be confessed that a careful search in the volumes of *Species Plantarum*, where these names are said to occur, has failed to reveal them. Instead this is what is found: *Veronica Anagall.* ▽ and *Alisma Plantago* Δ. Thus it seems that Linnaeus did not write even *Anagallis* in full; and we should like to be informed on what authority (in the *Species Plantarum*) we know that Δ and ▽ are both mysterious ways of writing *aquatica?* And if a triangle is said to mean *aquatica* why do not the reformers append that adjective to their *Roripa Nasturtium*, for Linnaeus wrote *Sisymbrium Nasturtium;* or does the position of the triangle in relation to the $\overset{\triangledown:\mathrm{m}}{\text{name}}$ give it a new meaning? Here is a great opportunity for someone to hunt up all the triangles in the *Species Plantarum* and thus give us a new lot of specific names. But, seriously, we may ask why, in the new edition of the *Catalogue* (as in the old), this modern fad was followed?

The triangles, like some other symbols occasionally used by Linnaeus, presumably descended from earlier authors, and if they are taken to mean *aquatica*, and that adjective is written as a portion of the plantname, we are simply reverting to the pre-Linnaean method of polynomial (or at least trinomial) names, and the whole system of binomials is weakened. The date 1753 has been generally accepted as the limit back of which we are not to go for names; and if Linnaeus himself did not use the name *Alisma Plantago-aquatica* or *Veronica Anagallis-aquatica*, are we justified in going back to some earlier author for such names? Right here is a very dangerous tendency in the usage of the reformers. If they will thus admit an occasional pre-Linnaean name which was not used in the first edition of the *Species Plantarum*, what assurance do they give us that their strict priority rule with a time-limit definitely set at 1753 may not at any time be made elastic enough to protect any whimsical exception its advocates choose to set up?

One of the members of the *Check List* Committee, speaking of the citation of the original author of a combination, has informed us that "it is no longer a question of credit, but a question of practical utility."[19] Surely this is the ideal for botanical nomenclature which every serious student will commend; and we may well put to ourselves the question, is "practical utility" in view or does it seem very near actual attainment, when we find the members of the committee which set out to give us a uniform system of names "at war with" their own rules? Has the "day of 'law'" really begun when those with whom a great trust has been placed juggle with it as with a toy, now following this principle, now that, and ignoring at their own wills such candid criticisms of their methods as show the inconsistencies in their work? Is the "day of 'authority' as such" indeed ended when, after one of their own associates on the committee has publicly reprimanded them and has pointed out the only course for one who would live up to the principles he has espoused, the supporters of the Rochester Code continue to

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[19] WARD, L. F.: Bull. Torr. Bot. Club **22**: 325.

employ names inconsistent with the principles there emphasized?

A member of the committee already quoted has said, in defending the principles of the Rochester Code (principles which as abstract principles need little defense), "if matters are to be left to the individual judgment of publishing botanists, there will be no comparing the confusion that is in store for us with that which we have had in the past."[20] Where in the past (as embodied in the recent editions of Gray's *Manual*, the book selected by this author for his comparisons and generalizations), will he find 25 per cent. of the names changed, as has occurred within four years in the case of our ferns, and that after the names were said to be established on strict priority principles?

The same author in speaking of the Rochester Code has written further: "Those who oppose this movement, if there be any (and I have no doubt there are) who *really see that it might be the last time* that serious changes would have to be made in botanical names, would seem to do so purely from a personal disinclination to incur the annoyance of accustoming themselves to a new set of names. It must be admitted that *this motive is not as high as we might hope botanists generally to be actuated by* [italics ours]."[21] An associate of this writer on the committee has expressed "the hope that Dr. Robinson and the few who think with him on this subject will *lay aside personal prejudices and join the remaining nine tenths of our botanists* . . . . in a nomenclature based on scientific needs and a scientific method [italics ours]."[22] Both of these authors wrote in 1895, when the *Check List* was a comparatively new topic for discussion. Can it be that now, in view of the facts here presented, they still believe that the *Check List* really represented "the last time that serious changes would have to be made in botanical names," or that the loose and undiscriminating methods employed by many who are now active exponents of the Rochester Code are bringing us any nearer that "last time?"

[20] WARD, L. F.: *ibid.*, 316.

[21] WARD, L. F.: *ibid.*, 319.

[22] COVILLE, F. V.: BOT. GAZ., **20**: 167.

In formulating a system of nomenclature we should keep constantly in view the "question of practical utility." If this fundamental point is neglected, what woeful confusion must be encountered by everyone who attempts to use plant names! Already matters have reached such a state, that few followers of the Rochester Code can say offhand what many common plants should be called. The well-known species described by Ventenat as *Dalea purpurea*, then by Michaux as *Petalostemum violaceum*, but generally known of late as *Petalostemon violaceus*, has been treated as follows during the past decade. Otto Kuntze, in his *Revisio Generum Plantarum*, called it *Kuhniastera violacea*, ascribing the name to Aiton, who, however, wrote *Kuhnistera violacea*. This latter name is taken up by Kellerman and Werner who ascribe it to Otto Kuntze although (according to Steudel's *Nomenclator*, ed. 2, **1**: 851, a well-known work) the name originated with Aiton. In the *Metaspermae of the Minnesota Valley* the plant is called *Kuhnistera purpurea* (Vent.) MacMillan; but it has recently been published as *Petalostemon purpureum* (Vent.) Rydberg, and in Mr. Heller's new *Catalogue* it is listed essentially under this name (as *P. purpureus*). After these Jekyll-and-Hyde-like changes it is certainly reassuring to see Dr. Jekyll getting the upper hand, and to find in the latest writings of some of the reformers the long established name *Petalostemum* (*on*) reappearing. But do these names used by various reformers represent uniformity? Even if an occasional systematic botanist can keep track of the changes in names, how about the morphologist, the histologist, the physiologist, the pathologist, the paleontologist, the ecologist, to say nothing of the horticulturist, the pharmacist, and the everyday student of plants? Should not all these followers of pure or applied botany be considered in our interpretation of the "question of practical utility?" And what can they hope for in a system of names which shows no more stability than the one under discussion?

To the student whose work is in other fields than systematic botany, the present lack of uniformity in plant names is necessarily most perplexing. But to the systematist, who sees more closely the constant haggling over names, the situation is quite as puzzling. The Rochester Code was formulated ostensibly to establish uniformity in our names. Its followers have worked vigorously to comply with its rulings. From time to time their attention has been publicly called to fundamentally weak spots in its wording. Again they have been asked to explain certain of their names seemingly inconsistent with their principles. Yet these criticisms have generally been ignored. Instead of strengthening the weak spots in their rules and correcting self-evident mistakes in their names, the reformers have faithfully clung to the discredited gods they had already set up. These statements are not extravagant nor vague generalizations. They are simple conclusions drawn from the facts presented in this discussion, and from others very apparent upon many recent pages. Is this the best the Rochester Code can do? Is this what we are to call "uniformity?"

If we are really desirous of obtaining stability in our nomenclature, and if at the same time the "question of practical utility" is to be considered, our clearest course cannot be by the Rochester Code, especially as followed by its originators. We shall, however, find a comparatively clear and practical method by adopting in our selection of generic names the Berlin rule; and in our selection of specific names, the so-called Kew rule of retaining the first specific name used under the accepted genus. In this way we are able to retain a very large proportion of the long-established and best-known combinations, without the necessity of wading (often blindly) through the mazes of obscure and poorly indexed literature. And, what is better, after comparatively slight alteration of the long-established names, we can feel that in only very rare cases must we abandon those known to practically all botanists. If, like Professor Ward, we all feel that "it is no longer a question of credit, but a question of practical utility," is not this simpler course worth testing?

Gray Herbarium, Harvard University.

BRIEFER ARTICLES.

OBSERVATIONS UPON THE FEEDING PLASMODIA OF FULIGO SEPTICA.

(WITH ONE FIGURE)

ALTHOUGH considerable attention has been paid to the plasmodia of the Mycetozoa, especially by the German botanists (De Bary, Zopf, Sachs), little work has been done upon the feeding habits of these interesting protoplasmic masses. In a valuable contribution to the life history of these organisms, Lister[1] sets forth in a painstaking way the manner in which the plasmodium of *Badhamia utricularis* behaves when actively feeding. Various substances were tried by way of experiment. Pieces of *Agaricus campestris, A. melleus, A. rubescens, A. fascicularis, Boletus flavus*, and *Corticium puteanum* were used, but none of these fungi seemed so desirable a food as *Stereum hirsutum*, which was devoured without leaving any residue. *Agaricus fascicularis* was found in these experiments to be a particularly unwholesome morsel. The digestion by the active plasmodium of the fungi above mentioned presupposes the presence of a nitrogenous ferment, namely a proteohydrolytic one. As far as Lister's observations show, starch seems to be refused by the moving plasmodium, contradicting the idea of the presence of a diastatic ferment. The following observations upon the plasmodium of *Fuligo septica* is in part a contribution to the life history of plasmodia in general.

While searching for Mycetozoa in the wooded valley incorporated as part of Woodlands cemetery, West Philadelphia, a luxuriant growth of *Pleurotus sapidus* was found upon some partially decayed logs, which had been piled up in a loose manner preparatory to burning. In removing several large pieces of this fungus, small patches of yellow plasmodium were found upon the lamellar surface of the fully expanded pilei. These protoplasmic masses had moved out from the rotten log where they were seen in the crevices, and had invaded the gill surface

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[1] Notes on the plasmodium of *Badhamia utricularis* and *Brefeldia maxima*. Ann. Bot. 2 : 1–23. 1888.

of *Pleurotus sapidus*. The appearance of the larger plasmodium at this time may be described as follows: The gills which were still rigid and in natural position were connected in the invaded portions of the lamellar surface by bridges of slimy yellow protoplasm. The basidial layers were covered by the more delicate portions of the plasmodial reticulum. The larger, more cord-like streams of protoplasm stretched from gill to gill, connecting as main cables the outlying pseudopodial fingers of protoplasm. The plasmodia growing upon several separate pieces of fungus were removed at 2 P. M. Friday, November 2, carried to the botanical laboratory of the University of Pennsylvania, and covered by two bell jars provided with dampened filter paper. By 6 P. M. of the same day the larger plasmodium had increased to such an extent as to cover completely the fungal pieces under one of the bell jars, and the gills showed signs of collapse. At 9 A. M., Saturday, November 3, the gills were found to be in a total state of collapse, Fuligo by this time having taken complete possession. Under the other bell jar the plasmodium, which was originally about the size of a silver dollar in superficial extent, had increased until it had spread to the outer circumferential margin of the lamellar area. In their attack upon the edible portions of Pleurotus, masses of protoplasm heaped themselves up into rounded knobs, or protuberances formed by condensations of the myxomycete substance. These would disappear, to be finally replaced by others of similar size and form. These observations were made on Saturday morning. The invasion and destruction of the gill surface was complete by Monday.

An examination of the growth under the bell jars showed a most remarkable development of the larger plasmodium. It not only covered the fungus, but also the inner sides of the bell jar in the form of a beautiful yellow reticulum. The wet filter paper plastered upon the top of the bell jar was completely covered by a dense mass of anastomosing protoplasm. Upon the main currents of plasmodial movement were beads of protoplasm of larger and smaller size. Where these hung, as pendent drops on the moist filter paper, they had grown until the protoplasm hung, as yellow stalactites, dangling from the dome-like roof of the inner side of the bell jar. The dome of the bell jar on Monday was almost entirely covered by the yellow plasmodium.

A strip of filter paper with the actively streaming plasmodium of Fuligo was removed from the moist chamber and placed in a dry situation in the bright sunlight. As the filter paper dried, the protoplasm rapidly streamed to the wettest portion, and then began to aggregate into an extended aethalium. The drying, however, took place so rapidly that the entire plasmodium had not time to withdraw itself from the filter paper, and therefore it dried *in situ*, leaving a characteristic network of dry anastomosing threads. The reproduced photograph was taken by Mr. W. H. Walmsley just before the moving plasmodium was placed in the sunlight.

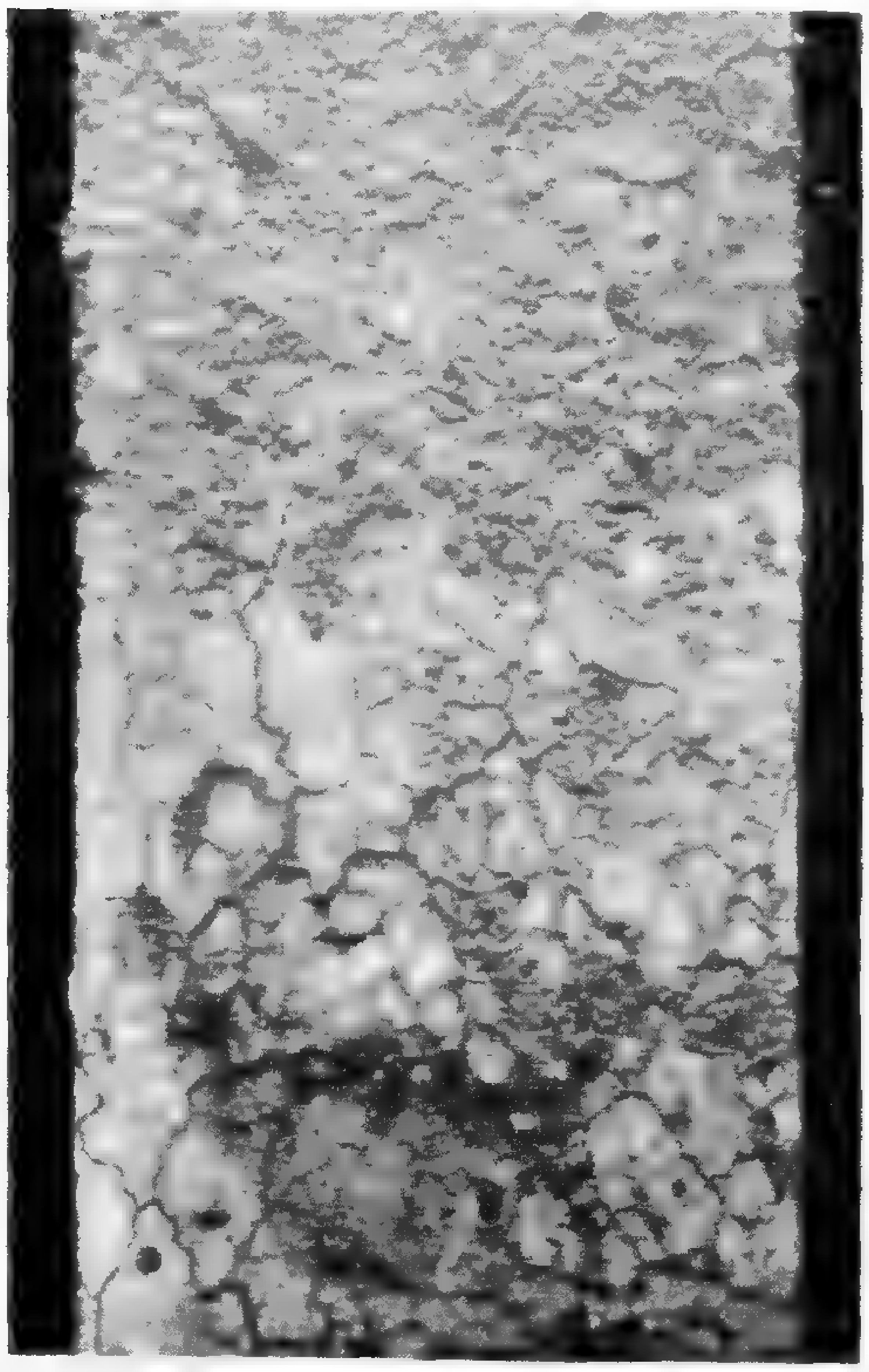

FIG. 1.—Moving plasmodium of *Fuligo septica* on moist filter paper, showing the varicose condition of the recticulum while actively streaming.

Beneath the bell jars, as the disintegration of the fungi proceeded with the production of a watery fluid and a gelatinous substance of a ropy consistency, the more active protoplasmic masses confined themselves to the tougher portions (the stipe and main substance of the pileus), heaping up on these portions in the concentrated effort to digest them. With the drying of the interior of the bell jars, condensation of the reticulum took place, so that the meshes became smaller and the anastomosing streams more closely aggregated. At this stage of growth experiments were begun by feeding Fuligo various substances.

At 1 : 30 P.M. Tuesday, November 6, pieces of fresh young Pleurotus were placed upon the living plasmodium. At 2 : 15 P.M. the small pieces used were invaded and the plasmodium had spread over about half of the superficial surface of the fungal food. Pieces of young pilei of *Coprinus comatus* were placed on different spots of the same plasmodium, and by 2 : 15 P.M. invasion had well advanced, but the rapidity of forward movement was much less when Pleurotus was used as a food. Two hours after the two food substances had been placed within reach of the streaming protoplasm, complete covering of the specimens had occurred.

Pieces of a partially dried toadstool, *Hypholoma perplexum*, were also placed within contact of another plasmodium of Fuligo at 1 : 30 P.M., November 6, but at five o'clock not a single pseudopodial branch of the plasmodium had moved up upon them. On the contrary, when at four o'clock several pieces of the pileus and stem of *Coprinus atramentarius* were laid upon the yellow protoplasmic mass, inside of three quarters of an hour the trophotropic action of the food substance began to manifest itself by the plasmodial invasion of the newly provided nitrogenous food substance. The incorporation of the nutritive matter had well proceeded up over the edges of the young pilei of *Coprinus atramentarius* by five o'clock, November 6. An examination on the morning of November 7 showed the inky Coprinus almost entirely digested, and a black mass of spores in a gelatinous matrix indicated a total collapse of the fungus. *Hypholoma perplexum* was also covered by a network of the mycelium, which had spread not only over the stipe, but also over the gills and upper surface of the pileus. By evening, this agaric had collapsed, and by the next morning, November 8, nothing remained but a soft gelatinous mass of substance.

Raw beefsteak was applied to the surface of the plasmodium at 11 : 30 A.M., November 7, and by noon a single strand of protoplasm had advanced upon the meat. At 1 : 30 P.M. one third of the surface of the meat, and by 5 : 00 P.M. the entire surface, was covered. Digestion must have been rapid during the night, because upon returning to the laboratory in the morning of November 8 not a trace of the beefsteak was to be found.

Pieces of the gleba and stipe of *Phallus impudicus* were also applied at the same time. During the afternoon of Wednesday, November 7, the pieces of gleba were well covered by the moving plasmodium, the stipe portions being left untouched. By the next morning the glebal pieces had almost entirely disappeared, and cuts from the stipe still remained untouched.

Beefsteak was again supplied to the plasmodium at 10 : 00 A.M., Thursday, November 8, and by 10 : 45 A.M. a few arms of the plasmodium had extended themselves over the free edges of the meat.

The purpose was next to extend the series of observations by feeding to the active plasmodium a variety of nitrogenous and fatty materials. Cheese, boiled white of egg, boiled yolk of egg, and butter were chosen. Pieces of these substances were applied to the surface of the reticulum on Thursday morning, November 8. The plasmodium seemed at first to refuse them, but by Friday morning the fragments of boiled white of egg were found to be partially covered by the creeping Fuligo. On Saturday morning, November 10, the hardened, coagulated egg albumen was completely covered and well-nigh digested. The yolk was but slightly affected by the plasmodium, even after exposure to the digestive action for two whole days. The butter was left untouched.

The presence of several ferments is naturally inferred from the digestive action accomplished by the plasmodium. According to De Bary, diastase can be extracted from the plasmodium of Æthalium (Fuligo).[2]

In his book on ferments Green[3] states: "One of the earliest known of these is the ferment which Krukenberg found to be procurable from the plasmodium of Æthalium, one of the Myxomycetes. A glycerine extract of the plasmodium was found to have very marked proteolytic powers in the presence of lactic or hydrochloric acid. Krukenberg's statement has been confirmed by Miss Greenwood, who has stated that the plasmodium of another member of the same group yielded to 0.4 per cent. hydrochloric acid an extract which showed marked solvent action on fibrin." Negative results were obtained when I removed some of the partially digested fungus with plasmodium upon it, and treated the mass with glycerine, according to the directions given above. To the glycerine extract, which had a slightly yellowish color, a few drops of 35 per cent. hydrochloric acid was added, and a small frayed piece of raw beefsteak. After two days of trial the beefsteak was found unchanged, although left in the glycerine extract for that length of time.

The plasmodium brought into the laboratory on Friday, November 2, was still in a streaming condition on Saturday, November 10, when observation upon it ceased. The original fungus, with the exception of the more fibrous stipe, had in this time been reduced to a fibrous gelatinous mass, upon which the plasmodium still streamed, finding apparently enough remaining food to feed upon, although by this time the common mold had invaded it. This mold appeared for the first time on Wednesday, November 7, but was then brushed off to prevent fruiting. The plasmodium, while actively streaming and feeding, kept the substratum remarkably sweet and clean, and it was not until the original food substance had been destroyed as food that foreign organisms, such as the mold, had any chance for development. This

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[2] This statement is somewhat at variance with the observations of Lister, *loc. cit.*

[3] The soluble ferments and fermentation 215. 1899.

was certainly one of the most instructive facts brought out during the course of my observations.[4]—JOHN W. HARSHBERGER, *University of Pennsylvania.*

SWARM SPORE FORMATION IN HYDRODICTYON UTRICULATUM ROTH.[5]

1. The methods of fixing were by means of Merkel's fluid and a mixture of iridium chlorid and acetic acid according to one of the following formulae:

(1) Eisen. Iridium chlorid (0.5 per cent. aqueous solution) - - 100^{cc}
Glacial acetic acid - - - - - - - 1^{cc}
(2) Iridium chlorid (1 per cent. aqueous solution) - - - 100^{cc}
Glacial acetic acid - - - - - - - 3^{cc}

The best results were obtained with the stronger iridium chlorid mixture.

2. There is no differentiated chromatophore in the cell. The pyrenoids and nuclei are scattered irregularly throughout the cytoplasm and the chlorophyll is contained in the whole cytoplasmic body. The nuclei in both the resting and dividing stages show the structure typical of higher plants and are not to be taken as types of primitive nuclei.

3. Cleavage takes place by means of surface constriction of the plasma membrane on the outside and the vacuolar membrane on the inside of the protoplasmic layer. The process is a progressive one, the cleavage furrows cutting out first large irregular multinucleated masses of protoplasm, which are in turn divided into smaller masses, until each contains a single nucleus, the entire protoplast thus being divided into spores. The swarm spores are uninucleated biciliated cells. At the base of the pair of cilia there is a clearly defined basal body.

A detailed description of the processes outlined above will be published soon in a more complete form.—H. G. TIMBERLAKE, *University of Wisconsin.*

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[4] One of the best methods of procuring material for microscopic study is to remove the protoplasm by scraping, and then to place portions of it on slides fitted into the bottom of Petri dishes provided with moist filter paper. In an hour or two these mounds of protoplasm will have spread out over the slides sufficiently to permit of their examination. At my suggestion, Dr. Mazijck Ravenel, bacteriologist of the Pennsylvania Live Stock Sanitary Board, tried to grow the plasmodium upon ordinary agar, and upon filter paper saturated with bouillon, but failure resulted in both cases.

[5] Résumé of results presented at the meeting of the Western Naturalists at the Hull Botanical Laboratory, December 27, 1900.

CURRENT LITERATURE.

BOOK REVIEWS.

Goebel's Organography.[1]

THE second volume of this notable work has appeared recently. It deals with the gametophyte and sporophyte of pteridophytes, and with the sporophyte of spermatophytes. The gametophyte of the pteridophytes is discussed under two heads, namely, (1) structure and development of the sex organs, and (2) the form of the prothallia. In discussing the development of antheridia the author advances views which are at variance not only with those of Belajeff and others, but also with his own previous accounts. In Isoetes, after the cutting off of the small cell which Belajeff has called the rhizoidal cell, two oblique walls divide the main body of the spore into two flat cells and a larger cell which is triangular in optical section. This last cell alone the author regards as the antheridium initial. It divides by a periclinal wall into an outer cover cell, and an inner cell, the latter of which by further division gives rise to four cells in each of which a spermatozoid is organized. According to this interpretation there is within the spore wall a prothallium consisting of three sterile cells and one antheridium, and only the cover cell can be regarded as belonging to the antheridium wall.

In presenting the development of both the antheridia and the archegonia the transition from free to imbedded organs is described in some detail. The prothallia of Ophioglossum, Botrychium, aud Lycopodium receive particular attention on account of their biological importance. The vegetative multiplication of prothallia is another interesting subject which is somewhat fully treated.

In the second part of the book, which is devoted to the sporophyte of pteridophytes and spermatophytes, the various organs are discussed in great detail. The account of the embryo is particularly helpful. Among other interesting subjects are the transition between leaf and shoot, leaf formation the relation between venation and leaf devolopment, transformed leaves, branching, etc.

The treatment throughout is dominated by what may be called experimental morphology, and the book cannot fail to have a good influence in

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[1] GOEBEL, K.: Organographie der Pflanzen insbesondere der Archegoniaten und Samenpflanzen. Zweiter Teil. Specielle Organographie. 2 Heft: Pteridophyten und Samenpflanzen. Erster Teil. 8vo., pp. xiii–xvi + 385–648. 173 illustrations. Jena: Gustav Fischer. 1900. *M* 7.

relaxing the too rigid notions of morphology which are still prevalent. While constantly calling attention to the variation which occurs in nature and which may also be brought about artificially, the author also recognizes that environment is not the only factor in plant development, but that heredity is equally important. Representing as it does the work which is being carried on in the author's laboratory, the book has the freshness of research, and is full of suggestions to those engaged in morphological investigation.

Those who have read the first part will be glad to learn that the present volume is not so difficult. An early English translation is announced.—CHARLES J. CHAMBERLAIN.

MINOR NOTICES.

THE SIXTH FASCICLE of Wildeman and Durand's *Illustrations de la flore du Congo* has appeared recently, containing plates 61 to 72 inclusive. This elaborate work, with its very handsome plates, needs no further commendation than has been given already in this journal.—J. M. C.

THE SECOND FASCICLE of Schumann's *Blühende Kakteen* (Iconographia Cactacearum) has appeared recently. It contains descriptions and beautiful colored illustrations of *Mamillaria Wissmannii* Hildmann, *M. raphidacantha* Lem., *Echinocactus horripilus* Lem., and *E. Mathssonii* Berge. The publisher is J. Neumann in Neudamm, and the price is four marks.—J. M. C.

THE SECOND VOLUME of *Primitiae Florae Costaricensis*, under the editorship of H. Pittier, bearing date 1898–1900, has appeared in seven fascicles. The collaborators are J. Donnell Smith (Polypetalae and Gamopetalae), Casimir DeCandolle (Piperaceae), G. Lindau (Acanthaceae), F. Pax (Euphorbiaceae), and A. Engler (Araceae). Numerous new species are described, but the only new genus published is *Kolobohilus* (Acanthaceae).—J. M. C.

THREE FASCICLES of the first volume of Engler and Prantl's *Nat. Pflanzenfamilien* have appeared recently, as follows: 204 contains the conclusion of fossil Filicales and the Sphenophyllales by H. Potonié, and the beginning of the living Equisetales by R. Sadebeck; 205 contains the conclusion of the living Equisetales by R. Sadebeck, the fossil forms by H. Potonié, and the beginning of the Lycopodiaceae by E. Pritzel; 206 contains the conclusion of the Lycopodiaceae and the Psilotaceae by E. Pritzel, the Psilotaceae by H. Potonié, and the beginning of Selaginellaceae by G. Hieronymus.—J. M. C.

A. M. FERGUSON (Twelfth Ann. Rep. Mo. Bot. Gard. 33–73. *pls. 4–31.* 16 F 1901) has published a revision of the species of *Croton* found in the United States. It seems to be a painstaking and judicious piece of work, and deals with a genus which greatly needed revision. Thirty-three species and varieties are recognized, all of which are illustrated. The conservative spirit of the work is indicated by the fact that in a genus of great possibilities only one new species is described, and five forms are made new varieties.

It is certainly true that the author's conception of a species differs from that which is rapidly becoming current, and that he still has some belief in its power to vary.—J. M. C.

MR. HERMANN VON SCHRENK (Twelfth Ann. Rep. Mo. Bot. Gard. 21–23. *pls. 1–3*. 10 F 1901) has described fully a disease of *Robinia Pseudacacia* L. caused by *Polyporus rimosus* Berk. The fungus attacks the locust after some heartwood has been formed in the larger branches, and from this time on the mycelium may be found in the heartwood. Access is obtained through wounds, so that a proper treatment of wounds will ward off the disease. Curiously enough the fungus, although growing in what is regarded as dead tissues, does not grow in the wood after it is cut from the living tree, and hence diseased wood when used for posts does not continue to rot. Whether such a fungus is to be regarded as a parasite or a saprophyte, therefore, becomes an interesting question.—J. M. C.

THE FIRST THREE PARTS of Engler's *Pflanzenreich* have appeared. The general purpose and method of this great work were announced in this journal for last December (**30**: 432. 1900), so that it only remains to note the contents of the parts as they appear. The families of spermatophytes to be presented are 280 in number. Part 1 (*M* 2.40) is by K. Schumann, and contains the Musaceae, the forty-fifth family, the six genera including eighty species. Part 2 (*M* 2) contains the eighth and tenth families, Typhaceae and Sparganiaceae, and is by P. Graebner. Each family is represented by a single genus, Typha containing nine species and Sparganium fifteen. Part 3 (*M* 5.60) contains the ninth family, Pandanaceae, and is by O. Warburg. He recognizes 219 species, 156 of which belongs to Pandanus. The publisher is Wilhelm Engelmann of Leipzig.—J. M. C.

BOTANICAL ACTIVITY in Vermont is indicated by the series of "Contributions to the Botany of Vermont," which has now reached its eighth number. The titles of the eight contributions are as follows: A list of the mosses of Vermont, with analytical keys to the genera and species, by A. J. GROUT (March 15, 1898); A partial list of the parasitic fungi of Vermont, by W. A. ORTON (September 1898); A preliminary list of the Hepaticae of Vermont, by CLIFTON D. HOWE (January 1899); Supplement to the list of mosses growing in the state of Vermont, by A. J. GROUT (January 1899); The trees of Vermont, by ANNA M. CLARK, with notes on the trees of Burlington and vicinity, by L. R. JONES (December 1899); A second partial list of the parasitic fungi of Vermont, by W. A. ORTON (December 1899); and Flora of Vermont, a list of the fern and seed plants growing without cultivation, by EZRA BRAINERD, L. R. JONES, and W. W. EGGLESTON (December 15, 1900). The last publication enumerates 1330 indigenous species.—J. M. C.

A FLORA of the German possessions (Kaiser Wilhelm's Land) in New Guinea (or Papua) and the adjacent islands has been published by Drs. Karl

Schumann and Karl Lauterbach.[2] Descriptions are given of numerous new and critical species, but those better known are merely named and their distribution given. The book begins with the Myxomycetes and follows the sequence of Engler and Prantl. This bringing together of a great amount of scattered material makes the book an admirable compendium of information concerning the plants of the "South Seas." The new genera described are as follows: *Dammera* (Palmaceae), *Scleromelum* (Santalaceae), *Lauterbachia* (Monimiaceae), *Macropsychanthus* (Leguminosae), *Syndyophyllum* (Euphorbiaceae), *Gertrudia* (Flacourtiaceae), *Xenodendron* (Sonneratiaceae), *Bamlera* (Melastomaceae), *Kentrochrosia* (Apocynaceae), and *Airosperma* (Rubiaceae).—J. M. C.

A VALUABLE CONTRIBUTION to the literature of special diseases of plants is the recent bulletin of the Division of Vegetable Physiology and Pathology on *Peach leaf curl*.[3] The bulletin is divided into eleven chapters. The first is introductory and treats of the distribution and origin of the disease and of the losses caused by it, which are estimated to reach at least $3,000,000 annually. Next is taken up the nature of the disease itself, which is caused by the fungus *Exoascus deformans*. It is shown that the perennial mycelium of this fungus is responsible for only about 2 per cent. of the infections each spring, the others being due to spores which have remained over winter in the crevices of the bark and between the bud scales. In the next five chapters the history of the various methods of treatment is discussed, and the plans of the experiments for the prevention of the disease and the results in saving of foliage and fruit are given in great detail. It is shown that from 95 to 98 per cent. of the injury to the foliage can be prevented by treating the trees, while still dormant, with various sprays, the best being a Bordeaux mixture containing five pounds each of copper sulfate and lime, and forty-five gallons of water. One chapter is devoted to a discussion of the preparation, use, and character of the different sprays used, another to the methods of applying the sprays, and still another to a description of the various substances used in preparing them. The sprays are shown to be successful only when applied while the tree is dormant, preferably one to three weeks before the flower buds open. The final chapter is devoted to a comparison of the susceptibility of different peach varieties to the disease, and to a discussion of the treatment of nursery stock. A short summary concludes the bulletin.—ERNST A. BESSEY.

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[2] Die Flora der deutschen Schutzgebiete in der Südsee. Small 4to, pp. xvi + 613. with map and 22 plates. Leipzig: Gebrüder Borntraeger. 1901. *M* 40 unbound, *M* 45 bound.

[3] PIERCE, NEWTON B.: Peach leaf curl: its nature and treatment. Bulletin 20. Division of Vegetable Physiology and Pathology, U. S. Department of Agriculture, 8vo, pp. 204. *figs. 10, pls. 30.* Washington: Government Printing Office. 1900.

NOTES FOR STUDENTS.

EBERHARDT[4] has performed a series of experiments with a view to finding the influence of dry and humid air on plant structures. These experiments in general confirm the work of Kohl and others. Humid air causes an increase in the length of the stem and the size of the leaf surface, while there is a decrease in the stem diameter, the amount of chlorophyll, and the root development. Dry air increases the thickness of the cuticle, the number of stomata, the woody tissue, the sclerenchyma, and the palisades.— H. C. COWLES.

SOME INTERESTING STUDIES have been made by Nestler[5] upon the well-known glandular hairs of *Primula obconica*. Physicians and gardeners have often asserted that this common primrose is poisonous, and Nestler has succeeded, not only in proving these statements, but also in localizing the poison. The glandular hairs contain the poison in the form of a yellowish green secretion; this when concentrated is very virulent, as the author discovered by testing the effect upon himself. The hairs of *Primula Sinensis* act in a similar way, but the poisonous effects are much less marked.—H. C. COWLES.

DR. G. KLEBS published last year[6] the third paper of a series on the physiology of reproduction in fungi in which he brings together the previous investigations with some hitherto unpublished researches, and seeks to present general considerations on the whole subject. The paper is full of suggestions and too valuable to mutilate by an attempt to summarize it. One general criticism lies against Klebs' work and his conclusions, namely, that he does not take into account sufficiently the effect of changes in osmotic pressure to which his experimental plants are subjected with the changing composition. It remains to be seen whether the conclusions are not vitiated by this untested factor.—C. R. B.

KEARNEY[7] discusses the Lower Austral element in the southern Appalachians. The mountains have representatives from all of Merriam's zones from the Lower Austral to the Hudsonian, though the Transition zone is most fully represented. Austro riparian colonies are found up to 1200 feet along the eastern boundary of Tennessee. Kearney divides the Austral mountain plants into those which are probably of neotropical origin and have come in since the ice age, and those which have probably descended from the Tertiary floras of northern regions. The plants of the first group are chiefly xerophytic, while those of the second group are mainly ligneous tropophytes. Lower Austral forms must have left the mountains during the

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[4] Compt. Rend. **131**: 193–196, 513–515. 1900.

[5] Ber. deut. bot. Gesell. **18**: 189–202, 327–331. 1900.

[6] Jahrb. f. Wiss. Bot. **35**: 80–203. 1900.

[7] Science N. S. **12**: 830–842. 1900.

glacial period. Interesting hypotheses are given on the origin of the Austral forms.—H. C. COWLES.

MLLE. RODRIGUE[8] has made a painstaking study of the anatomy of variegated leaves with a view to ascertaining the relation between color and structure. The author gives an excellent summary of the literature of her subject, and makes a detailed study of thirty-three species. The white effect is due in most cases to the absence of chlorophyll, although a similar appearance is given by certain dissolved pigments, and by the reflection of light in some special instances. The modifications in the latter cases are slight and are confined to the epidermis. Where chlorophyll is absent, the leaf may be regarded as diseased, and the tissues are different from normal leaves, having no palisade development, and consequently a great reduction in thickness. In other words, the primitive tissues remain unchanged, where chlorophyll is absent.—H. C. COWLES.

ALB. NILSSON[9] has made some interesting studies on the dynamics of some Swedish plant societies, especially of cliffs and moors. He finds three types of cliffs, those which are forested either with conifers or deciduous trees, and those without trees. On all cliffs the first plants are crustaceous lichens. On the conifer cliffs there follow in succession fruticose lichens, herbs, heath plants, conifers. Cliffs with deciduous trees have no fruticose lichen or heath stages, the author attributing the absence of the fruticose lichens to wind. On the third type of cliff the lichens remain longer and foliose lichens and mosses are added to the stages after crustaceous lichens. Dying lakes pass into sedge moors, then into cotton-grass moors, finally into shrub moors and forest moors with pines or birches. Retrogressive phases are common on the moors, lichens growing over the peat moss and shrubs; again the water collects and the lichens pass away. The peat moss appears again and we have what Nilsson calls a secondary moor.—H. C. COWLES.

THE STYLIDIACEAE (Candolleaceae in Engler and Prantl's *Nat. Pflanzenfam*), a small family almost confined to Australia, New Zealand, and farther India, has been recently studied by G. P. Burns.[10] The greater part of the paper is devoted to a morphological study of the various tissues. Before fertilization the structures of the embryo sac present no unusual features, but immediately after the entrance of the pollen tube the micropylar portion of the sac grows out into an enormous haustorium much larger than the remainder of the sac. The endosperm forms rapidly and fills the sac with tissue before the first division of the egg takes place. Shortly after fertilization the antipodals disintegrate, and the posterior portion of the sac also

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[8] Mém. l'Herb. Boiss. 17: 1900.

[9] Bot. Not. **1899**: 89–101; 123–135.

[10] Beiträge zur Kentniss der Stylidiaceen. Flora **87**: 313–354. *pls. 13, 14* (and 45 text figures). 1900.

forms an haustorium. Finally, the protoplasmic contents of both haustoria become transformed into a network of cellulose threads which in case of the upper haustorium form a plug effectually closing the micropyle. The sac is surrounded by a jacket or "tapetum" which is even more conspicuous than in the Compositae.—CHARLES J. CHAMBERLAIN.

THE FUNCTION of latex, so often in past years a motive for investigation, has again been made a subject for study. Gaucher[11] gives a historical summary of the two chief views, excretory and nutritive, from the time of Trécul to the present. The author gives no new theories, but presents a large number of facts which favor the nutritional function, very much as presented by Haberlandt. The substances contained in latex, the connection between the latex tubes and the palisade, and the reciprocal relations between latex tubes and conductive parenchyma are all studied, and Gaucher in these cases confirms and extends Haberlandt's observations. In one instance he finds a ring or festoon of chlorophyll cells arranged about a latex tube.

Parkin[12] has studied the latex in rubber plants of Ceylon, and holds a somewhat intermediate view. While he regards the proteids of latex as probably nutritive, he does not so regard the starch, unless perhaps the latter aids in the nutrition of the latex tubes themselves. The author finds that the latex flows far less abundantly at the first tapping than subsequently, showing an apparent adaptation. Parkin regards the chief function of latex to be water storage.—H. C. COWLES.

SOME VALUABLE CONTRIBUTIONS to the literature of forest distribution have been made recently by the United States Geological Survey.[13] This report is under the supervision of Henry Gannett, chief of the division, and is a companion volume to a similar one published last year. It contains special considerations of the Pike's peak, Plum creek, and South Platte reserves by John G. Jack; White river plateau timber land reserve by George B. Sudworth; the Flathead forest reserve by H. B. Ayres; and the Bitterroot forest reserve by John B. Leiberg. Topographic features, soil conditions, climate and rainfall, forest conditions, fires, and lumbering are some of the topics treated in these reports. A large number of plates, including both maps and reproductions from photographs, are incorporated in the volume, and a portfolio containing topographic maps showing distribution of timber areas presents the subject in a graphic way.

If the department would but incorporate in its excellent geological and physiographical atlases an additional topographic map showing the distribution of forest and other floral areas, including descriptions of the edaphic and climatic conditions, it would add much to their educational, economic,

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[11] Ann. Sci. Nat. Bot. VIII. **12**: 241–260. 1900. [12] Ann. Bot. **14**: 193–214. 1900.

[13] *Twentieth Annual Report, U. S. G. S.*, Part V. Forest reserves, pp. xviii + 498. *pls. 159.* 1898–9.

and scientific value. Some such careful study of a large number of floral areas is an absolute necessity to a correct understanding of the complex climatic and ecologic factors governing the distribution of trees. Indeed, in the last atlas[14] issued by the department an approach has been made to such a realization. This atlas contains a brief summary of the vegetal and climatic features, a map of the floral features, and three maps showing precipitation, evaporation, and types of rainfall.—H. N. WHITFORD.

THE STUDIES of Brenner[15] on succulent plants must prove of great interest to all physiologists and ecologists. His work was experimental and for the most part on the Crassulaceae and Mesembryanthemum. After a discussion of the normal anatomy, he describes the effects produced on succulent plants by moist air. The most striking effect in Sedum is pronounced internodal elongation, which the author refers to the increased turgor incident to lessened transpiration. At first the leaves are fleshy, but later leaves are larger and thinner and placed like normal fleshy leaves in dry air in the form of a rosette. There is thus a striking correlation between stem elongation and leaf form. Another effect of moist air on the leaves is epinasty, so that the new leaves place themselves at right angles to the stem; when these plants are placed in a dry chamber hyponasty is shown. Notable changes in anatomy are also induced. In two plants the normally straight side walls of the epidermis become wavy, and doubtless give greater mechanical strength to the otherwise weakened leaf. The tangential increase of the epidermal cells as against the radial is very noticeable, though Brenner is at a loss to find a physical explanation therefor. The stomata at first are the same in number as on normal leaves, though of course they are farther apart, since the leaf is larger. On later leaves the stomata are more numerous though the number per unit area may be much as in normal leaves. There is a decrease of the storage tissue and an increase of the chlorophyll tissue, though the cells in the latter tissue are more nearly isodiametric than in dry air. The vascular system and air spaces are decreased in moist air; the reduction in the bundles is rather in number of cells and ramifications than in cell size. The author finds the dry weight and ash and also the acid content to be less than in normal plants. At first moist air increases the size of the chloroplasts, though they decrease in size later, pointing to an apparent readjustment to the new conditions.

Various comparative physiological experiments were made on plants grown in dry and moist air. In Mesembryanthemum nutation movements were noticed in the latter but not in the former. Normal leaves in normal air transpire the same per unit area as do moist-air leaves in moist air, though the leaf form is very different. This observation is very instructive

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[14] HILL, ROBERT T.: Topographic atlas of the Texas region, pp. 12. *pls. 11.* 1900.

[15] Flora **87**: 387–439. 1900.

as it shows strong powers of readjustment in such highly specialized forms as succulent plants. The author concludes by saying that the air and not the soil relations are determinative for the above changes. This is in harmony with Kohl's results on Tropaeolum. Brenner thinks that the phenomena which he observed are in a high degree purposeful, and that purely physical explanations are very difficult at many points.— H. C. COWLES.

ITEMS OF TAXONOMIC INTEREST are as follows: ARTHUR MINKS (Mém. Herb. Boiss. 22:1–74. 1900) has published a full discussion and synopsis of the genus *Umbilicaria*.— WILLIAM R. MAXON (Proc. Biol. Soc. Washington **13**: 199, 200. 1900) has described a new *Polypodium* (*P. hesperium*), which is "the common form of the whole mountain region of the western United States." The same author (Bull. Torr. Bot. Club **27**: 638. 1900) has described a new *Dryopteris* from Alaska.— P. A. RYDBERG (Bull Torr. Bot. Club **27**: 614–636. 1900), in continuing his "Studies on the Rocky mountain flora," has published an account of some of the smaller genera of Compositae. Those considered are *Stenotus*, formerly a section of Aplopappus, containing seven species, of which two are new; *Stenotopsis*, a new genus established on *Aplopappus* (*Stenotus*) *linearifolius*, and including also *Aplopappus* (*Stenotus*) *interior; Macronema*, containing seven species, of which one is new; *Sideranthus*, a genus revived to include species formerly under Aplopappus, and more lately under Eriocarpum, and which is recognized as containing seven species, three of which are new; *Pyrrocoma*, with sixteen species, five of which are new; *Balsamorrhiza*, with nine species, two of which are new; *Thelesperma*, with seven species, two of which are new; *Hymenopappus*, with eight species, four of which are new.— EDWARD L. GREENE (Pittonia **4**: 159–226. 1900) has recently made some important contributions as follows: A fascicle of new forms of *Arnica* contains twenty-four species; Gentianaceae are enriched by three new species of *Gentiana*, three of *Swertia*, and three of *Frasera;* the third of the "Studies in the Cruciferae" discusses certain species of *Arabis*, describing seventeen as new, describes new species in *Cheiranthus*, *Sophia*, *Thelypodium*, *Thysanocarpus*, *Draba*, and *Cardamine* (4 spp.), expresses his conclusion as to the type of the genus *Draba*, and establishes a new genus (*Abdra*) upon what is known as *Draba brachycarpa;* the second of the papers on "Neglected generic types" brings to us *Halerpestes* as a new genus established to include *Ranunculus Cymbalaria* Pursh, *R. salsuginosus* Pallas, and *R. tridentatus* HBK., *Peritoma* DC. to include certain species of Cleome (*serrulata, inornata, lutea*), *Celome* founded on *Cleome platycarpa* Torr., *Carsonia* founded on *Cleome sparsifolia*, and *Aldenella* founded on *Polanisia tenuifolia* T. & G.; eighteen new species are added to the genus *Aster*, all but one of which are from the Rocky mountains; among the "Corrections in nomenclature" *Oreostemma* is substituted for the untenable *Oreastrum* Greene (containing certain species formerly referred to Aster), *Nerisyrenia* is substituted for the untenable *Parrasia* Greene (Greggia), and *Eremosemium* is substituted for *Grayia* of the western deserts on account of a prior use of the name. The same author (*idem* 227–241. 1901) has begun the segregation of *Taraxacum* in North America by describing eight new species; and has described new species under *Thalictrum*, *Rumex* (2), *Lappula*, *Allocarya* (2), *Solidago*, *Coleosanthus* (5), *Coreopsis*, *Parthenium*, *Picradenia*, and *Zygadenus* (2).—M. L. FERNALD (Rhodora **2**: 230–233. *pl. 21.* 1900) has described two new northeastern species of *Thalictrum*, and two new varieties of *Scirpus maritimus* (*idem* 241. 1900), and has presented (*idem* **3**: 13–16. 1901) *Monarda fistulosa* and its allies.—B. L. ROBINSON (Rhodora **2**: 235–238. 1900) has discussed and reorganized the nomenclature of the New England representatives of *Agrimonia*, has presented (*idem* **3**: 11–13. 1901) the results of his search for the type of the Linnean *Gnaphalium plantaginifolium* which proves to be *A. plantaginea* as interpreted by Fernald, and has discovered (*idem* 16–17. 1901) that *Sisymbrium Niagarense* Fourn. should be transferred as a doubtful synonym under *S. officinale* L. to *Brassica nigra* Koch.—G. E. DAVENPORT (Rhodora **3**: 1–2. *pl. 22.* 1901) has described a new plumose variety of *Asplenium ebeneum* from Vermont.—J. M. GREENMAN (Rhodora **3**: 3–7. 1901) has set forth the genus *Senecio* as it exists in New England, describing two new varieties of *S. Balsamitae.*—SPENCER LE MOORE (Jour. Bot. **38**: 457–469. *pl. 416.* 1900) has described two new genera of Compositae from Africa (*Delamerea* and *Nicolasia*), both belonging to the Inuloideae—A. B. RENDLE (Jour. Bot. **39**: 12–22. 1901) has described eleven new species of *Ipomoea* from Africa.—F. LAMSON-SCRIBNER and ELMER D. MERRILL (U. S. Dept. of Agric., Div. of Agrost. Bull. **24**: 1–54. 1901) have published new species of *Tripsacum*, *Andropogon* (3), *Paspalum* (2), *Panicum* (3), *Muhlenbergia*, *Agrostis*, *Tristachya*, *Leptochloa*, *Aristida* (2), and *Elymus* (5); and have given the results of a study of the types of *Panicum nitidum*, *P. pubescens*, and *P. scoparium.*—J. M. C.

IN A RECENT PAPER Hans Fitting[16] has given the results of his investigations on the mode of origin of the megaspores, and the development of their coats in Isoetes and Selaginella. His work was done chiefly with living spores examined in a physiological salt solution, and in water. Microtome sections were used to trace the phases of karyokinesis in the spore mother cells, and for a check on the conclusions drawn from the living material.

He agrees with Smith[17] in his account of the origin of the sporangium of Isoetes. It will be remembered that the latter author differed from Goebel, Bower, and Campbell, in asserting that "the rudiment of the sporangium is

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[16] Bau und Entwickelungsgeschichte der Makrosporen von Isoetes und Selaginella, etc. Bot. Zeit. **58**: 107–164. *pls. 5–6.* 1900.

[17] BOT. GAZ. **29**: 225–258, 323–346. *pls. 12–20.* 1900.

a transverse row of superficial cells below the ligule." Also, as regards the formation of the trabeculae and tapetum, Fitting's account is identical with Smith's.

The spore mother cell is distinguished by its finely granular protoplasm, large nucleus, and nucleolus. At one side of the nucleus lies a dense mass of coarse-grained protoplasm, in which are imbedded many small starch grains. Preceding the first division of the mother cell, radiations appear in the protoplasm, extending in all directions to the wall, but from no common center. The mass of mingled protoplasm and starch divides into two nearly equal parts, and new radiations appear between them as they separate. They finally take the positions of two foci of an ellipse, the spore mother cell being nearly of that shape. During this process the nucleus has shifted from the center to the periphery of the cell, and at its conclusion has returned to its original position. The two daughter masses (*Tochter-Klumpen*) elongate and lie in planes at right angles to each other and to the long axis of the cell. The starch grains arrange themselves in straight lines in each mass. Those near the middle slip toward either end and reunite in two groups, surrounded by the dense protoplasm. This process results in four masses of starch surrounded by the coarse granular protoplasm, arranged tetrahedrally. These changes the author followed in living material, observing the spore through the sporangium wall and the several layers of sterile cells, tapetum, etc. The nucleus then divides by two rapid successive divisions, the spindle lying in such fashion that each of the four daughter nuclei lies by one of the *Tochter-Klumpen*. New fibers arise from the surrounding protoplasm and extend themselves between the nuclei, thus forming a sextuple spindle. Equatorial cell-plates cross these spindles, cutting completely through the protoplasm in six planes from the center of the cell to its wall. Partition walls develop in these plates. It is evident that four of these walls have no connection with the spindles concerned in the division of the nucleus.

The origin of the four megaspore membranes is worked out with great detail. The main points are as follows: While the four "special mother" cells are still lying in the form of a tetrad enclosed by the mother cell membrane, each surrounds itself with a separate membrane called the "special mother cell" membrane. The author did not determine whether this was formed by the mother cell membrane or by the protoplasm of the special mother cell. This thickens rapidly and divides into three lamellae which taken together constitute the *exospore*. Between the exospore and the protoplasm of the cell (now called megaspore) developing from the latter, appears the *mesospore*. The outer layer of the exospore becomes roughened with spines or reticulations, and following their exact contour is laid down an incrustation with much silica, which Fitting styles the *perispore*. Some species of

Isoetes lack this coat. All of these membranes grow by intussusception, and the author lays stress on the fact that the perispore and exospore are of quite different chemical nature, and yet are both growing simultaneously by intussusception. Finally, between the mesospore and the protoplasm content appears a thin film of cellulose, the endospore. The nourishment needed for the growth of these membranes is derived from the sporangium wall and trabeculae, not from the tapetal cells. Until the walls are formed the spore content is relatively very small.

The author was less successful in his work in Selaginella. Owing to the smallness of the megaspore and to imperfect technique (he never succeeded in avoiding shrinkage) he failed, like all his predecessors, to make out the stages of the development of the megaspore. The megaspore mother cell is easily recognized, but how it divides into spores is not known.

Heinsen's account and Fitting's disagree in almost every particular as regards the interpretation of the spore contents and the origin of the several coats. The "nucleus" (according to Heinsen) is the entire protoplasmic content. Heinsen's "nucleolus" Fitting interprets as the nucleus. The several small "corpuscles," whose nature Heinsen could not explain, are, according to this author, the nucleoli. The sequence of events as regards the development of the coats is much like that of Isoetes, making an additional reason why Isoetes and Selaginella should not be separated in any system of classification. The author thinks that the extremely small amount of protoplasm in the spore can have nothing to do with the nourishment of the spore coats, which soon far exceed it in thickness and bulk. Between the tapetum and the four megaspores is a sort of slimy matter which Bower interpreted as the remains of the disorganized sterile mother cells. Fitting says that these cells do not disorganize, and that the slime is a secretion from the tapetum, which acts like a gland. This material nourishes the spores up to their maturity, when they fill the entire sporangial cavity. Like those of Isoetes, the spore walls develop by intussusception. A very significant fact is that the greatest growth of the spore walls takes place when they are not in contact with the plasma body within. Four walls are found, exospore, mesospore, endospore, and perispore (the latter sometimes lacking in certain species). The increase in size of the plasma body without corresponding increase in the amount of matter of which it consists, followed by cell division and the formation of the prothallium, were not followed in detail. The author says, however, that in some species this occurs before the spores are shed (*S. Martensii, S. Galeottii*), and in others "a long time afterward."—FLORENCE MAY LYON.

NEWS.

On March 30 the Imperial Zoological-botanical Society of Vienna will celebrate its fiftieth anniversary by a jubilee session in which related academies, societies, associations, and institutes are invited to participate.

A new monthly botanical journal, *Torreya*, has been begun by the Torrey Botanical Club of New York City, under the editorship of Marshall A. Howe. The journal is intended for the shorter notes and items which have been lately rather crowded out of the *Bulletin*.

The Yale Summer School of Forestry, under the direction of Henry S. Graves and James W. Toumey, will hold its sessions at Grey Towers, the estate of Mr. James W. Pinchot, near Milford, Pa. The school begins July 8, 1901, and continues eight weeks.

In a recent "minor notice" (**30**: 418. 1900) in this journal, certain publications being issued by the botanists of Japan were confused. A letter from Professor Y. Yabe makes the following statement: Three series are being issued, whose titles may lead to confusion. *Icones Florae Japonicae* is a university (Imperial Univ., Tokyo) publication, and but one part has appeared, having been issued last April. It is in the editorial charge of Mr. T. Makino. *Phanerogamae et Pteridophytae Japonicae Icon. Illustr.* and *Cryptogamae Japonicae Icon. Illustr.* are the private publications of a few botanists.

The Society for Plant Morphology and Physiology met at Johns Hopkins Medical School, Baltimore, Md., Dec. 27 and 28, 1900, under the presidency of D. P. Penhallow. The following officers were elected for the ensuing year: *president*, Erwin F. Smith; *vice presidents*, F. C. Newcombe and L. M. Underwood; *secretary*, W. F. Ganong. The following new members were elected: M. A. Carleton, F. D. Chester, E. B. Copeland, T. H. Kearney, J. W. Toumey. The most important business of general interest was the presentation in printed form of the report of the committee on reviews of botanical literature, which has already been referred to in this journal (p. 143). A committee (Messrs. Ganong, Lloyd, and Atkinson) was appointed to take into consideration the subject of a standard college entrance option in botany, to be made as widely acceptable as possible. The address of the retiring president, *A Decade of North American Paleobotany*, has been published in full in *Science*, together with abstracts of the papers presented.


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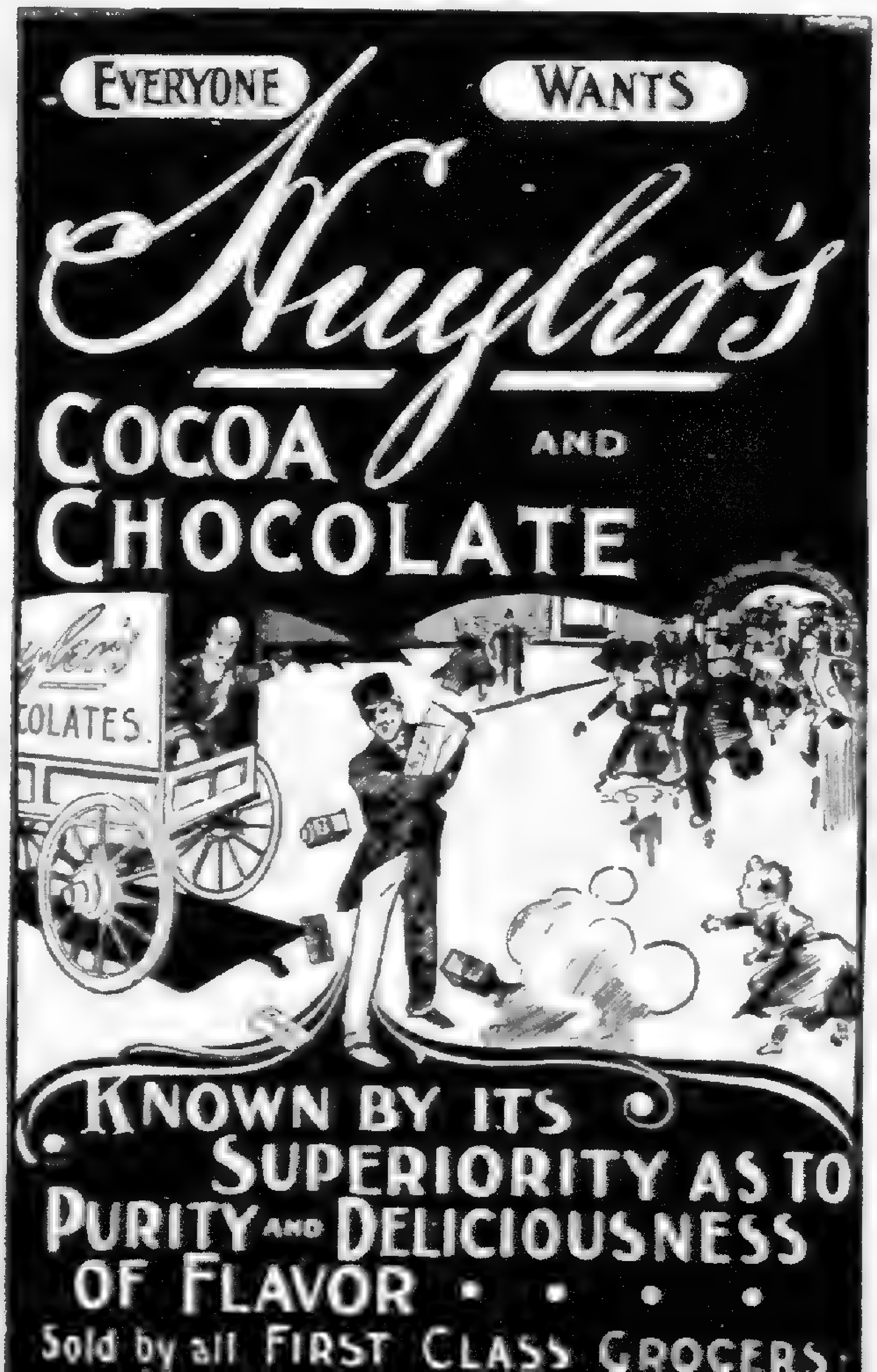
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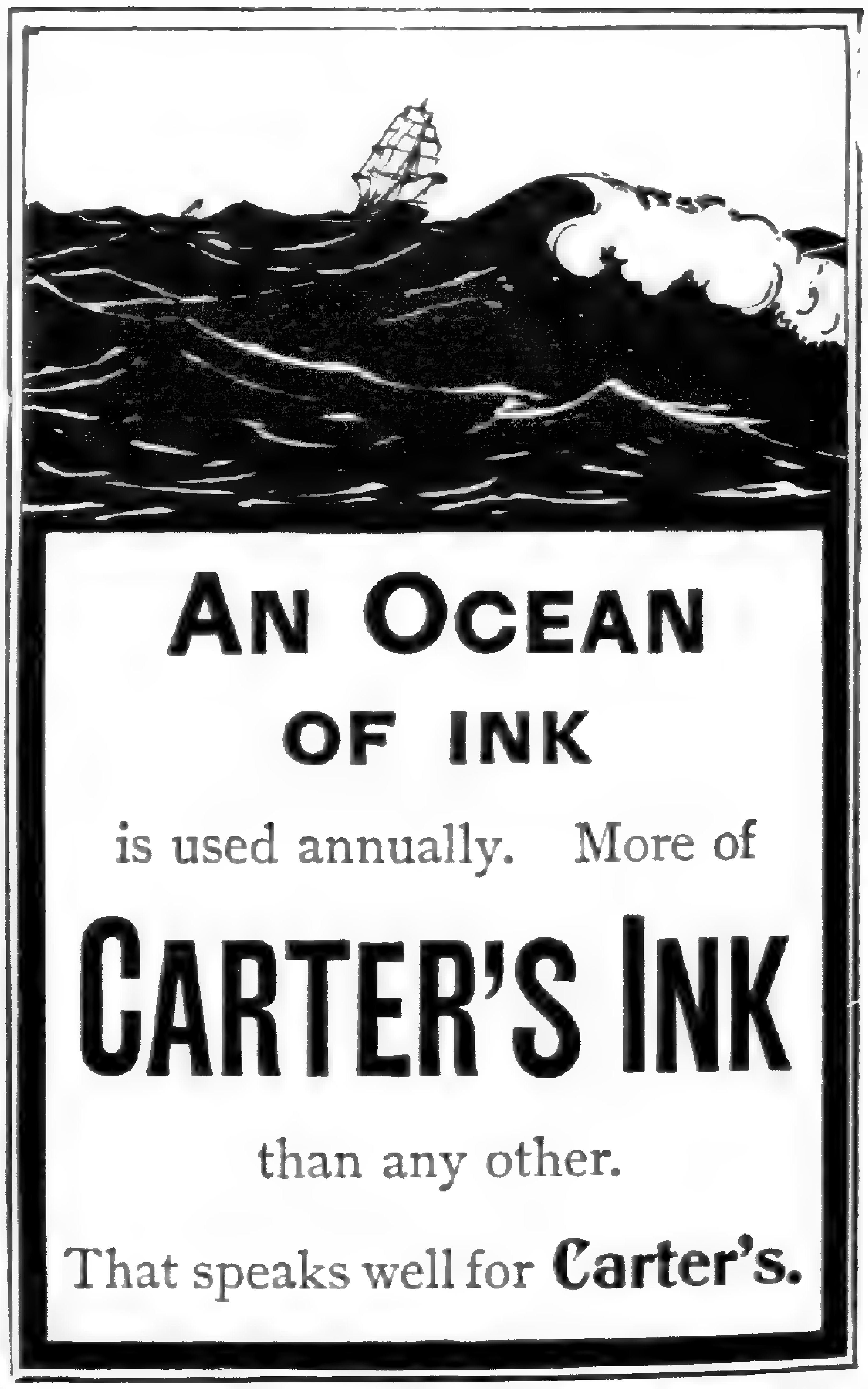

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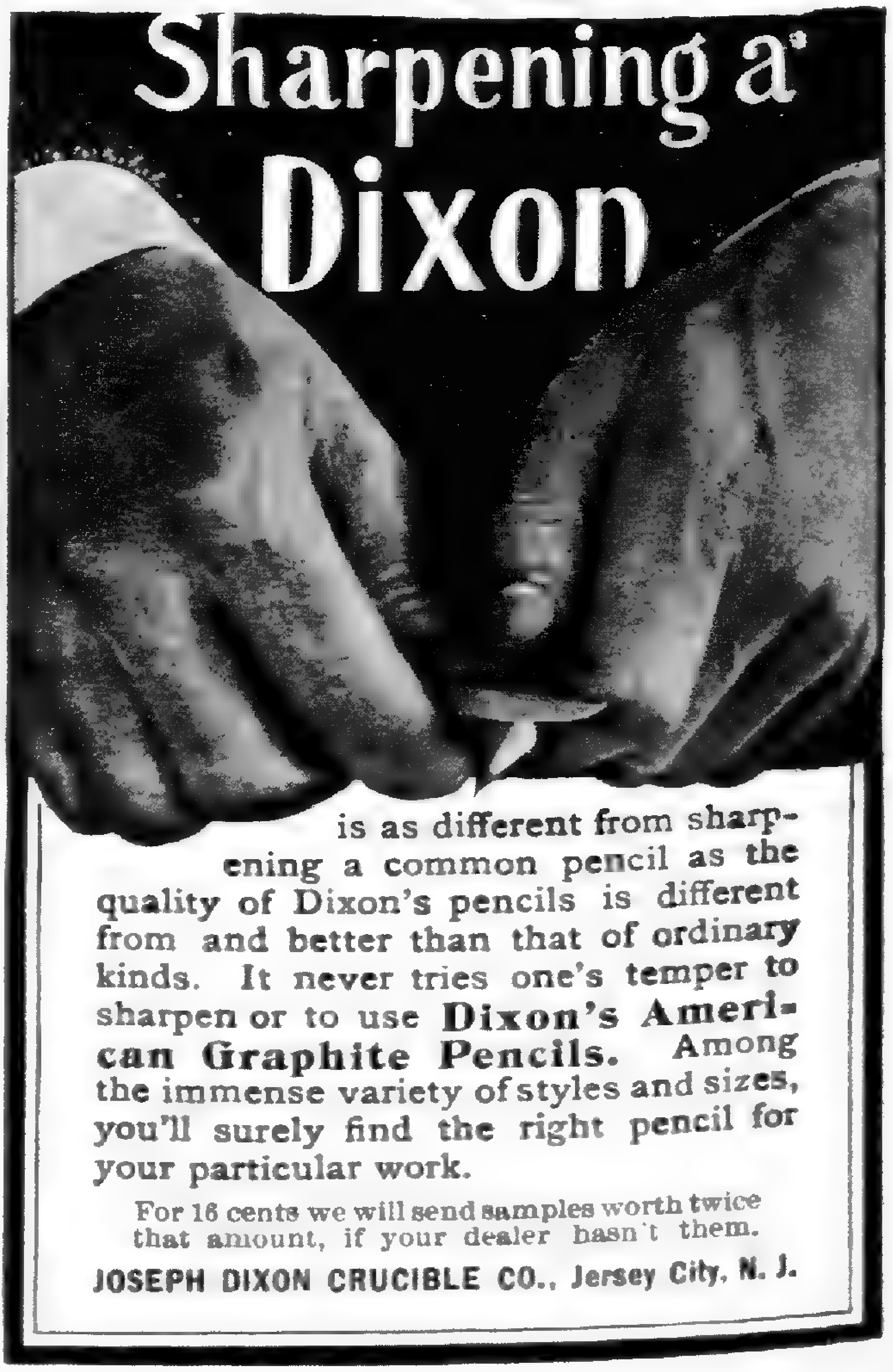

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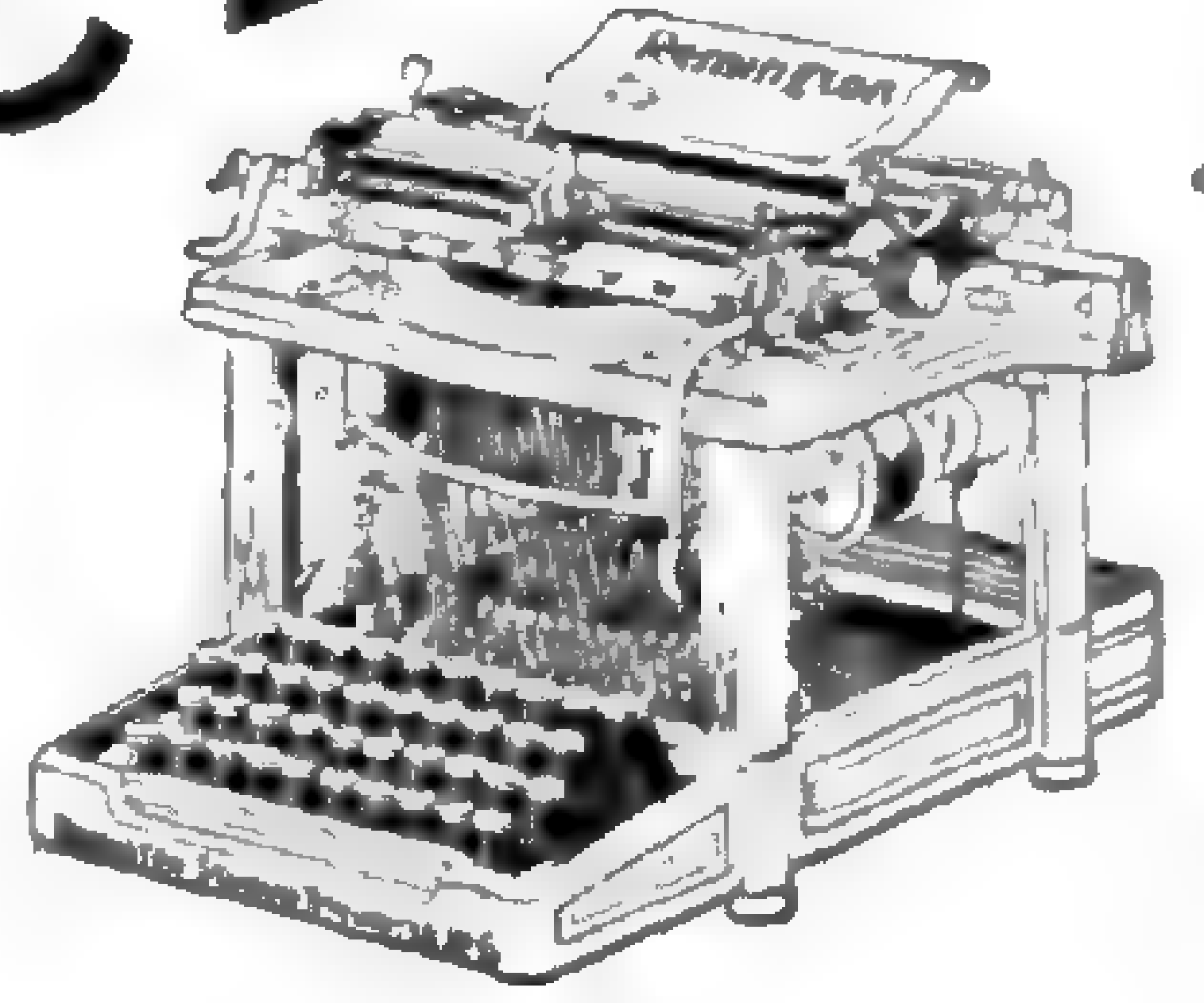

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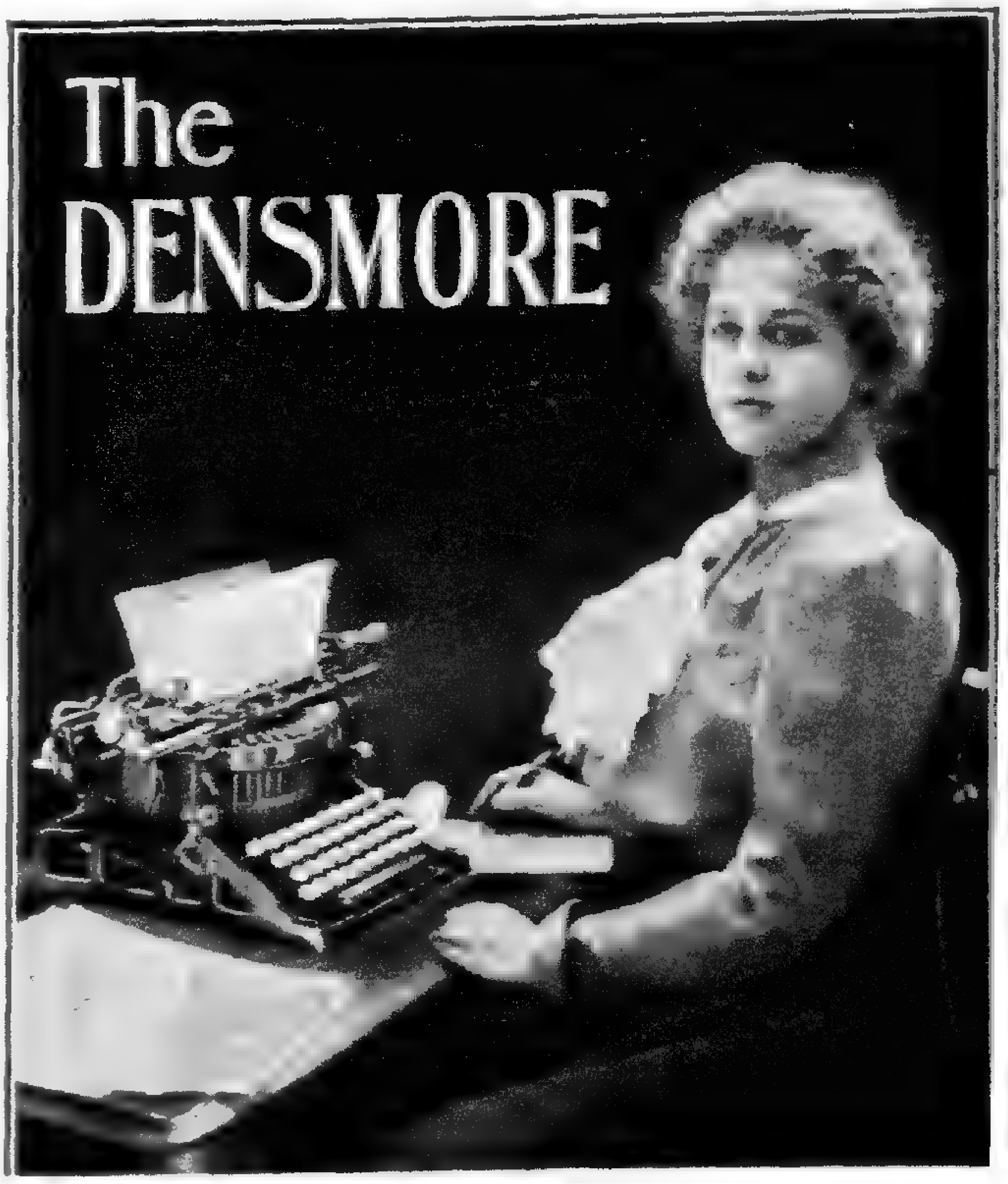

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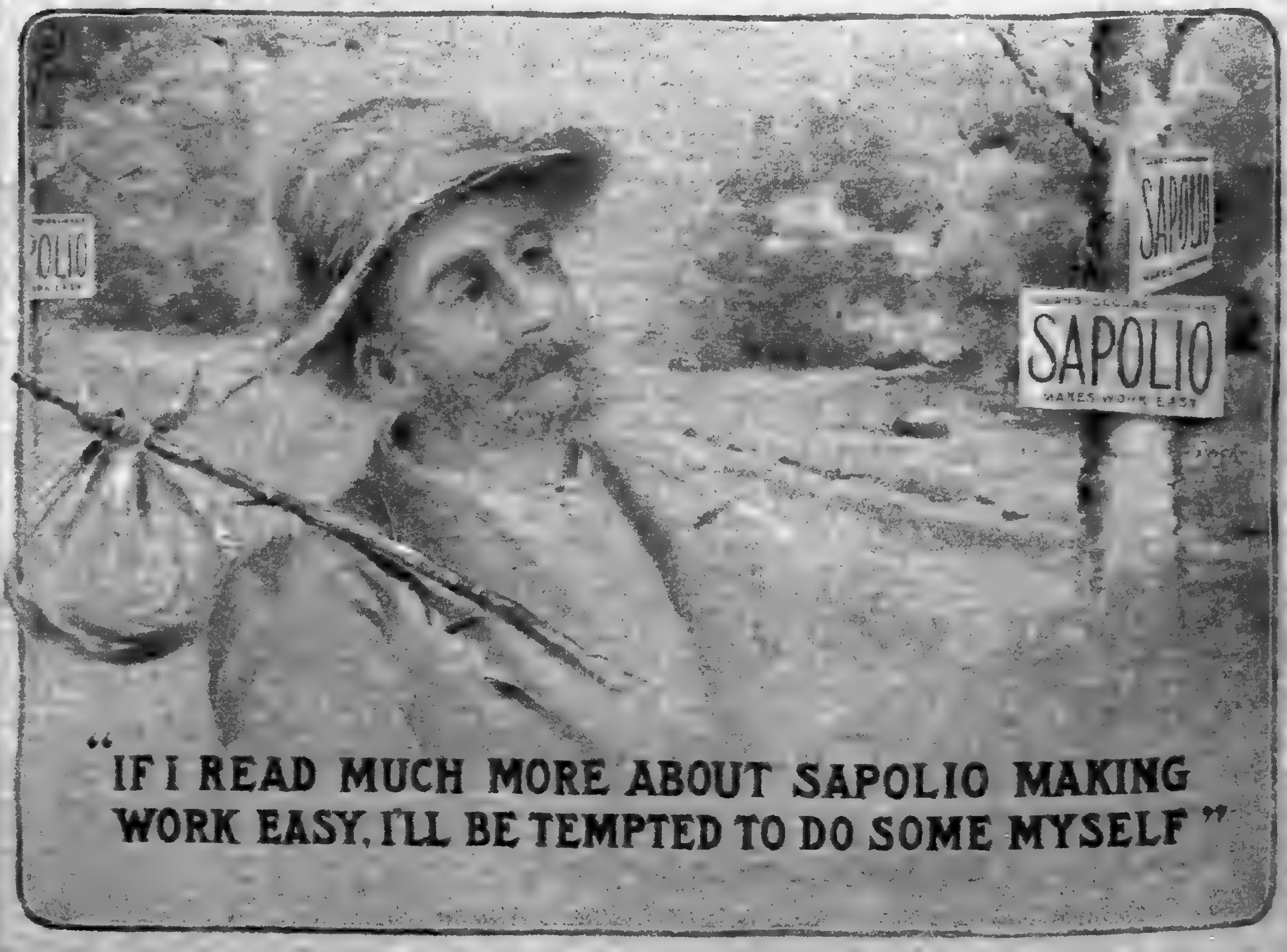
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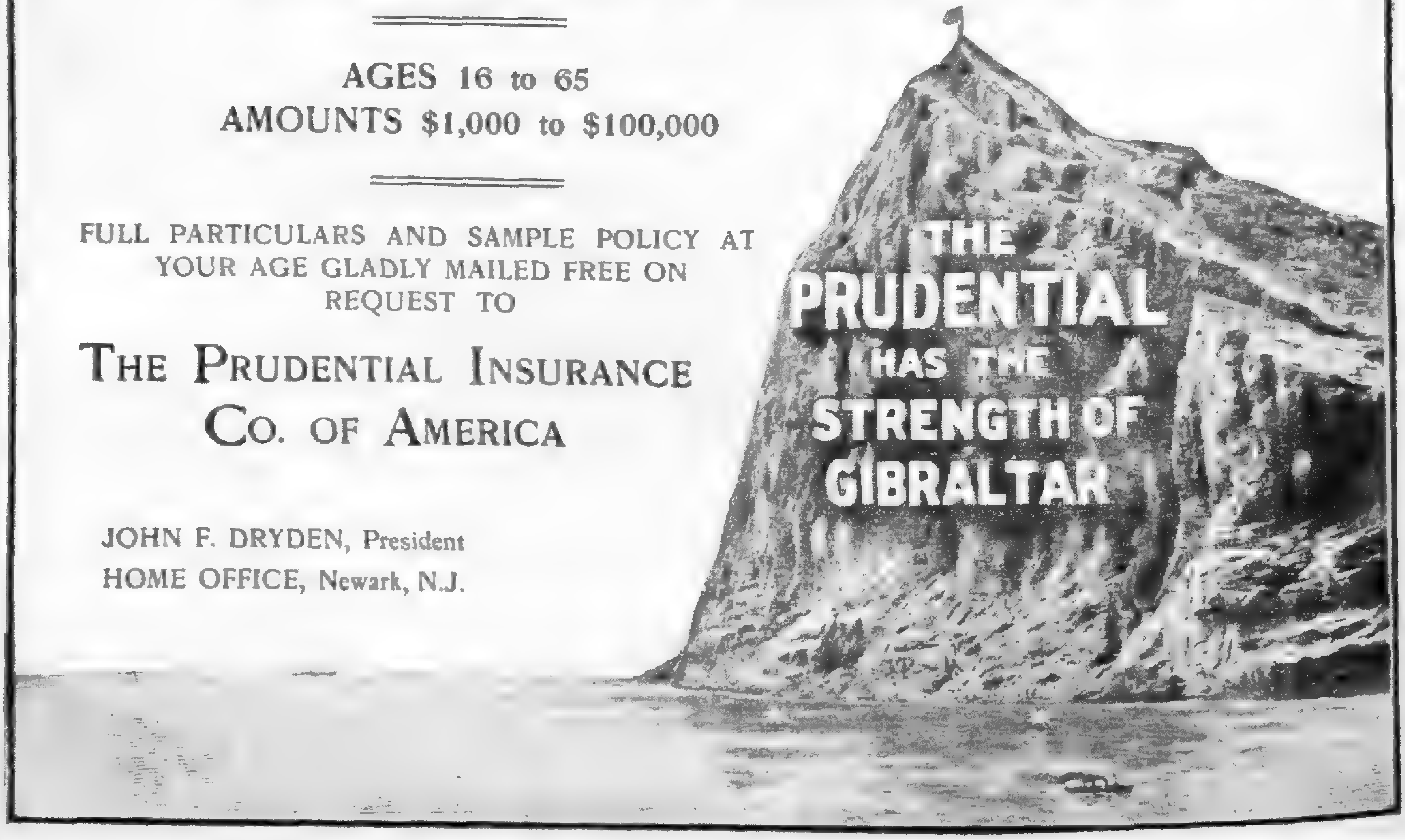
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VOLUME XXXI NUMBER 4

BOTANICAL GAZETTE

APRIL, 1901

NEW OR LITTLE KNOWN NORTH AMERICAN TREES. III.

CHARLES S. SARGENT.

Crataegus acutifolia, n. sp.—Glabrous. Leaves oval to oblong-obovate, acute or acuminate, or rarely rounded at the apex, cuneate at the base, finely crenulate-serrate with gland-tipped teeth except toward the base, or occasionally only above the middle, on vigorous leading shoots sometimes irregularly divided toward the apex into two or three pairs of short acute lobes; nearly fully grown when the flowers open and then thin and lustrous above and at maturity thin but firm in texture, dark green and very lustrous on the upper surface, pale yellow-green on the lower surface, about 1½ in. long and 1 in. wide, and on leading shoots sometimes 2½ to 3 inches long and nearly 2 in. wide, with slender light yellow midribs comparatively deeply impressed above, and four or five pairs of thin primary veins without the parenchyma; petioles slender, winged above by the decurrent bases of the leaf-blades, deeply grooved, glandular with minute dark caducous glands, from ¼ to ⅓ in. in length; stipules linear, elongated, dark red, caducous. Flowers ½ in. in diameter on slender pedicels, in compound many-flowered compact corymbs; bracts and bractlets linear, glandular-serrate, caducous; calyx-tube narrowly obconic, the lobes lanceolate, acuminate, entire or occasionally obscurely glandular-serrate; stamens 10; filaments slender, elongated; anthers small; styles

2 or 3. Fruit in drooping few-fruited clusters, oblong, full and rounded at the ends, bright scarlet, marked by few large dark lenticels, about $\frac{1}{3}$ in. long; calyx-tube prominent with a broad deep cavity, the lobes closely appressed, often deciduous before the maturity of the fruit; flesh thin, yellow, dry and mealy; nutlets 2 or 3, broad, prominently ridged on the back with broad rounded ridges, about $\frac{3}{16}$ in. long.

A tree 25 to 30 ft. in height with a trunk 8 or 10 in. in diameter, and wide-spreading branches forming a broad symmetrical rather flat-topped head and slender nearly straight branchlets marked by oblong pale lenticels, dark chestnut-brown or orange-brown and lustrous during their first year, becoming dull gray-brown during their second season, and slightly armed with few slender straight chestnut-brown spines from 1 to nearly 2 in. in length.

Flowers early in May. Fruit ripens toward the end of September.

Open oak woods near the bank of the Mississippi river at Carondelet in South St. Louis, Missouri. First collected in May 1887 by *H. Eggert*, and in September 1900 by *Eggert*, *Norton*, and *Sargent*.

This is one of several forms which have been usually confounded with *Crataegus Crus-galli* of Linnaeus, but which can probably best be separated from that species. From *Crataegus Crus-galli* as limited by Linnaeus and Aiton, and now universally recognized, it differs in its thin usually acute or acuminate leaves with comparatively prominent veins, in its smaller flowers, much smaller early-ripening scarlet fruit, and in its more slender branchlets only sparingly armed with much more slender spines.

Crataegus erecta, n. sp.—Glabrous. Leaves broadly oval to obovate, or on leading shoots nearly orbicular, acute and short-pointed at the apex, cuneate and entire at the base, finely crenulate-serrate above, or on vigorous shoots coarsely dentate with broad nearly straight gland-tipped teeth, thin, dull green and nearly fully grown when the flowers open, and at maturity thin but firm in texture, dark dull green on the upper surface, pale on the lower surface, 1½ to 2 in. long, 1 to 1¼ in. wide, and on leading shoots sometimes 3 in. long and 2½ in. wide, with slender midribs and thin prominent primary veins; petioles slender, deeply grooved, wing-margined above particularly on vigorous shoots, glandular with minute dark glands, often dark red after midsummer, from ¼ to ½ in. long; stipules linear, glandular-serrate, fading red, ½ in. long, caducous. Flowers ½ to ⅝ in. in diameter, on slender elongated pedicels, in broad loose many-flowered very thin-branched compound corymbs; bracts and bractlets linear, glandular-serrate, caducous; calyx-tube narrowly obconic, the lobes narrow, acuminate, elongated, entire or occasionally obscurely dentate; stamens usually 10, occasionally 11 to 13; filaments slender; anthers small, pale yellow; styles 3 or 4, surrounded at the base by a narrow ring of short pale hairs. Fruit in few-fruited drooping clusters, subglobose, usually a little longer than broad, full but flattened at the ends, dark dull crimson, marked by occasional large dark lenticels, from ¼ to ⅓ in. in length; calyx-tube very short with a broad shallow cavity, the lobes gradually narrowed from broad bases, closely appressed, usually persistent on the mature fruit; flesh thin, yellow, dry and mealy; nutlets 3 or 4, broad, prominently doubly ridged on the back, about $\frac{3}{16}$ in. long.

A tree usually 25 to 30 ft. in height with a trunk a foot in diameter covered with dark gray-brown or nearly black bark broken irregularly into thick plate-like scales, ascending branches forming a broad open erect head and slender slightly zigzag branchlets marked by numerous large oblong pale lenticels, green more or less tinged with red when they first appear, orange or reddish-brown during their first season and gray or gray-brown during their second year, and armed with numerous straight slender chestnut-brown spines from 1 to 2 in. in length.

Flowers about May 10. Fruit ripens toward the end of September. The leaves before falling turn dull orange-color.

Rich bottom-lands of the Mississippi river in Illinois opposite St. Louis. First noticed October 5, 1899, in a vacant lot in the city of East St. Louis by *Eggert*, *Norton*, and *Sargent*, and on May 12, 1900, collected in flower by *J. B. S. Norton*, and in October 1900 with ripe fruit by *Eggert*, *Norton*, and *Sargent*.

This is another of the *Crus-galli* group, differing from the species of Linnaeus by its thin pointed or suborbicular leaves with prominent veins, which even on vigorous shoots show no tendency to lobing, by its pale yellow not rose-colored anthers, small nearly globose bright scarlet fruit, by its ascending not wide-spreading branches, and by its less numerous spines standing out from all sides of the branchlets, as they do usually in Crataegus with the exception of *Crataegus Crus-galli*. This species in its typical form can always be recognized by the direction of the spines which point downward from the branch in two ranks.

Growing in a field in the Mississippi bottom near Fish lake in the village of Cahokia about four miles below East St. Louis there is a specimen of *Crataegus erecta* forty feet in height with a trunk three feet in diameter three feet above the surface of the ground and a broad head of numerous large upright branches.

✓ **Crataegus Lettermani,** n. sp.—Leaves obovate to broadly oval on leading shoots, acute, acuminate or rounded and short-pointed at the apex, gradually narrowed from near the middle to the base and decurrent on the stout elongated glandular tomentose but ultimately nearly glabrous petioles, often slightly and irregularly divided above into three or four pairs of short acute lobes, coarsely doubly serrate, often nearly to the base, with glandular incurved or straight teeth; as they unfold strongly plicate, tomentose above and below like the young branchlets, with a thick coat of hoary tomentum, and when the flowers open covered on the upper surface with short soft hairs and villose on the lower surface, and at maturity thin but firm in texture, scabrate and dark green above, pale below, from 2 to 2½ in. long and from 1 to 1½ in. wide, with slender midribs and primary veins impressed on the upper surface and puberulous below, and conspicuous forked secondary veins and reticulate veinlets. Flowers about ¾ in. in diameter in compact many-flowered thick-branched tomentose cymes; bracts and bractlets linear, glandular-serrate, caducous; calyx-tube narrowly obconic, coated with thick hoary tomentum, the lobes narrow, acuminate, villose, finely glandular-serrate, reflexed after anthesis; stamens 10; filaments slender, elongated; anthers small; styles 5, surrounded at the base by a broad ring of white tomentum. Fruit nearly globose and somewhat flattened at the ends, dark red, marked by a few large pale lenticels, ⅝ in. in diameter; calyx-cavity broad and shallow, the lobes serrate, villose, spreading and closely appressed; flesh thin and yellow; nutlets 5, thick, very prominently doubly ridged on the back, about ¼ in. long.

A tree from 15 to 18 ft. in height, with a trunk 6 or 8 in. in diameter, and stout wide-spreading branches forming a symmetrical round-topped head and slender branchlets dull red and puberulous during their first season and dark gray-brown during their second year, and armed with stout straight spines from 1½ to 2 in. in length.

Flowers in May. Fruit ripens late in October.

Rich woods, Allenton and Pacific, Missouri, *George W. Letterman*, May and October 1882.

This species, which was referred by Engelmann to *Crataegus tomentosa* Linnaeus, and to *Crataegus punctata* Jacquin, is still very imperfectly known. Its relationship appears to be with *Crataegus collina* Chapman, from which it differs in its more tomentose young leaves and branchlets, in its short thick-branched and more tomentose corymbs, ten stamens, rather larger fruit, and in its much later flowers.

Crataegus Arnoldiana, n. sp. — Leaves broadly ovate or rarely oval, acute at the apex, rounded, truncate or occasionally broadly cuneate at the base, irregularly divided above the middle into numerous short acute lobes, coarsely doubly glandular-serrate except at the base; in early spring densely villose above and below, and at maturity from 2 to 3 in. long and broad, membranaceous, smooth, dark green and lustrous on the upper surface, paler on the lower surface, slightly villose on the under side of the slender midribs and thin remote primary veins running to the points of the lobes and faintly impressed above; petioles slender, only slightly grooved, densely villose, ultimately puberulous, from ¾ to 1½ in. long; stipules linear, coarsely glandular-serrate, often 1 in. long, caducous. Flowers ¾ in. in diameter on slender pedicels in broad loose compound many-flowered thin-branched tomentose cymes; bracts and bractlets lanceolate to oblanceolate, coarsely glandular-serrate;

calyx-tube broadly obconic, densely tomentose, the lobes narrow, elongated, acuminate, glandular-serrate, villose on both surfaces, reflexed after anthesis; stamens 10; filaments slender; anthers large, pale yellow; styles 3–5, usually 3 or 4, surrounded at the base by a broad ring of thick white tomentum. Fruit on slender pedicels in erect, spreading or sometimes drooping few-fruited slightly villose clusters, subglobose but rather longer than broad, bright crimson, marked by numerous large pale lenticels, villose particularly toward the ends with long white scattered hairs, ¾ in. long; calyx-cavity broad and shallow, the lobes coarsely glandular-serrate, villose, wide-spreading, often deciduous before the falling of the fruit; flesh thick, bright yellow, subacid; nutlets usually 3 or 4, thick, light-colored, prominently ridged on the back with high rounded ridges, about ¼ in. long.

A tree 15 to 20 ft. in height with a short trunk 10 or 12 in. in diameter, stout ascending branches forming a broad open irregular head, and slender strongly zigzag branchlets marked by large oblong pale lenticels, coated when they first appear with long matted hairs, becoming dark orange-brown and lustrous before midsummer and glabrous or puberulous during their first winter, light orange-brown and lustrous during their second season, and finally ashy-gray, and armed with very numerous stout straight or slightly curved bright chestnut-brown lustrous spines from 2½ to 3 in. long and brilliant for four or five years. Winter buds oblong, gradually narrowed to the obtuse apex, bright red and lustrous, about $\frac{3}{16}$ in. long.

Flowers during the last week of May. Fruit ripens by the middle of August and falls before the 1st of September.

Known in a wild state only in a small group of plants growing on a wooded bank in the Arnold Arboretum, but now frequently cultivated in the neighborhood of Boston, and in cultivation forming a tall trunk and promising to attain a large size.

When it is covered with its brilliant and abundant fruit *Crataegus Arnoldiana* is one of the most beautiful of the thorns which ripen their fruit in summer or early autumn. From *Crataegus submollis* (Sargent, BOT. GAZ.

31 : 7. 1901) of the same region it differs in its broader darker green more villose leaves which are usually rounded, not cuneate, at the base, in its smaller flowers, subglobose, not oblong or pear-shaped, crimson fruit with smaller spreading calyx-lobes, borne on shorter peduncles and ripening two or three weeks earlier, and by its much more zigzag and more spiny branches which make this tree particularly noticeable in winter when it may be readily recognized from all other thorn trees. From *Crataegus Champlainensis* (Sargent, Rhodora **3** : 20), another of the eastern species of the *mollis* group with 10 stamens, it differs in its larger thinner leaves which are yellow-green, not blue-green, in its smaller subglobose, not oblong or obovate, early-ripening fruit, the fruit of *Crataegus Champlainensis* beginning to ripen early in September and remaining on the branches until midwinter. It differs also from this northern species in the form of the fruiting calyx and in its much more zigzag branchlets.

✓ **Crataegus Arkansana,** n. sp.—Leaves oval to oblong-ovate, acute at the apex, broadly cuneate, or on vigorous leading shoots occasionally rounded at the base, usually divided above the middle into three or four pairs of short broad acute lobes, sharply serrate, sometimes to the very base, with spreading gland-tipped teeth; in early spring coated with short soft pale hairs, particularly on the under surface of the midribs and veins, and at maturity thick and leathery, dark dull green and glabrous on the upper surface, pale yellow-green on the lower surface, from 2 to 3 in. long, from 1¾ to 2 in. wide, or on vigorous shoots often 4 in. long and 3 in. broad, with stout light yellow midribs and primary veins deeply impressed above and slightly villose below with scattered pale hairs, conspicuous secondary veins and reticulate veinlets; petioles stout, deeply grooved, more or less winged above, glandular with minute usually deciduous dark glands, tomentose, ultimately glabrous or puberulous, usually dull red in the autumn, from 1 to 1½ in. long; stipules glandular-serrate, villose, linear-lanceolate to linear-obovate, about ½ in. in length. Flowers 1 in. in diameter in broad compound many-flowered thin-branched villose corymbs; bracts and bractlets oblong-ovate, acuminate, finely glandular-serrate; calyx-tube narrowly obconic, coated with long matted pale hairs, the lobes short, acute, very coarsely glandular-serrate, glabrous or slightly villose; stamens 20; filaments slender; anthers large, pale yellow; styles 5. Fruit in few-fruited clusters, oblong or rarely obovate, full and rounded at the ends, bright crimson, lustrous, marked by few large dark lenticels, slightly tomentose at the ends, particularly at the apex, from ¾ to 1 in. long, ¾ in. thick; calyx-cavity deep but comparatively narrow, the lobes small, linear-lanceolate, coarsely glandular-serrate, red at the base on the upper surface, erect and persistent; flesh yellow, thick, dry, subacid; nutlets small in comparison with the size of the fruit, thin, rounded or slightly and irregularly ridged on the back, ⅓ in. long.

A tree from 15 to 20 ft. in height with a tall straight stem covered with pale scaly bark, thick ascending branches and stout slightly zigzag branchlets marked by large oblong pale lenticels, dark green and covered with long scattered pale hairs when they first appear, light orange-brown and very lustrous during their first winter, becoming ashy-gray during their second year, and unarmed or armed with occasional straight bright chestnut-brown spines gradually narrowed from broad bases and usually from ⅓ to ½ in. long. Winter-buds about ⅛ in. in length, nearly as broad as long, dark red, puberulous along the margins of the scales.

Flowers at the Arnold Arboretum about the middle of May. Fruit ripens at the end of October and remains on the branches for several weeks longer, falling gradually. Late in October or early in November the leaves turn bright clear yellow.

Apparently common in southern Arkansas (*B. F. Bush* 953), but first distinguished from plants in the Arnold Arboretum raised from seeds collected in 1883 by *George W. Letterman* at Newport, Ark.

From *Crataegus mollis* Scheele, with which it has been confounded, *Crataegus Arkansana* differs in the form and particularly in the leathery texture of the leaves which when young are villose, not tomentose, in its villose corymbs, its oblong late-ripening fruit, the fruit of *Crataegus mollis* falling from the middle of August to the middle of September, and in its unarmed or only slightly armed branchlets. Perfectly hardy in the Arnold Arboretum, *Crataegus Arkansana* is unsurpassed late in the autumn in the beauty of its large brilliant and abundant fruits which make it one of the most desirable garden plants of the genus.

Crataegus Texana Buckley, *Proc. Phil. Acad.* **1861**: 454.—Leaves broadly ovate, acute or rarely rounded at the apex, cuneate or on leading shoots truncate or slightly cordate at the base, usually divided above the middle into four or five pairs of broad acute lobes, very coarsely and doubly glandular-serrate except toward the base; when they first unfold covered above with short soft pale hairs and below with a thick coat of hoary tomentum, and at maturity thick and firm in texture, dark green and lustrous on the upper surface, pale and pubescent or tomentose on the lower surface particularly along the stout light-colored midribs and primary veins, and on the conspicuous secondary veins and reticulate veinlets, from 3 to 4 in. long, from 2½ to 3 in. wide; petioles stout, more or less winged above, deeply grooved, tomentose, ultimately nearly glabrous, from ½ to ¾ in. long; stipules lunate, apiculate, often stipitate, coarsely serrate, from ¼ to ½ in. long. Flowers ¾ in. in diameter on elongated slender pedicels in broad loose many-flowered tomentose cymes; bracts and bractlets oblong to oblong-ovate, broad, acuminate, villose, sometimes ½ in. long, very conspicuous; calyx-tube broadly obconic, coated with thick pale tomentum, the lobes gradually rounded from broad bases, acuminate, very coarsely glandular-serrate, villose with long matted hairs, reflexed after anthesis; stamens 20; filaments slender; anthers large, dark red; styles 5. Fruit in broad drooping many-fruited tomentose ultimately nearly glabrous clusters, short-oblong or somewhat obovate, full and rounded at the ends, tomentose until nearly fully grown, at maturity bright scarlet, lustrous, marked by occasional large pale lenticels, puberulous toward the apex, from ¾ to 1 in. in length; calyx-cavity broad and deep, the lobes much enlarged, glandular-serrate, villose, dark red at the base on the upper side, usually erect, often deciduous; flesh thick, yellow, sweet and edible; nutlets 5, thick, slightly grooved on the back, from ⅓ to ¼ in. long.

A tree often 30 ft. in height with a tall trunk sometimes a foot in diameter covered with dark closely appressed scales, stout spreading branches forming a symmetrical round-topped head, or on young trees upright and forming an open irregular crown, and comparatively slender slightly zigzag branchlets, dark bronze-green and villose when they first appear, soon becoming dull reddish-brown, lighter reddish-brown in their second season, and ultimately pale ashy-gray, and often unarmed, or armed with occasional slender nearly straight bright chestnut-brown spines usually about 2 in. in length.

Flowers the middle of March. Fruit ripens toward the end of October.

Rich bottom-lands, central and western Texas.

Long confounded with *Crataegus mollis* Scheele (see Gray, *Proc. Phil. Acad.* 1867: 163), it can be distinguished from that species by the shape of the thinner leaves which are nearly always cuneate and only rarely cordate at the base even on the most vigorous shoots, and are usually less deeply lobed and much more coarsely serrate, by the smaller flowers in fewer-flowered more tomentose cymes, by the late-ripening fruit, and by the color of the branchlets and their more numerous spines. *Crataegus mollis* apparently does not extend south of central Missouri and middle Tennessee, being replaced in southern Missouri and Arkansas by several forms of the Mollis group which are still imperfectly known.

Crataegus pedicellata, n. sp.—Leaves broadly ovate, oval, or occasionally obvate or rhomboidal, acute or acuminate, broadly cuneate or rounded, and on vigorous leading shoots occasionally truncate or slightly cordate at the base, divided above the middle into four or five pairs of short acuminate lobes, coarsely and often doubly serrate, except toward the base, with spreading glandular teeth; in early spring roughened above by short rigid pale hairs and at maturity membranaceous, dark rich green and scabrate on the upper surface, pale and glaucous below, from 3 to 4 in. long, from 2 to 3 in wide, with slender midribs slightly impressed above and thin remote primary veins arching to the points of the lobes; petioles slender, only slightly grooved, villose but ultimately glabrous, obscurely glandular with minute scattered dark glands, from 1½ to 2 in. in length; stipules of leading shoots strongly falcate, stipitate, coarsely glandular-serrate, ⅓ in. long. Flowers ½ in. in diameter on slender-elongated pedicels, in loose lax rather few-flowered slender-branched slightly villose corymbs; bracts and bractlets laciniate, glandular-serrate, caducous; calyx-tube narrowly obconic, glabrous, the lobes broad, acute, very coarsely glandular-serrate reflexed after anthesis; stamens 10; filaments slender, elongated; anthers rose color; styles 5, surrounded at the base by a conspicuous ring of pale tomentum. Fruit in few-fruited drooping glabrous clusters, oblong, full and rounded at the ends, bright scarlet, lustrous, marked by numerous small dark lenticels ¾ in. long, from ½ to ⅝ in. thick; calyx-cavity broad and deep, the lobes much enlarged, coarsely serrate, usually erect and incurved; flesh thin and pale; nutlets 5, rounded and deeply grooved on the back, ⅓ in. long.

A tree from 18 to 20 ft. in height with a stout trunk a foot in diameter and short ascending branches forming a broad open shapely head, and rather slender slightly zigzag branchlets marked by numerous small pale lenticels, dark chestnut-brown and slightly villose when they first appear, becoming bright chestnut-brown and very lustrous during their first season and ashy-gray during their second year, and armed with few stout straight or slightly curved chestnut-brown lustrous spines from 1½ to 2 in. long. Winter-buds nearly globose, bright red, very lustrous, ⅛ in. in diameter.

Flowers during the last week of May. Fruit ripens and mostly falls during the second half of September.

Rochester, N. Y., *C. C. Laney* and *John Dunbar*, 1899 and 1900.

This handsome tree is most conveniently placed in the *Flabellatae* group with *Crataegus Holmesiana* Ashe. From that species it differs in its larger darker green and more scabrous mature leaves, in its more lax villose corymbs, larger flowers on longer pedicels, with coarsely glandular-serrate calyx-lobes, more numerous stamens and styles, and in its larger and later-ripening fruit.

✓ **Crataegus lucorum,** n. sp.—Leaves broadly ovate to obovate or rarely oval, acute or acuminate, gradually narrowed and full and rounded or broadly cuneate at the base, deeply divided above the middle into three or four pairs of broad acute or acuminate lobes, dentate, except at the very base, with straight glandular teeth; when the flowers open not more than one third grown, bronze color, covered above with short soft pale hairs, glabrous below, and at maturity membranaceous, smooth dull dark green and glabrous on the upper surface, pale yellow-green on the lower surface, from 1½ to 2 in. long and broad, with slender yellow midribs slightly impressed above and thin primary veins running obliquely to the points of the lobes; petioles very slender, often short-winged above, nearly terete below, glandular, from 1 to 1½ in. in length; stipules lanceolate to oblanceolate, finely glandular-serrate, from ¼ to ½ in. in length, caducous. Flowers ¾ in. in diameter on slender pedicels in narrow compact few-flowered thin-branched slightly villose corymbs; bracts and bractlets linear-lanceolate, glandular, caducous; calyx-tube broadly obconic, glabrous, the lobes narrow, acuminate, conspicuously glandular-serrate, villose on the upper surface, reflexed after anthesis; stamens 20; filaments slender; anthers small, dark purple; styles 4 or 5. Fruit in erect few-fruited slightly villose clusters, pear-shaped until nearly fully grown, but at maturity oblong or somewhat obovate, full and rounded at the ends, crimson, lustrous, marked by small pale lenticels, from ½ to ⅝ in. long; calyx-cavity deep but narrow, the lobes elongated, glandular-serrate, villose above, spreading and closely appressed, often deciduous before the maturity of the fruit; flesh thick, yellow, dry, and mealy; nutlets 4 or 5, thin, rounded, and obscurely or not all ridged on the back from ½ to ⅝ in. in length.

A tree from 20 to 25 ft. in height, with a tall trunk from 6 to 8 in. in diameter covered with close dark red-brown bark, slender erect branches forming a narrow head and thin slightly zigzag branchlets marked by numerous oblong pale lenticels, dark green and slightly villose when they first appear, dull orange-brown in their first season, ultimately dark gray-brown, and armed with occasional straight or slightly curved bright red-brown spines from 1 to 1½ in. in length.

Flowers during the first week of May. Fruit ripens about the middle of September and soon falls.

Margins of oak groves in rich moist soil along the banks of sloughs near Barrington, Illinois, *E. J. Hill*, May and June 1899; *Hill* and *Sargent*, September 1900.

Distinguished from the other species in the *Tenuifoliae* group now recognized by it more numerous stamens.

Crataegus Columbiana, n. sp.—Leaves oval to obovate, or on vigorous shoots often broadly ovate to oblong-oval, usually acute, or occasionally rounded at the apex, full and rounded or gradually narrowed or abruptly cuneate at the base, irregularly doubly glandular-serrate, except toward the base, with broad spreading teeth; on leading shoots sometimes slightly divided above the middle into three or four pairs of short acute lobes; when they unfold conspicuously plicate, covered above with long soft white hairs and below with a thick coat of snow-white tomentum, and at maturity thin but firm in texture, dark green, lustrous and scabrate on the upper surface, paler and pubescent or tomentose on the lower surface, from 2 to 2½ in. long and broad, and on leading shoots often from 2 to 4 in. long and broad, with slender midribs, few thin primary veins and conspicuous reticulate veinlets; petioles stout, tomentose, about ½ in. long; stipules lunate, often apiculate, more or less stipitate, often coarsely glandular serrate, villose, from ¼ to ½ in. long. Flower ¾ in. in diameter on slender elongated pedicels covered with hoary tomentum like the slender branches of the broad lax many-flowered compound corymbs; bracts and bractlets oblong-obovate, acute or rounded and apiculate at the apex, finely glandular-serrate, slightly villose; calyx-tube narrow, obconic, coated with thick hoary tomentum, the lobes short, acute, coarsely glandular-serrate, tomentose on both surfaces; stamens 20, filament slender, elongated; anthers small, dark red; styles 5, surrounded at the base by long tufts of snow white hairs. Fruit in few-fruited spreading tomentose clusters, subglobose, often rather longer than broad, full and rounded at the ends, tomentose until nearly grown, dark red, marked by numerous large pale dots, glabrous at maturity, from ⅜ to nearly ½ in. in diameter; calyx-tube prominent, with a broad deep cavity, the lobes short, spreading, usually deciduous before the ripening of the fruit; flesh thin, light-colored, hard, and dry, shrivelling on the branches; nutlets 5, rounded and usually ridged on the back, about ¼ in. long.

A tree 25 ft. in height, with a tall trunk from 6 to 8 in. in diameter covered with pale closely appressed scales becoming dark brown near the base of old individuals, and numerous upright branches often forming a broad symmetrical head, and slender slightly zigzag branchlets coated when they first appear with hoary deciduous tomentum, light reddish-brown and more or less villose during their first season, becoming rather darker during their second year and ultimately pale ashy-gray, and armed with numerous stout straight or slightly curved chestnut-brown lustrous spines usually from 1 to 1¼ in. in length.

Flowers toward the end of March. Fruit ripens after the middle of October and sometimes does not entirely fall until the following spring.

Sandy bottom-lands of the Brazos river, usually in open forests of live oaks at Columbia, Texas, *B. F. Bush*, November 1899; *Canby, Bush,* and *Sargent,* March 1900; *Bush,* April and October 1900.

Crataegus Berlandieri, n. sp.— Leaves oblong-obovate to oval, acute or acuminate at the apex, gradually narrowed below from near the middle and cuneate and entire at the base, irregularly divided into numerous acute or acuminate or, on vigorous shoots, rounded lobes, coarsely and often doubly serrate with broad spreading or incurved gland-tipped teeth; at the flowering time coated above with short pale soft caducous hairs and below with thick hoary tomentum, and at maturity rather thin but firm in texture, glabrous, dark green and very lustrous on the upper surface, pale and pubescent below, usually about 3 in. long and 2 in. wide, and on leading shoots often 4 or 5 in. long and from 2½ to 2 in. wide, with slender midribs and remote primary veins slightly impressed above and conspicuous secondary veins and reticulate veinlets; petioles stout, usually more or less winged above, tomentose, ultimately pubescent, from ½ to ¾ in. long;

stipules villose, falcate or on vigorous shoots lunate, coarsely glandular-serrate and frequently ½ in. in length. Flowers ¾ in. in diameter on stout elongated pedicels coated with hoary tomentum like the stout branches of the broad compound many-flowered cymes becoming lax after anthesis; bracts and bractlets oblong-obovate to lanceolate, finely glandular-serrate, conspicuous; calyx-tube broadly obconic, tomentose, the lobes broad, acute, very coarsely glandular-serrate, villose on both surfaces; stamens 20, filaments slender, elongated; anthers small; styles 5, slender, surrounded at the base by small tufts of snowy white hairs. Fruit in lax drooping clusters, short-oblong to subglobose, scarlet, about ½ in. long; calyx-cavity broad and deep, the lobes enlarged, coarsely serrate; flesh thin, yellow, dry, and hard; nutlets 5, rounded but not ridged, and occasionally obscurely grooved on the back, about ¼ in. long.

A tree 15 to 20 ft. in height, with spreading branches forming a broad open head, and slender slightly zigzag branchlets coated when they first appear with hoary tomentum, becoming puberulous and dull reddish-brown during the summer and pale gray-brown and glabrous during their second year, and nearly unarmed or furnished with occasional straight spines 1 in. in length.

Flowers from the middle to the end of March. Fruit ripens after the middle of October.

"De Bejur à Austin, Avril 1828," and "Villa d'Austin frio de los Brazos, Maio 1828," *J. L. Berlandier*, nos. 356 and 267 in Herb. Gray; near the banks of the Brazos river at Columbia, Texas, *B F. Bush*, October 1899, March, April, and October 1900.

✓ **Crataegus nitida,** n. sp. (*Crataegus viridis* var. *nitida* Britton & Brown, *Ill. Fl.* **2**: 242. 1897).—Glabrous with the exception of a few scattered pale caducous hairs on the upper side of the midribs of the unfolding leaves. Leaves lanceolate to oblong-obovate, acuminate at the apex, abruptly or gradually narrowed and cuneate at the entire base, coarsely glandular-serrate above with straight or incurved glandular teeth, more or less divided, particularly on leading shoots, into two or three pairs of broad acute lobes; when they first unfold membranaceous, dark red, soon becoming green and lustrous, almost fully grown when the flowers open, and at maturity thick and coriaceous, dark green and very lustrous on the upper surface, pale and dull on the lower surface, from 2 to 3 in. long, from 1 to 1½ in. wide, and on vigorous shoots often from 4 to 5 in. long and from 2 to 2½ in. wide, with prominent midribs usually red on the lower side and few slender prominent primary veins slightly impressed above and usually running to the points of the lobes; petioles stout, grooved, more or less winged above by the decurrent bases of the blades, glandular particularly on vigorous shoots, from ½ to ¾ in. long; stipules on vigorous shoots lunate, stipitate, coarsely glandular-serrate, occasionally ½ in. in length. Flowers ¾ in. in diameter on slender elongated pedicels in broad compound very thin-branched many-flowered corymbs; calyx-tube narrowly obconic, the lobes narrow, acuminate, elongated, entire or sparingly and irregularly glandular-serrate, reflexed after anthesis; stamens 15 to 20; filaments slender; anthers small, pale yellow; styles 2 to 5. Fruit in many-fruited drooping clusters, oblong, dull brick red, pruinose with a slight glaucous bloom, marked by small dark lenticels, from ½ to ⅝ in. long, ⅓ in. thick; calyx-cavity deep and narrow, the lobes little enlarged, dark red near the base on the upper side, usually erect, often deciduous before the maturity of the fruit; flesh yellow, thick, dry, sweet, and mealy; nutlets 2 to 5, rounded and ridged on the back with a low broad rounded ridge, light-colored, about ¼ in. long.

A tree often 30 ft. in height with a tall trunk from 12 to 18 in. in diameter covered with close dark bark broken into thick plate-like scales, spreading lower and erect upper branches forming a broad open rather irregular head, and slender nearly straight branchlets, bright orange-brown and lustrous during their first and second seasons, becoming pale reddish-brown during their third year, and ultimately ashy-gray, and unarmed or armed with few straight slender bright chestnut-brown lustrous spines from 1 to 1½ in. in length.

Flowers early in May. Fruit ripens toward the end of October.

Rich woods on the drier parts of the bottom-lands of the Mississippi river opposite St. Louis. East St. Louis, Illinois, *G. W. Letterman*, June 10, 1881, and *H. Eggert*, 1882. Banks of Mississippi river, near Oquawka, Illinois, *H. N. Patterson*. In November 1882, Mr. Letterman collected specimens of a Crataegus at Prescott, Arkansas, which may possibly belong to this species but the specimens are too fragmentary to make the determination satisfactory.

In the Arnold Arboretum the flowers of *Crataegus nitida* open during the first week in June and the fruit ripens towards the end of October and falls gradually. At this season of the year it is a handsome object, the large leaves of the long vigorous shoots having gradually turned to a rich orange-yellow color through shades of bronze and orange-red, while the leaves on the shoots of lateral branchlets are still green and very lustrous and make a beautiful contrast with the abundant but rather dull-colored fruit.

This species, which was distinguished by Dr. Engelmann on its discovery as *Crataegus nitens* in herb. was not published by him. It has been variously considered a variety of *Crataegus viridis* L., and as a natural hybrid of that species and of *Crataegus Crus-galli* L. The supposition of a hybrid can probably be safely dismissed. The plants are too numerous and were formerly too generally distributed over the Mississippi bottoms near St. Louis to make such a supposition probable; and the seedlings of this tree raised at the Arnold Arboretum which flower and fruit freely every year show none of the variation found in the descendants of hybrids when these are fertile. From *Crataegus viridis* it differs in its larger and much thicker and more lustrous leaves, larger flowers, much larger oblong pruinose fruit, and in its dark close bark, the bark of *Crataegus viridis* being pale or often nearly white and covered with thin loose scales.

✓ **Crataegus Brazoria,** n. sp.— Leaves oval to obovate, acute or acuminate at the apex, sharply wedge-shaped, or on leading shoots occasionally oblong and usually broadly cuneate or sometimes rounded at the base, coarsely and irregularly glandular-serrate above the middle with spreading teeth, mostly entire below; when the flowers unfold covered on both surfaces with short soft pale hairs, particularly on the lower side of the thin midribs and primary veins, and at maturity thin and firm, glabrous, dark green and lustrous on the upper surface, paler on the lower surface, from 2 to 2½ in. long, from 1¼ to 1½ in. wide, and on leading shoots often from 3 to 4 in. long and 3 in. wide; petioles slender, more or less winged above, tomentose, ultimately glabrous or puberulous, from ½ to ¾ in. long; stipules foliaceous, slightly falcate, acuminate, coarsely serrate, villose, long-stalked, from ⅓ to ½ in. long, often ⅓ in. wide, or on vigorous shoots lunate and usually entire. Flowers about ¾ in. in diameter in loose broad many-flowered compound thin-branched villose corymbs; calyx-tube narrowly obconic, villose with long matted white hairs, the lobes lanceolate, acuminate, obscurely glandular-serrate or nearly entire, villose on both surfaces, reflexed after anthesis; stamens 20; filaments slender, elongated; anthers small, dark red; styles 5, surrounded at the base by a thin ring of hoary tomentum. Fruit in spreading or drooping few-fruited glabrous clusters, subglobose or often rather longer than broad, bright canary-yellow, marked by a few large dark lenticels about ⅓ in. long; calyx-tube elongated, with a broad deep cavity, the lobes deciduous before the maturity of the fruit; flesh thin, light-colored, dry and mealy; nutlets 5, rounded and ridged on the back, about ¼ in. long.

Flowers from the middle to the end of March. Fruit ripens after the 1st of October.

A tree 20 ft. in height with a trunk 6 in. in diameter and 8 ft. tall with ashy gray bark covered with small closely appressed scales, numerous upright branches forming a handsome symmetrical round-topped head and slender slightly zigzag branchlets marked by small oblong pale lenticels, coated when they first appear with hoary tomentum, soon becoming glabrous and light reddish-brown, and ashy-gray during their second year, and apparently unarmed.

Still known only from a single individual growing by the roadside in the bottoms of the Brazos river in the town of Brazoria, Texas, where it was found on March 25, 1900, by *W. M. Canby*, *B. F. Bush*, and *C. S. Sargent*, and subsequently visited by Mr. Bush in April and October, 1900.

This very distinct and interesting species can perhaps be best grouped with *Crataegus viridis* Linn. From that species it differs in its larger flowers, in the bright canary-colored fruits, unlike in color those produced by any of the North American species now known, in the form and texture of the leaves and in the color of the bark of the trunk and branchlets.

Crataegus glabriuscula, n. sp. Glabrous with the exception of a few soft caducous hairs on the under surface of the large leaves of vigorous shoots and on the upper side of the calyx-lobes. Leaves oblong-ovate to semi-orbicular, or to broadly ovate on vigorous shoots, rounded, acute, or short-pointed at the apex, cuneate from below the middle and decurrent on the slender often glandular petioles, coarsely doubly serrate except toward the base, occasionally more or less deeply lobed above the middle, particularly on vigorous shoots, with two or three pairs of short broad acute lobes, membranaceous at the flowering time but at maturity subcoriaceous, hard and firm, dark green and lustrous on the upper surface, pale on the lower surface, from 1½ to 2 in. long, from ¾ to ½ in. wide, with slender pale yellow midribs and primary veins running obliquely toward the apex of the leaf, conspicuous secondary veins and reticulate veinlets; stipules lunate to semiorbicular, coarsely glandular serrate, from ⅓ to ½ in. wide, Flowers ½ in. in diameter on slender elongated pedicels, in few-flowered rather compact compound thin branched corymbs; bracts and bractlets linear, obscurely glandular-serrate, minute, caducous; calyx-tube broadly obconic, the lobes short, acute, entire or slightly and irregularly glandular-serrate, reflexed after anthesis; stamens 20; filaments slender, elongated; anthers comparatively large; styles 5. Fruit drooping on slender stems, oblong to obovate, dull orange-color, marked by minute dark lenticels, ¼ in. long; calyx-tube elongated with a deep broad cavity, the lobes but little enlarged, dull red on the upper surface toward the base, spreading or appressed, often deciduous; flesh very thin, yellow, dry and hard; nutlets 5, rounded or obscurely grooved on the back, about $\frac{3}{16}$ in. long.

A tree 20 to 25 ft. in height with a slender trunk often 12 in. in diameter, covered with brown scaly bark, ascending branches, forming a narrow head, and thin branchlets marked by many small pale lenticels, dark red-brown when they first appear, becoming bright chestnut-brown and very lustrous during their first summer and ashy-gray during their second year, and unarmed or armed with very slender straight chestnut-brown lustrous spines usually from ¾ to 1 in. in length.

Flowers about the middle of April. Fruit ripens in August. High dry bottom lands of the Trinity river and its branches at Dallas, Texas, in forests of *Ulmus crassifolia* and *Celtis Mississippiensis*, *J. Reverchon*, July 1899, *B. F. Bush*, April 1900.

Betula Alaskana, n. sp.—Leaves rhomboidal to broadly ovate and truncate or rounded at the base, acuminate, very coarsely dentate above the middle with glandular teeth, entire below, more or less covered with resinous glands while young, from 1½ to 3 in. long, from 1 to 1½ in. wide, dark green on the upper surface, yellow-green on the lower surface, the slender midribs and remote veins puberulous below or ultimately glabrous. Staminate catkins clustered, sessile, about 1 in. long, ⅛ in. thick, their scales ovate, acuminate, puberulous, light red, yellow on the margins. Pistillate catkins slender, cylindrical, pedunculate, about 1 in. long and ⅛ in. thick. Fruiting catkins from 1 to 1¼ in. long, from ⅓ to ½ in. thick, their scales about as long as broad, ciliate on the margins of the lobes, the central lobe acute or acuminate, the lateral lobes erect and acute or spreading and rounded.

A tree with close light red bark, usually from 35 to 40 ft. in height with a trunk 6 or 8 in in diameter, and occasionally 50 ft. in height with a trunk a foot in diameter, spreading and pendulous branches, slender red-brown branchlets more or less verrucose with conspicuous resinous glands, and obovate obtuse winter buds ¼ in. in length.

Saskatchewan, *E. Bourgeau*, 1858 (in Herb. Gray); near Prince Albert in latitude 53, July 1876, *John Macoun;* northwestward, reaching the Alaskan coast on the shores of the Lynn Canal (*Muir*, *Canby*, and *Sargent*, August 1897); and westward.

This is the "canoe birch" of all travelers in Alaska, and it is the common birch tree of the Yukon valley, where it grows sparingly near the banks of that river in coniferous forests and abundantly on sunny slopes and hillsides, and extends down the river at least as far as the Russian mission, two hundred and thirty-three miles above its mouth (M. W. Gorman *in litt.*).

From *Betula papyrifera* Marsh, which is common in one of its forms in southern Alberta, northern Idaho, and Montana, and in the Blue mountain region of eastern Washington and Oregon, *Betula Alaskana* may be distinguished by the close reddish bark of the trunk which is less flexible and does not separate as easily into layers as the bark of the eastern canoe birch, by the much more verrucose branches, obtuse winter buds, rhomboidal long-pointed leaves, stouter fruiting catkins, and by the more habitually acute or acuminate central lobe of their scales. The specimen in Herb. Gray collected by Bourgeau in flower on the Saskatchewan was referred by Regel (*Bull. Mosc.* **18** : 398; *DC. Prodr.* **16**^{2} : 164) to his *Betula alba*, subspecies *verrucosa δ resinifera*, the Asiatic types of this variety being from Udskoi in eastern Siberia and from Transbaical. Specimens of the Alaska tree sent by me to the Herbarium of the Imperial Botanic Garden at St. Petersburg were pronounced, however, unlike any Asiatic species, and with the slight knowledge of the northern Asiatic species of Betula which we possess in this country it does not seem safe to follow Regel in uniting North American with Asiatic species. To Mr. Gorman I am indebted for very complete specimens of *Betula Alaskana* collected at different points on the Yukon in 1899, and for the first reliable information I have been able to obtain in regard to the trees of the Yukon valley and their distribution.

BETULA OCCIDENTALIS Hooker. There are three arborescent birches in the region between the eastern base of the Rocky mountains in the United States and the shores of Puget sound and British Columbia.

First, *Betula papyrifera* Marsh, in one of its forms which enters this region from the east and is not rare in northwestern Nebraska, northern Dakota, Idaho, and Montana, and reaches the mountains of eastern Oregon.

Second, the large tree which grows on the lower Fraser river, on the shores and islands of Puget sound, and on Vancouver island. This tree has reddish bark which is particularly noticeable on young plants, pubescent branchlets, acute winter-buds, leaves pubescent on the lower surface, and fruiting catkins about 1¼ in. long and ½ in. thick, with scales longer than broad, the middle lobe being acuminate and much elongated. Specimens of this tree, which is perhaps the largest of all birch-trees, were first gathered on the shores of the straits of Fuca by Dr. John Scouler during his visit to the northwest coast in 1825–1827. These specimens were described by Hooker in his *Flora Boreali-Americana* as *Betula occidentalis*, although with them he united a specimen collected by Douglas in the interior but west of the Rocky mountains. The tree from the straits of Fuca appeared first in the description of *Betula occidentalis* which was evidently drawn principally from the specimen of that tree, and must be considered the type of Hooker's species, while the second specimen included in this description, collected by Douglas, is the Rocky mountain form of Betula papyrifera. In the shape of the leaves this species resembles some of the forms of *Betula papyrifera*. The bark, however, is very different from that of the eastern tree, and it is probably best to consider it a species.

Third, the half-shrubby dark-barked species with spreading gracefully drooping stems which ranges as far south as Colorado, Utah, and northern California. This plant was collected by Nuttall on the Sweetwater, one of the branches of the Platte, and was first described and figured by him as *Betula occidentalis* (*Sylva* **1** : 23. *pl. 7*). Torrey in the Botany of Fremont's Expedition repeats this error. This same species was also described and figured in *King's Rep.* (**5** : 323. *pl. 35*) as *Betula occidentalis* by Watson who repeated his error in the *Botany of California*, and it is this plant which is described and figured as *Betula occidentalis* in my ninth volume of *The Silva of North America*, where an allusion only is made to the true *Betula occidentalis* of the coast in a note under *Betula papyrifera*. Nuttall found another small birch in the Rocky mountain region and on the plains of the Columbia which he described and figured as *Betula rhombifolia* in the first volume of his *Sylva* published in 1842. This plant, judging by one of Nuttall's original specimens in the Gray Herbarium, is the narrow-coned form of the plant described by

Nuttall as *Betula occidentalis*, which is common in eastern Oregon and Washington and eastward into Montana and Idaho. If the two forms, which seem to vary only in the thickness of the cones, are considered to belong to one species, this would have to bear Nuttall's name of *Betula rhombifolia*, if Tausch four years before had not used that name for an European species. Some of the specimens of this third species bear a strong resemblance to a fragmentary specimen of *Betula microphylla* Bunge, as pointed out to me by Mr. M. L. Fernald, but this evidence of the identity of the Rocky mountain and the Altai plants would hardly seem to warrant the adoption of Bunge's name for our tree, for which I now propose the name of **Betula fontinalis.**

✓ **Cupressus pygmaea,** n. sp. (*Cupressus Goveniana* var. *pygmaea* Lemmon, *Handbook West-American Cone-bearers* 77. 1895. *Cupressus Goveniana* Sargent, *Silva, N. Am.* **10** : 107 in part (not Gordon). 1896.—The Cupressus of the coast region of Mendocino county, California, can be readily distinguished from the other North American species by its thin black seeds not more than ⅛ in. long which show no tendency to vary to the thick light red seeds of *Cupressus Goveniana* which are fully ¼ in. in length. This character and the isolation of the region which it inhabits remote from that occupied by other species make it possible and convenient to separate this northern tree from the *Cupressus Goveniana* of central and southern California, to which it was doubtfully referred by Englemann in herb. who, like myself when the tenth volume of *The Silva of North America* was published in 1896, was unacquainted with the seeds. From *Cupressus Goveniana* the northern tree differs also in its rather stouter branchlets with deeper green never glaucous foliage, usually sessile often oblong cones with less prominent bosses on their scales which vary from six to ten in number, while the cones of *Cupressus Goveniana* are usually composed of six scales. In a genus like Cupressus where individuals vary greatly within certain limits and good specific characters are so difficult to find, these peculiarities would hardly justify the separation of the northern tree from *Cupressus Goveniana* were it not for the character found in the seeds which make this the easiest of our species to recognize.

Cupressus pygmaea inhabits the high barren region on the coast of Mendocino county, extending from Ten Mile run on the north to the Navarro on the south, and, beginning about three quarters of a mile from the ocean, does not extend inland more than four miles. The soil of these barrens is yellow clay covered with deposits of sea sand and a thin layer of peat. On this poor soil the plants begin to bear cones when only a foot or two high, but on the borders of the barrens and of the deep gullies which penetrate them where trees occasionally escape for several years the fires which constantly sweep over the region they grow in better soil to a height of 30 or 40 feet, but from overcrowding rarely develop the spreading branches peculiar to all species of Cupressus growing in abundant space.

The name *pygmaea* used by Lemmon to distinguish the dwarf plant stunted by overcrowding and insufficient nourishment is unfortunate as a specific name, for there is no difference between the smallest and the largest plants except in size; and it is probable that individuals of this species on the borders of the barrens, if they could be protected from fire, would in time grow to a large size, for the oldest plants now standing show no signs of maturity and none of them are believed to be much more than fifty years old (C. Purdy *in litt.*).

ARNOLD ARBORETUM.

THE EFFECT OF HYDROCYANIC ACID GAS UPON GRAINS AND OTHER SEEDS.

C. O. TOWNSEND.

(WITH SIX FIGURES)

INTRODUCTION.

THE experiments which form the basis of this paper were undertaken more than two years ago for the purpose of determining the effect of hydrocyanic acid gas upon the germination of seeds. The necessity for the work arose from the rapidly increasing use of this gas in the destruction of insect pests infesting stored grains and other seeds. Since these experiments were begun a number of the largest flour mills in this country and Canada have been fumigated for the destruction of insects without removing the thousands of bushels of grain stored in the mills, and likewise numerous barns and granaries filled with grain have been fumigated for the same purpose. Since the grain thus fumigated may be used either for seed or for food, it is important to know whether or not the germinating quality of the grain has been injured and whether grain thus treated would be injurious for food. A preliminary account of the experiment in regard to germination of seeds after treatment with hydrocyanic acid gas was read before the Botanical Section of the A. A. A. S. at the Columbus meeting and subsequently published.[1]

The use of hydrocyanic acid gas for fumigating purposes is of comparatively recent origin, having been introduced by the U. S. Department of Agriculture, Division of Entomology, in 1886, for the fumigation of orange trees. It was first used for the fumigation of greenhouses by Dr. A. F. Woods,[2] Director of the

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[1] TOWNSEND: "The effect of hydrocyanic acid gas upon the germination of seeds." Sci. Amer. Suppl., no. 1248, 2 D. 1899.

[2] WOODS: The variable effects of hydrocyanic acid gas on plants and animals. Rep. Soc. Plant Morph. and Physiol., Am. Nat. 1899.

Division of Vegetable Physiology and Pathology, and even before it was used for fumigating purposes its effect in solution was determined by Dr. Loew.[3]

This gas has now come into universal use not only for the fumigation of trees and grains as above indicated, but also for the fumigation of greenhouses,[4] nursery stock, and even orchard trees of all kinds.[5]

The object of the writer in performing these experiments, the results of which are herein recorded, has been simply to determine whether or not hydrocyanic acid gas has any injurious effect upon grains or other seeds; and, if so, under what conditions and to what extent the injury is produced. Hence this paper is merely preliminary to the more minute study of the subject, since it deals only with the cause and effect, while the nature of the action of the poison upon the several parts of the seed still remains for further investigation.

In general the methods employed in these experiments have consisted simply in placing the seeds to be tested in air tight chambers in which hydrocyanic acid gas is generated. In the first experiments the chambers consisted of air tight boxes of several cubic feet capacity, used primarily for the fumigation of nursery stock. These boxes were open on one side, the open side being placed next the ground, which was first made perfectly smooth and level. In experimenting with these boxes, they were raised slightly on one edge, the material to be fumigated was placed under them, and at the moment the hydrocyanic acid gas was generated the boxes were lowered and sand quickly pressed around the edges next the ground, making them practically gas-tight. In these as in the subsequent experiments the gas was generated by placing cyanid of potassium (KCN) in dilute sulfuric acid (H_2SO_4), the result of the chemical action being the evolution of hydrocyanic acid gas (HCN) according

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[3] LOEW: Natur. System der Giftworkung. Bull. Imp. Univ. Coll. Agr. 1: 34. 1893. The poisonous action of dicyanogen.

[4] WOODS and DORSETT: The use of hydrocyanic acid gas for fumigating greenhouses and cold frames. Circ. no. 37. Ser. 2, U. S. Dept. Agr., Div. Ent.

[5] JOHNSON: Report on the San José scale. Bull. 57, Md. Agr. Exper. Station. 1897.

to the following chemical equation: $2KCN + H_2SO_4 = 2HCN + K_2SO_4$. In the later experiments bell jars were used having a capacity of approximately one third of a cubic foot each (*fig. 1*). The bell jars were provided with ground glass stoppers, and were placed on ground glass plates, the edges being sealed with oil to prevent the escape of the gas. Having prepared the seeds in the manner desired, they were placed on the ground glass plate, and in a small beaker directly in the center of the plate was the dilute sulfuric acid, so that when the bell jar was placed in position the beaker containing the sulfuric acid was exactly below the glass stopper in the bell jar. The potassium cyanid was carefully weighed and wrapped in fine tissue paper. A piece of twine, just equal in length to the distance from the lower surface of the glass stopper in the bell jar to the bottom of the beaker containing the sulfuric acid, was tied to a package containing the desired weight of potassium cyanid, and the other end of the string was fastened by means of soft paraffin to the lower surface of the glass stopper of the bell jar. When everything was ready to begin the experiment the package of potassium cyanid attached to the string was lowered through the opening in the top of the bell jar, and just at the instant when this package came into contact with the dilute sulfuric acid the ground glass stopper fell into place and thus hermetically sealed the jar. By this means it was possible to keep the seeds for any required length of time in an atmosphere of hydrocyanic acid gas of desired strength. When the bell jars were opened, even after several months, the characteristic odor resembling peach kernels could be detected, showing that the gas had neither escaped nor been absorbed, although in at least some of the experiments a portion of the gas was probably absorbed, since it has a strong affinity for moisture. It should be borne in mind that both the potassium cyanid and the hydrocyanic acid gas are deadly poisons and great care should be exercised in using them. Potassium cyanid is a white solid and is on the market in several forms. It should be purchased for use in the lump form usually known as 98 per cent. cyanid of

FIG. 1.—Bell jars in which the effect of hydrocyanic acid gas upon the germination of seeds is being determined.

potassium, and should be kept in air tight cans or jars until ready for use.

If the seeds were to be treated in the dry state, no moisture was added except what was used to dilute the acid, and this consisted of only a few cubic centimeters of water. On the other hand, if damp seeds were to be treated with hydrocyanic acid gas, they were first soaked for the desired length of time in water, and then placed on moist filter paper under the bell jar, which was lined with damp filter paper, thus providing for the seeds a moist atmosphere favorable for their germination. All the chambers, whether damp or dry, were kept in the general laboratory where a pretty constant temperature of about 18° C. was maintained. Further details in regard to methods can best be made clear by referring to the accompanying tables and their descriptions. The materials used in these experiments consisted for the most part of corn, wheat, beans, and clover seed. Occasionally other seeds were used in addition to those mentioned, but these four were carried through all the experiments and may be considered as fairly representing the seeds of monocotyledonous and dicotyledonous plants. Under certain conditions some of the seeds used seemed to be more sensitive to the treatment to which they were subjected than the others, but in general the behavior of the seeds under the conditions used was similar for all seeds under identical conditions, the difference being simply a matter of degree. In other words, if the effect of the treatment was to accelerate germination all the seeds germinated more quickly than under normal conditions, whereas if the effect of the treatment was to retard germination then all germinated less readily than under normal conditions, although all seeds of the same kind did not germinate at the same moment.

The strength of hydrocyanic acid gas used in these experiments is stated in terms of the weight per cubic feet of space to be fumigated of the cyanid of potassium used in generating the gas. In fumigating nursery stock for the destruction of insect pests, as well as for fumigating mills, barns, etc., 0.25^{gm} of cyanid of potassium is used for each cubic foot of space to be fumigated.[6]

In these experiments the strength of the gas varied from 0.003^{gm} per cubic foot to 1.45^{gm} per cubic foot. While in the first experiments the object was simply to determine whether or not the ordinary strength of the gas used in fumigation would be harmful to the grain or other seeds, in the later experiments an effort was made to determine the maximum and minimum strength of gas that the seeds could resist under the several conditions employed. It should be noted that time is an important factor in these experiments. Nursery stock may be fumigated in thirty minutes, so that all insect life will be destroyed; but in fumigating buildings in which large bulks of grain are stored time must be allowed for the gas to penetrate the mass of grain and thus reach the insects that may be scattered through it. While time is being given for the gas to penetrate the bulk of grain, the grain on the surface of the bulk is exposed to the influence of the gas from the time it is generated. Hence an effort was made to determine the maximum and minimum time required for the grains to respond to the influence of the various strengths of gas used under the several conditions employed, and with this point in view the exposures varied from one hour to one year.

EXPERIMENTS WITH DRY SEEDS.

Trial experiments.—In the first experiments dry seeds were placed in shallow dishes and exposed for one hour to charges of gas varying in strength from 0.25^{gm} to 1.45^{gm} of potassium cyanid per cubic foot. Only a thin layer of seeds was placed in each dish, so that the gas came directly into contact with each seed. At the end of one hour the seeds were taken from the fumigating chamber and placed in hydrant water for twenty-four hours. At the expiration of this time they were spread upon moist filter paper in damp chambers and kept at ordinary room temperature of about 18° C. In this, as in all the other tests, control experiments were used in which the seeds were treated in precisely

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[6] JOHNSON, *loc. cit.*

the same manner and kept under exactly the same conditions as in the subsequent experiments, except that they were not subjected to the influence of the gas.

The first line in each table expresses the result of the control experiments for that particular set of experiments, so that in whatever manner the seeds under examination behaved it was clear that the variation in behavior from the seeds in the control experiments resulted entirely from the effect of the hydrocyanic acid gas.

In all cases it was found that the seeds that had been subjected to the gas for one hour germinated just as readily as if they had not been in the gas at all. Hence it may be concluded that perfectly dry seeds may be subjected for a short time to the influence of gas six times as strong as that ordinarily used in fumigation without any appreciable injury to the germinating quality of the seed.

TABLE I.

Dry seeds subjected to the influence of hydrocyanic acid gas, then soaked and placed under conditions favorable for germination; temperature 18° C.

Amount of KCN per cubic foot	Time of exposure to gas	Time of soaking	Time required for germination	Percentage of germination	Subsequent growth of seedlings
0.00 . . .	1 hour	24 hours	24 hours	100	normal
0.25 . . .	1 "	24 "	24 "	100	"
0.45 . . .	1 "	24 "	24 "	100	"
0.60 . . .	1 "	24 "	24 "	100	"
0.75 . . .	1 "	24 "	24 "	100	"
1.00 . . .	1 "	24 "	24 "	100	"
1.25 . . .	1 "	24 "	24 "	100	"
1.45 . . .	1 "	24 "	24 "	100	"

Subsequent experiments.—In the trial experiments the seeds were subjected to the influence of hydrocyanic acid gas for one hour only. In order to determine the influence of this gas upon seeds exposed for a long time, subsequent experiments with dry seeds were undertaken. The seeds were placed in shallow dishes which were covered by bell jars, made air tight, and the gas generated in the manner described. Control experiments were started at the same time, in which the seeds were covered by bell jars under the same conditions as in the experiments, with the exception that no KCN was placed in the dilute sulfuric acid. The results are best expressed in the following table:

TABLE II.

Dry seeds treated with hydrocyanic acid gas for long periods of time: temperature throughout about 18° C.

Amount of KCN per cubic foot	Time of exposure to gas	Time of soaking	Time required for germination	Percentage of germination	Subsequent growth of seedlings
0.000	0	24 hours	24 hours	100	normal
0.333	15 days	24 "	12 "	100	accelerated
1.000	15 "	24 "	7 "	100	accelerated
0.333	60 "	24 "	9 "	100	accelerated
1.000	60 "	24 "	14 "	100	slightly retarded
0.333	153 "	24 "	30 "	75	slightly retarded
1.000	153 "	24 "	36 "	60	greatly retarded
0.333	240 "	24 "	76 "	50	retarded half
1.000	240 "	24 "	96 "	10	very slight
0.333	365 "	24 "	240 "	20	none
1.000	365 "	24 "	no germination	0	

From the foregoing table it will be seen that the seeds were constantly under the influence of the gas for from fifteen days to one year. The strength of the gas was constant in each jar, *i. e.*, it did not vary except possibly by the absorption of a small quantity of the gas into the seeds and into the few cubic centimeters of dilute acid used in generating the gas. It is surprising that the seeds should germinate more readily after they had been exposed to the gas for a few days, although the same phenomenon was observed in the action of ether upon the germination of seeds.[7]

At the expiration of sixty days the acceleration of germination had passed its maximum, and shortly after began to be retarded, until at the end of two hundred and forty days germination practically ceased for those seeds that were exposed to the gas from one gram of KCN per cubic foot (*fig. 2, c*). The seeds that were in the weaker charge of gas continued to

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[7] TOWNSEND: The influence of ether upon the germination of seeds and spores. BOT. GAZ. **27**:458. 1899.

germinate about four months longer, but that was evidently the limit, as only a few of the seeds germinated very feebly at the expiration of that time (*fig. 3, b*). Not only was the germination hastened, but the subsequent growth was likewise accelerated for a limited time. Although the subsequent growth of seedlings was in some instances very marked, being almost double that of the normal, this acceleration was of short duration, rarely lasting more than one week, and then gradually resuming the normal rate of growth. Hence the acceleration is probably not of sufficient duration to be of any commercial value.

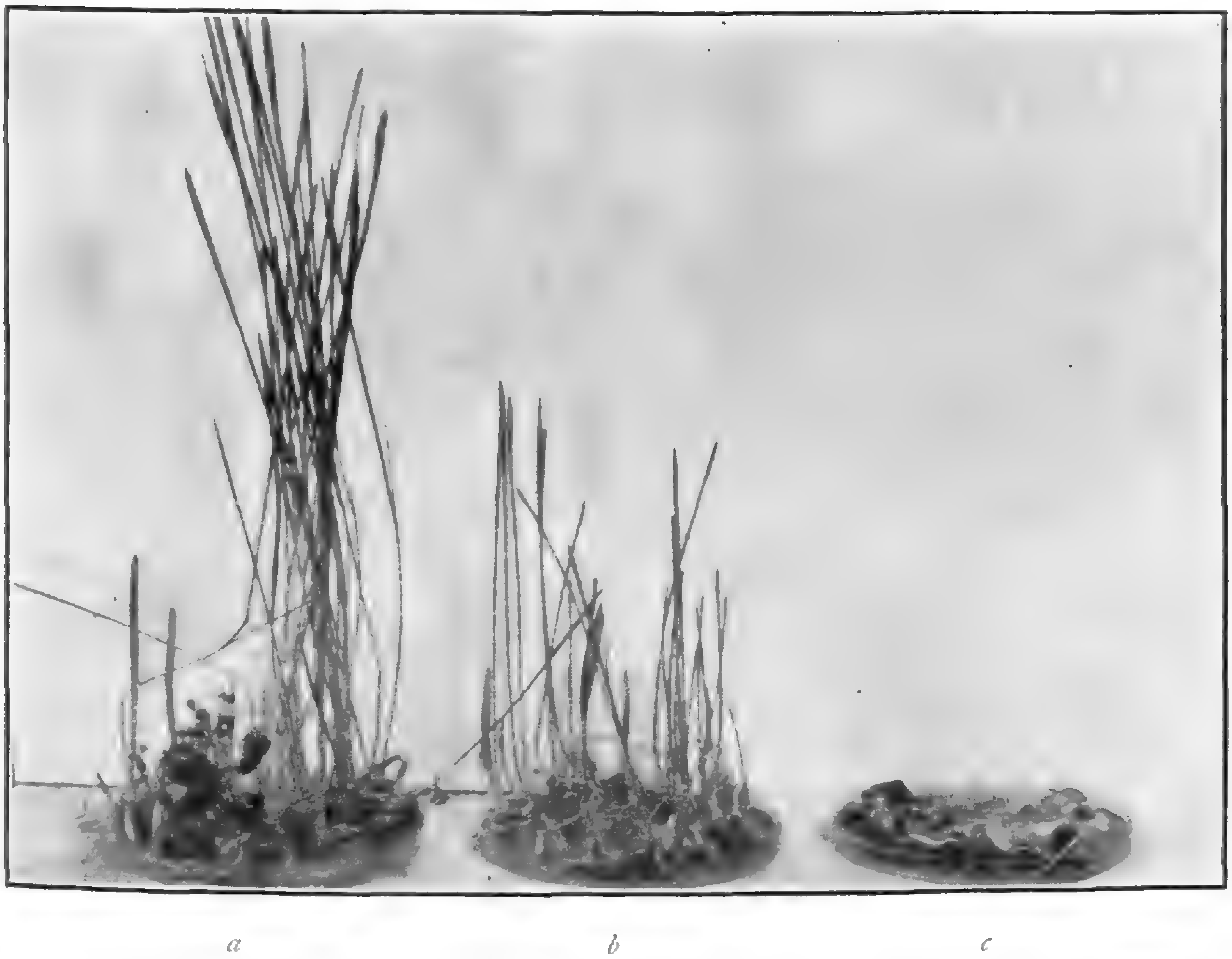

FIG. 2.—*a*, control; *b*, from seeds that were eight months in gas from 0.333^{gm} KCN per cubic foot; *c*, seeds that were eight months in gas from 1^{gm} KCN per cubic foot.

It appears from these experiments that dry seeds may be treated with hydrocyanic acid gas continuously for several weeks without reducing the percentage of germination or interfering seriously with the subsequent growth of the seedlings. It is clear, however, that the gas has a marked influence upon dry seeds. The extent of the influence depends upon the amount of gas per cubic foot and upon the time the seeds are subjected to its influence. After sixty days the percentage of germination was gradually reduced, and the subsequent growth of seedlings was likewise retarded. The greater reduction in the percentage of germination, as well as in retardation of growth, depended upon the length of time of exposure to the gas and upon the amount of gas present. At the end of eight months the seeds in the gas from one gram of KCN had practically lost their ability to germinate, since only one in ten was capable of even slight germination, and those were too feeble for subsequent growth (*fig. 2, c*). If the gas was generated from only one third of a gram of KCN per cubic foot, the seeds retained their ability to

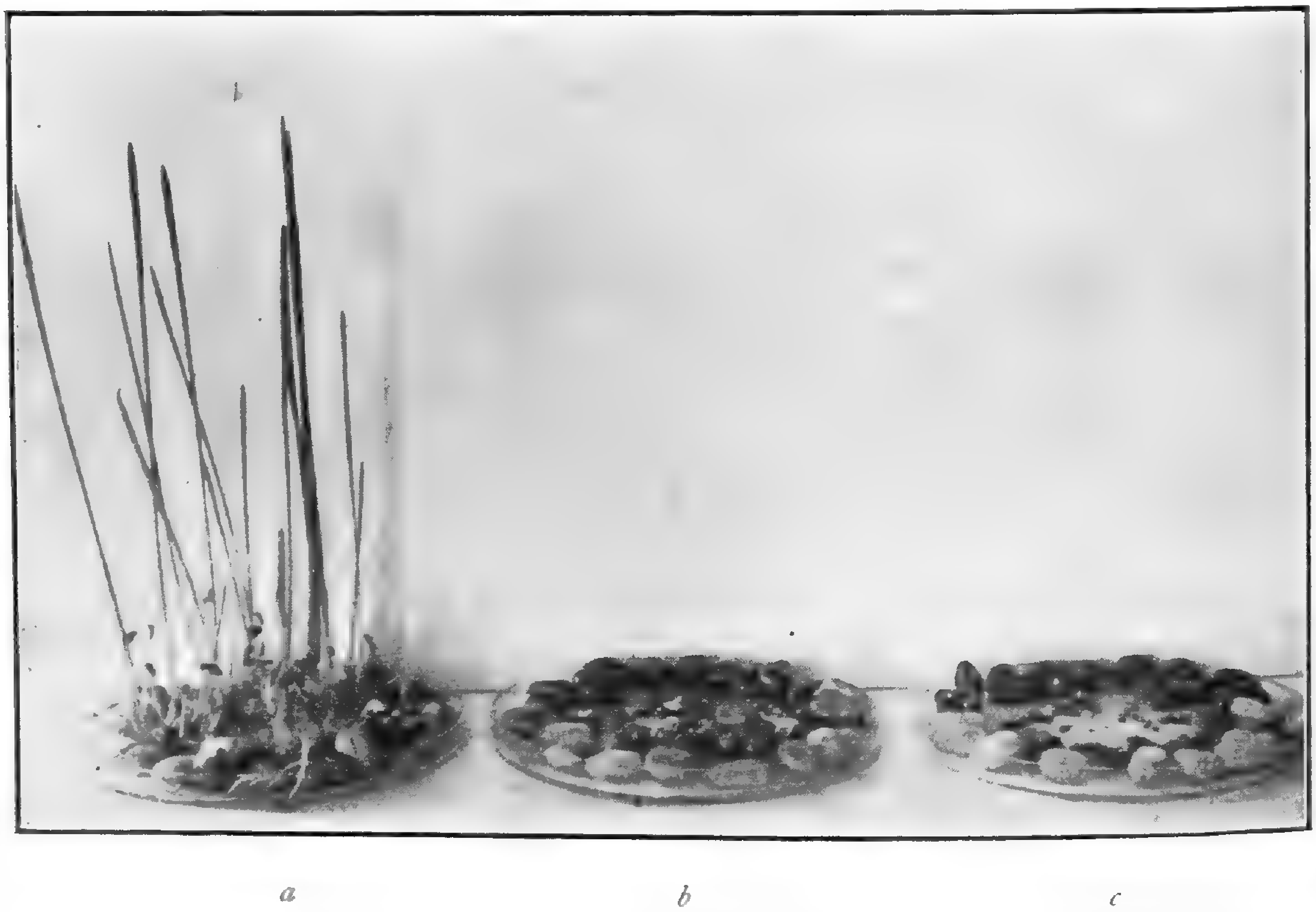

FIG. 3.—*a*, control; *b*, seeds that were one year in gas from 0.333^{gm} KCN per cubic foot; *c*, seeds that were one year in gas from 1^{gm} KCN per cubic foot.

germinate four months longer, or one year from the beginning of the experiment (*fig. 3, b*). In general it may be stated that the length of time that dry seeds retain their ability to germinate varies inversely with the strength of gas to which the seeds are subjected. Likewise the converse of this is true, viz., that the strength of gas that will prevent seeds from germinating varies inversely with the time that the seeds are subjected to the influence of the gas. These rules are stated only for the seeds that are subjected to the gas under the foregoing conditions, and will not apply with certainty to seeds under other conditions. It should be stated in this connection that the seeds in the control jar did not germinate quite normally either in percentage or point of time at the end of twelve months (*fig. 3, a*). To what this slight variation was due has not yet been determined, but it does not seem probable that it was sufficient to affect the results in the jars containing the gas. Seeds from the original packages not inclosed in a jar germinated normally, *i. e.*, 100 per cent. in twenty-four hours.

EXPERIMENTS WITH MOIST SEEDS.

Since it may sometimes be necessary to fumigate grain or other seeds while in a moist condition, experiments were undertaken for the purpose of determining what effect hydrocyanic acid gas would have upon seeds that had been soaked for a longer or shorter time in water. After soaking the seeds the following conditions were observed, viz., the damp seeds were left to germinate in the gas which was of different strengths in different jars; they were then placed for a time in the gas of different strengths and then removed to a gas free atmosphere.

Damp seeds allowed to remain in hydrocyanic acid gas.—By referring to tables III, IV, and V it will be seen that the seeds were soaked for different lengths of time, and that they were subjected to atmospheres of gas of different strengths.

FIG. 4.—Corn and wheat seedlings. The larger one in each case is normal, while the smaller ones were from seeds treated eight months with gas from 0.333^{gm} KCN per cubic foot.

TABLE III.

Germination of damp seeds and subsequent growth of resulting seedlings in hydrocyanic acid gas; temperature throughout about 18° C.

Amount of KCN per cubic foot	Time of soaking	Time required for germination	Percentage of germination	Subsequent growth of seedlings
0.000	24 hours	24 hours	100	normal
0.003	24 "	168 "	90	very slow
0.010	24 "	no germination	0	. . . .
0.050	24 "	no germination	0	. . . .
0.060	24 "	no germination	0	. . . .
0.075	24 "	no germination	0	. . . .

It will be observed in table III that the amount of KCN used varied from 0.003 to 0.075^{gm} per cubic foot, but that no germination took place if more than 0.003^{gm} was used, and indeed in this strength of gas germination was delayed for six days. Other quantities of KCN between 0.003 and 0.010^{gm} were used, but the seeds seemed to be unable to germinate in any charge stronger than 0.003^{gm} per cubic foot. The subsequent growth of the seedlings in this very small amount of hydrocyanic acid gas was very slight, and did not exceed two inches in ten days, in some instances the growth being only a fraction of an inch.

TABLE IV.

Same as table III, except that the seeds were soaked for a shorter time before placing in the gas.

Amount of KCN per cubic foot	Time of soaking	Time required for germination	Percentage of germination	Subsequent growth of seedlings
0.000	12 hours	24 hours	100	normal
0.003	12 "	36 "	80	slight
0.010	12 "	36 "	40	very slight
0.050	12 "	40 "	20	none
0.060	12 "	no germination	0	. . . .
0.075	12 "	" "	0	. . . .

In the experiments recorded in table IV the seeds were soaked only twelve hours, but the control seeds germinated in practically the same time as in the preceding case where the seeds were soaked for twenty-four hours. It is also important to note that the small charge of only 0.003^{gm} of KCN retarded the germination but a few hours as compared with the retardation produced by the same charge of gas when the seeds were soaked for twenty-four hours. It is likewise a noteworthy fact that when the seeds were soaked but twelve hours they were much more resistant to the influence of hydrocyanic acid gas, as evidenced by the fact that at least a few of the seeds were able to germinate in as much as 0.050^{gm} of KCN per cubic foot. The subsequent behavior of the seedlings was the same as in the preceding case, *i. e.*, there was little or no growth after the plant escaped from the seed coats. In general it was found that the shorter time the seeds were soaked the more resistant they were to the influence of the gas.

TABLE V.

Same as table III, except that the seeds were soaked for a longer time before placing in the gas.

Amount of KCN per cubic foot	Time of soaking	Time required for germination	Percentage of germination	Subsequent growth of seedlings
0.000	36 hours	20 hours	100	normal
0.003	36 "	48 "	60	slight
0.010	36 "	no germination	0	. . . .
0.050	36 "	" "	0	. . . .
0.060	36 "	" "	0	. . . .
0.075	36 "	" "	0	. . . .

In these experiments it will be seen that the extra amount of soaking caused the seeds to germinate more readily than they would have done had they been soaked but twenty-four hours, both in the case of the control experiments and in the experiments in which but 0.003^{gm} of KCN was used. However, the seeds did not germinate as readily as they did when soaked but twelve hours, nor was the percentage of germination so high as in either of the preceding cases. It is probable that the germination took place more quickly than in the experiments recorded in table III, because the seeds were more advanced before they were removed from the water and placed in the gas. In all cases the seeds were extremely sensitive and made but very slight growth after breaking through the seed coats. Leaving out of account the advance that the seeds made toward germination while they were in the water and before placing them in the gas, it appears that their sensitiveness increased with the length of time that they were allowed to soak. This is to be expected since hydrocyanic acid gas has a strong affinity for moisture and is readily absorbed by water.

Seeds soaked for a definite time in water, placed for a given time in hydrocyanic acid gas, and then removed to a gas free atmosphere.— When it was observed that the seeds which had been soaked and then placed in hydrocyanic acid gas germinated more slowly than under normal conditions, it was apparent that the seeds were being held in a dormant state for a longer or shorter time depending upon the length of time the seeds were soaked, upon the strength of gas used, and upon the length of time that the seeds were allowed to remain in the gas. In order to get more definite information in regard to this point, experiments were undertaken whose results are recorded in tables VI and VII.

TABLE VI.

Germination of seeds and subsequent growth of seedlings after soaking in water, then placing for a definite time in hydrocyanic acid gas, and then removing to a gas free atmosphere; temperature 18° C.

Amount of KCN per cubic foot	Time of soaking	Time of exposure to gas	Time required for germination	Percentage of germination	Subsequent growth of seedlings
0.000 . . .	24 hours	0	24 hours	100	normal
0.003 . . .	24 "	168 hours	already germ.	90	slow
0.010 . . .	24 "	168 "	168 hours	50	very slow
0.050 . . .	24 "	168 "	336 "	20	barely started
0.060 . . .	24 "	168 "	no germination	0	....
0.120 . . .	24 "	168 "	" "	0	....

As shown in table III, seeds that have been soaked for twenty-four hours and then left for seven days or 168 hours in an atmosphere containing gas from 0.003^{gm} of KCN per cubic feet were able at the end of that time to germinate without removing from the gas, while seeds subjected to a stronger charge of gas were unable to germinate in the gas. Hence the experiments as recorded in table VI were undertaken. In these experiments the seeds were treated as in the experiments recorded in table III, except that at the end of seven days the seeds exposed to the gas from 0.010^{gm} of KCN or more per cubic foot were removed from the gas and placed in a gas free atmosphere. At the end of seven days, after placing the seeds in ordinary atmosphere, 50 per cent. of those that had been exposed to the gas from 0.010 of KCN germinated. In other words, the seeds that germinated had been held in a dormant condition for seven days in the gas and for seven days after removing from the gas, a total of fourteen days. Likewise seeds that had been in the gas from 0.050^{gm} of KCN per cubic foot were held in a dormant condition for twenty days. In the preceding case only five

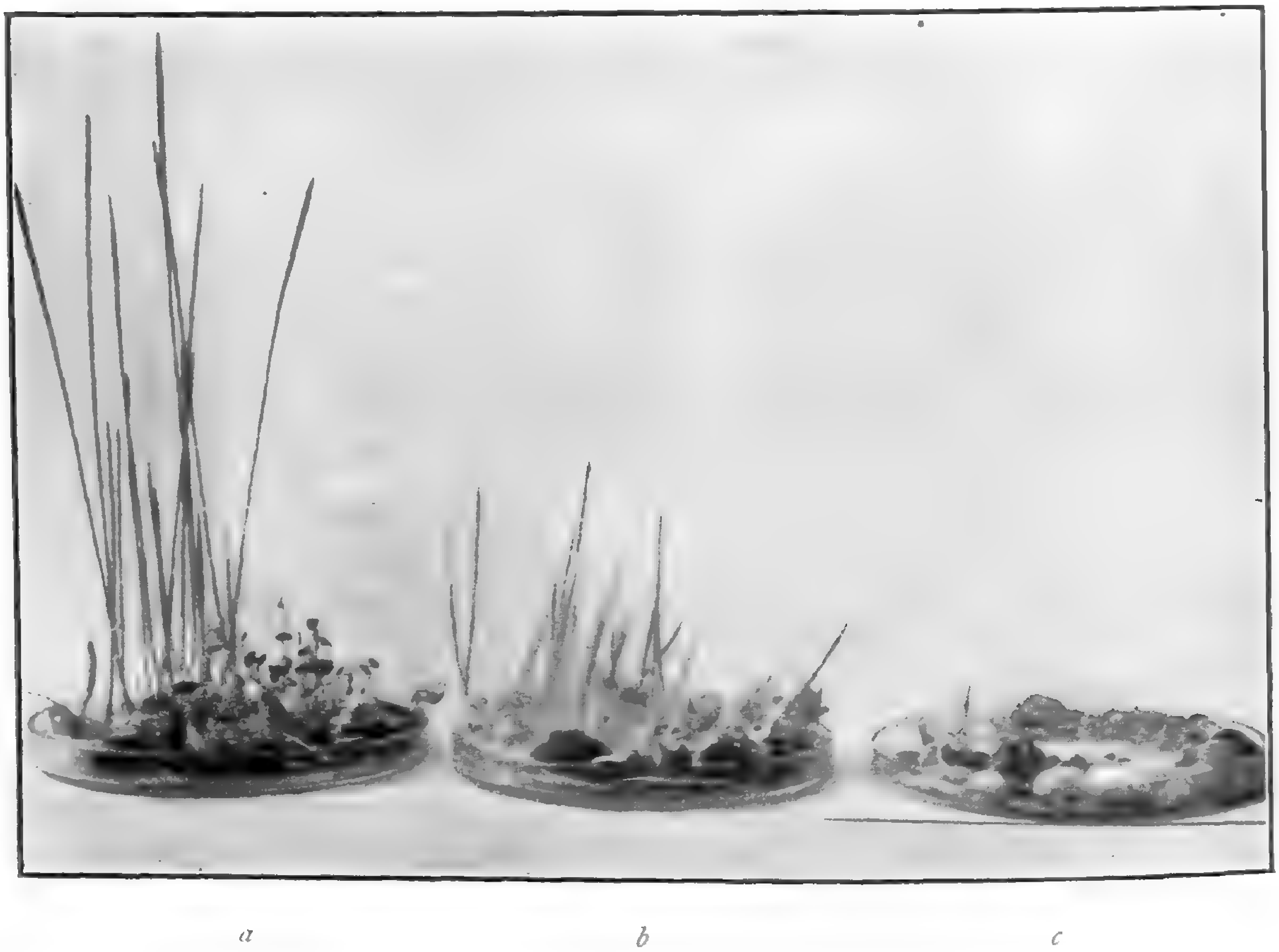

FIG. 5.—*a*, control; *b*, seeds were in gas from .030^{gm} KCN per cubic foot for 168 hours; *c*, seeds were in gas from .010^{gm} KCN per cubic foot for 168 days.—Photographed at end of 18 days. See table VI.

seeds out of every ten germinated, while in the latter instance only two seeds out of every ten germinated. Hence it should be noted that much depends upon the natural vitality of the seeds, not only in these experiments but in all cases where seeds are subjected to similar treatment. If the seeds were subjected for seven days to a charge of gas greater than that produced from 0.050^{gm} of KCN per cubic foot, they were unable to germinate in a single instance. In those cases where germination did take place, the subsequent growth of the seedlings was always slow and feeble. It is true that some of the seedlings, in these as well as in other experiments where the subsequent growth was slow, were able to overcome the influence of the gas after a longer or shorter time and to grow at the normal rate.

Since the seeds subjected to the gas from more than 0.050^{gm} of KCN per cubic foot were unable to germinate, it was decided to test the effect of a comparatively strong charge of the gas for a short time. The results of these experiments are recorded in table VII.

TABLE VII.

Same as table VI, except that a stronger charge of hydrocyanic acid gas was used for a short time.

Amt. of KCN per cubic foot	Time of soaking	Time of exposure to gas	Time required for germination	Percentage of germination	Subsequent growth of seedlings
0.000 . .	24 hours	0	24 hours	100	normal
0.250 . .	24 "	3 hours	72 "	50	"
0.250 . .	24 "	6 "	no germination	0	....
0.250 . .	24 "	12 "	" "	0	....

In these experiments it was found that some of the seeds were able to resist for more than three hours the influence of the gas from 0.25^{gm} of KCN per cubic foot, although after three hours one half the seeds were unable to germinate and the other half were held in check for seventy-two hours or forty-eight hours beyond the usual time of germination. However, the seeds that did germinate produced seedlings that grew at the normal rate.

Seeds soaked, treated with gas, washed and placed in HCN-free atmosphere.— The experiments recorded in table VIII were undertaken in order to determine whether the hydrocyanic acid gas that retarded germination after the seeds were removed from the atmosphere of the gas remained in the moisture that adhered to the seeds, whether the gas was primarily absorbed by the seeds, or whether retardation was simply an after effect of the gas upon the seeds.

TABLE VIII.

Seeds soaked, placed for a definite time in hydrocyanic acid gas, then washed and placed in an atmosphere free from hydrocyanic acid gas; temperature throughout experiment about 18° C.

Amt. of KCN per cubic foot	Time of soaking	Time of exposure to gas	Subsequent treatment	Time required for germination	Percentage of germination	Subsequent growth of seedlings
0.000	24 hours	0	(placed in pure air)	24 hours	100	normal
0.100	24 "	6 hours	washed	72 "	100	"
0.100	24 "	6 "	not washed	96 "	50	¾ nat. size
0.250	24 "	6 "	washed	144 "	100	normal
0.250	24 "	6 "	not washed	no germ.	0	....
0.250	24 "	18 "	washed	168 hours	60	½ nat. size
0.250	24 "	24 "	washed	240 "	10	slight
0.250	24 "	48 "	washed	no germ.	0	....

It is apparent that more or less of the hydrocyanic acid gas remains in the film of water that adheres to and surrounds the seeds after they are removed from the gas, since they germinate much more readily after washing. It should be noted that the washing did not consist in soaking the seeds but simply rinsing them under the hydrant. If the seeds were not washed they were unable to germinate after six hours in the gas from 0.250^{gm} of KCN per cubic foot, whereas the seeds were able to germinate after eighteen hours in the gas, providing they were washed immediately after removal. If they were exposed to the same charge of gas, viz., 0.250^{gm} of KCN per cubic feet for twenty-four hours or more, they were unable to germinate even when they were thoroughly washed after removing from the gas. It would seem from the experiments that more or less of this poisonous gas remains in the moisture that surrounds the seeds, and that the gas clings to the damp surface of exposed seeds. If the gas is not removed by washing it seems to have a strong affinity for moisture and for the seed, and eventually penetrates the seed even after the treated seeds have been exposed to the ordinary atmosphere. However, not all of the gas remains on the outer surface of the seed nor in the moisture sorrounding it, since a marked influence of the gas could be observed in those seeds that were first treated with the gas and then washed.

FIG. 6.—*a*, seeds in gas from 0.10^{gm} KCN per cubic foot for six hours, then washed and placed in gas-free atmosphere; growth practically normal; *b*, seed in gas from 0.25^{gm} KCN for eighteen hours, then washed and placed in gas-free atmosphere; *c*, seeds in gas from 0.25^{gm} KCN per cubic foot for twenty-four hours, then washed and placed in gas-free atmosphere.—Photographed at end of two weeks. See table VIII.

Conclusions.—Seeds, whether in the dry or moist condition, are capable of absorbing hydrocyanic acid gas from the surrounding atmosphere, whether the amount of gas in the atmosphere is large or small per cubic foot. The gas thus absorbed has a marked influence upon the germination of the seeds and upon the subsequent growth of the seedlings. This influence is exerted upon the embryo or upon the enzymes or upon the stored food material of the endosperm, or it may be that the gas exerts influence directly or indirectly upon two or more of these seed parts. If the grain or seeds are dry the influence of the gas is far less marked than if they are moist, and the drier they are the less the influence of the gas. It would seem that the gas exerts its influence, therefore, through the medium of the moisture contained in the seeds and in the seedlings. Even in older plants it is the more succulent parts that are most readily affected by the gas. The seed coats serve more or less as a protection to the inner seed parts, for as soon as the seedlings escape from the seed coats they are more seriously affected by the gas, and if the charge is sufficiently strong, the seedlings refuse to grow almost as soon as they leave the seed coats. Dry seeds are sufficiently resistant to the influence of hydrocyanic acid gas to be treated for several weeks with an atmosphere saturated with the gas without destroying their vitality. It would be impossible, however, to preserve even dry seeds indefinitely in any strength of the gas, since it eventually penetrates them and impairs and finally destroys their vitality. If the seeds are damp they are much more susceptible to the influence of the gas, and should not remain more than two or three hours in gas of sufficient strength to destroy animal life. If for any reason it becomes necessary for the damp seeds to remain for a longer time in the gas, the injury will be materially lessened by thoroughly washing the seeds in water as soon as they are removed.

The fact that damp seeds are more susceptible to hydrocyanic acid gas than dry seeds would indicate that the gas is taken up more readily by the damp seeds, and the same is true of other gases.

EFFECT OF HYDROCYANIC ACID GAS ON SEEDS FOR FOOD.

Dry seeds.—Only a few experiments have been performed along this line, but probably a sufficient number to determine the point in question, viz., whether dry seeds treated with hydrocyanic acid gas retain enough of the poison to make them injurious to animal life. Grain was subjected to gas of different strengths and for longer or shorter periods of time, varying from one to sixty days. Grains thus treated were from time to time fed to mice that had been caught without injury and placed in glass cages so that they could be observed constantly. The cages were provided with an abundant supply of air and water and kept at ordinary normal temperature of the laboratory where the mice had been living previous to the beginning of the experiment. Occasionally the mice began eating the grains as soon as they were placed within reach, but as a rule several minutes to several hours elapsed between the time the grains were taken from the hydrocyanic acid gas and the time they were eaten by the mice, thus giving time for any gas that remained in contact with the seed or that had penetrated the seed coat to escape into the atmosphere. In one instance, for example, a mouse was fed one dozen kernels of corn and three dozen grains of wheat that had been for four and one fourth days in an atmosphere containing gas from one gram of potassium cyanid per cubic foot. The mouse began eating the grain at once, and at the end of twenty-four hours had eaten the whole of five grains of corn and had eaten the chit out of five other grains. It had also eaten fourteen grains of wheat and had eaten the chit out of eleven others with no pathological results. Several similar experiments were carried through with like results. Hence it seems safe to conclude that dry grains treated for several days with hydrocyanic acid gas of sufficient strength to destroy insect pests that may be in the grain will in no way affect animal life, and may therefore be used for food without injury.

Damp seeds.—The damp seeds were soaked for twenty-four hours and then treated with gas in the same manner as in the preceding experiments, and were kept in the gas for different periods of time varying from several hours to several days. Here as in the germination experiments we find that moisture has a decided influence upon the susceptibility of the grains to the gas. For example: after some corn and wheat had been soaked for twenty-four hours in water and then left for forty-eight hours in the gas obtained from one gram of potassium cyanid per cubic foot, a mouse in apparently good health was given twelve grains of the corn and thirty-six grains of the wheat. The mouse began eating at once and ate the chit out of one kernel of corn and began on a second kernel when he suddenly became stupid and was unable to walk without staggering. That the mouse was hungry is evidenced by the fact that it began eating as soon as the grain was placed in the cage, and from the fact that it had been given but little food on the preceding day for the purpose of having it hungry enough to begin at once on the grain as soon as it should be removed from the gas. Although the mouse lived for several hours, it eventually died apparently from the effects of the small amount of grain eaten, as it did not eat any more of either kind of grain nor would it eat cheese or any other material placed before it. In general, it was found that if the mice ate the grain immediately after taking it from the gas they became stupid and eventually died from the effects. However, if the grain was allowed to remain for a time out of the gas before it was eaten, no ill effects seemed to be produced, although the grain did not seem to return to its normal condition, as it was never eaten readily even after it became perfectly dry. When the mice could be induced to eat it, as they were in several instances, it did not seem at all injurious. It may be concluded, therefore, that the fumigation of dry grains with hydrocyanic acid gas does not in any way injure the grain for food purpose. And even if the grain is damp it will not be injured for food if it is allowed to air for a short time after fumigating before it is prepared for use.

SUMMARY.

Dry seeds may be fumigated with the usual strength of hydrocyanic acid gas for the length of time required for the destruction of animal life without in any degree interfering with the germinating power of the seeds.

Dry seeds may be subjected for several months to the influence of hydrocyanic acid gas at the rate of one gram or less of potassium cyanid per cubic foot without entirely destroying the ability of the seeds to germinate.

Dry seeds subjected to the influence of hydrocyanic acid gas derived from one gram of potassium cyanid per cubic foot will lose their germinating power at the expiration of eight months, while the same seeds subjected to the gas from one third of a gram of potassium cyanid per cubic foot will retain their vitality until the expiration of twelve months.

The exposure of dry seeds for from fifteen to sixty days to the influence of hydrocyanic acid gas from one third to one gram of potassium cyanid per cubic foot will hasten germination and accelerate the growth of the resulting seedlings. Although the acceleration continues for several days, it does not seem to be of sufficient duration and degree to be of any practical value.

Damp seeds are much more sensitive to the influence of hydrocyanic acid gas than dry seeds.

Seeds soaked twenty-four hours or more will not germinate in gas stronger than 0.003^{gm} of potassium cyanid per cubic foot, whereas, if the seeds are soaked but twelve hours, they are able to germinate in an atmosphere containing hydrocyanic acid gas from 0.050^{mg} of potassium cyanid per cubic foot, and in much less time than when soaked for twenty-four hours.

Seeds soaked thirty-six hours will germinate much more readily than when soaked only twenty-four hours, but will not germinate in a stronger atmosphere of hydrocyanic acid gas than 0.003^{gm} of potassium cyanid per cubic foot.

Seeds soaked for twenty-four hours and then left for seven days in an atmosphere of hydrocyanic acid gas will remain inactive while in the gas, and from seven to twelve days after removal, but will eventually germinate to some extent if the strength of gas used does not exceed 0.050^{gm} of potassium cyanid per cubic foot, *i. e.*, hydrocyanic acid gas is capable of holding seeds in an inactive state for two weeks or longer without destroying their vitality, even when the conditions are otherwise favorable for germination.

Damp seeds are injured to a much less extent when fumigated with hydrocyanic acid gas if they are washed immediately after removing from the poisonous atmosphere.

The vitality of damp seeds is seriously injured if treated for three hours with gas from 0.25^{gm} of potassium cyanid per cubic foot, provided the seeds are not washed after removing from the influence of the gas. On the other hand, damp seeds may be treated with the same strength of gas for six hours with no appreciable injury, provided they are washed and placed in an atmosphere of ordinary air to germinate.

Dry seeds treated for several days with hydrocyanic acid gas of any strength will not be injured for food.

Damp seeds treated with hydrocyanic acid gas of any strength, and even for short periods of time, should not be used for food until several hours after removing from the gas. The effect of the gas eventually passes off and the grain may be eaten with safety, although long exposure to the gas seems to render it unpalatable. Grains and other seeds may be fumigated with hydrocyanic acid gas for the destruction of insect pests without injury to the germinating quality of the seeds and without rendering them injurious as foods.

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THE TUBER-LIKE ROOTLETS OF CYCAS REVOLUTA.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. XXVI.

A. C. LIFE.

[WITH TEN FIGURES]

THE coral-like outgrowths in connection with the roots of *Cycas revoluta* have long been known. In 1871 and 1872 Reinke[1] published an account of them and described the associated endophytic alga, which he referred to Anabaena (*fig. 10*). In 1894 Schneider[2] published further details, and referred to these structures as root tubercles. My own work was begun at Indiana University and continued at The University of Chicago.

The occurrence of these structures in *Cycas revoluta* is by no means uniform in greenhouse plants, as they are abundant in some cases, few in others, and entirely lacking in still others. They are connected with the upward rising rootlets, usually spreading radiately from the apex and just behind it, and are most abundant at or very near the surface of the ground, but may occur several inches beneath it. They vary considerably in size, but are always larger than the normal roots of the same age, and by branching may form clusters 2.5^{cm} or more in diameter (*fig. 1*).

This branching is apparently dichotomous and such a claim has been made for these rootlets. According to Reinke[3] this fact indicates relationship with the Lycopodiales, while Schneider[2] suggests that it is a case of atavism. If by true dichotomy it is

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[1] Einige Bemerkungen über das Spitzenwachstum der Gymnospermen Wurzel. Gött. Nachrichten 530. 1871.

Parasitische Anabaena in Wurzeln der Cycadeen. Gött. Nachrichten 107. 1872.

[2] Mutualistic symbiosis of algae and bacteria with *Cycas revoluta*. BOT. GAZ. 19:25-32. *pls. 3, 4.* 1894.

[3] Beitrag zur Kenntniss der Gymnospermwurzel. Just's Bot. Jahresb. 1: 205-207. 1873.

meant that the whole of the apical meristem passes into the meristem of the branches, this is not a case of true dichotomy. At an early stage the meristems of the two branches become definitely outlined, but between them, retaining a central apical position, there remains a portion of the original meristem. This true apical meristem gives no indication of continuing the axis, and does not even begin to form bundle elements, but soon becomes indistinguishable, and the later stages of the rootlets show what seems to be a real dichotomy. The conclusion is that this is a case of apparent dichotomy in which the meristem of the main axis ceases to function almost as soon as the meristems of the two branches are differentiated from it. It may be of interest to note that some of the tubercled rootlets do not branch, and that the normal rootlets do not show even an apparent dichotomy.

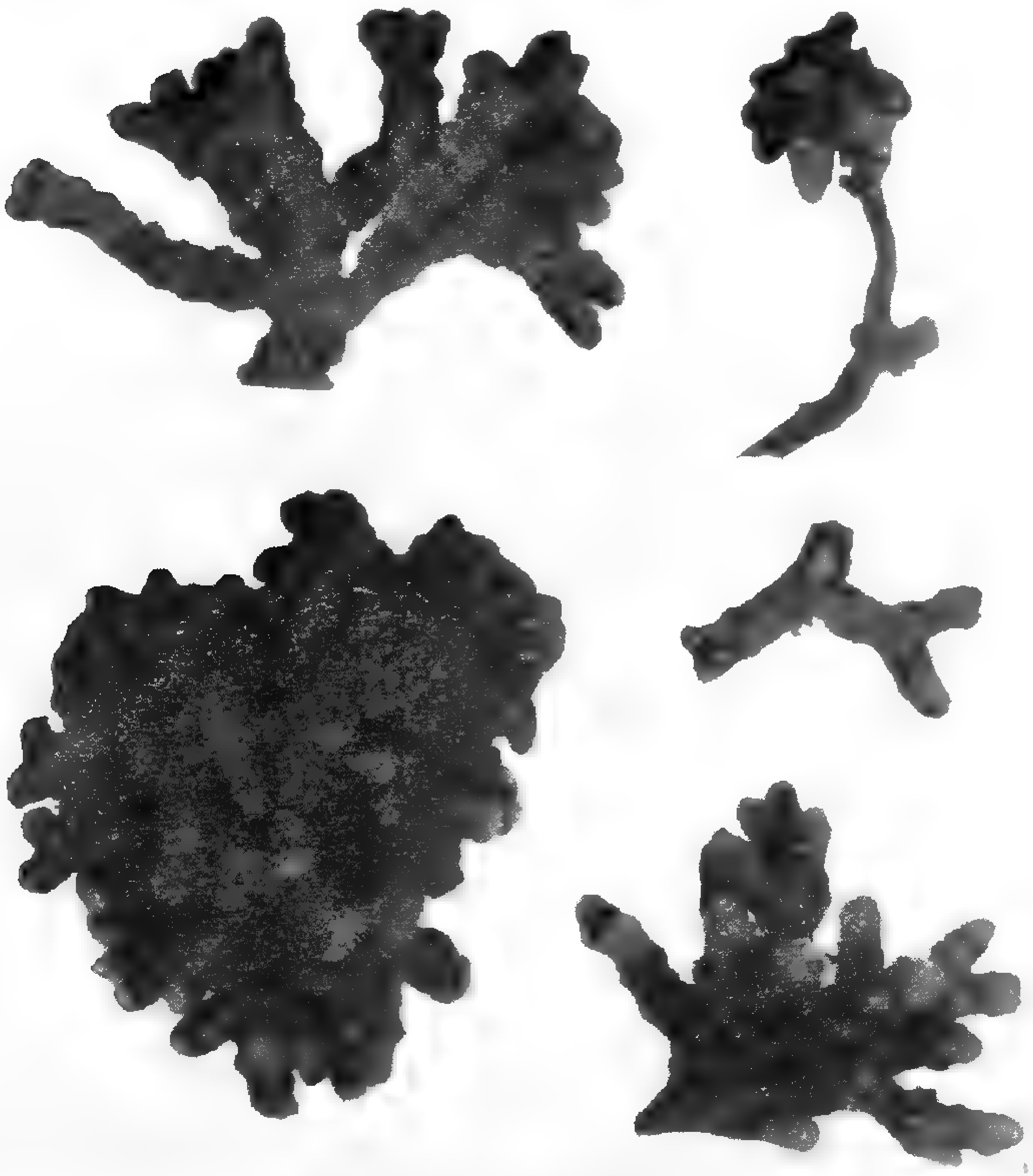

FIG. 1.—Habit of tubercles; nat. size.

A transverse section of one of the tubercles (*fig. 2*) shows a central vascular cylinder like that of the normal root, and a very thick cortex interrupted about midway by the greenish algal zone (*fig. 2, a*). The inner mass of cortex consists of ten or twelve layers of cells. The outer region is more differentiated, consisting of elongated parenchyma cells next to the algal zone, a zone of roundish cells with small intercellular spaces, a layer of cork cambium, and two layers of corky cells.

In longitudinal sections the algal zone is seen to extend from the base of the tubercle almost to the very apex (*fig. 3*). Where first distinguishable it consists of cells whose contents are somewhat denser than those of the neighboring cells, and before any intercellular spaces appear the cells next to the zone on both sides become very distinctly differentiated into a layer (*f*) resembling a tapetum. When fully developed the algal zone consists of loosely connected cells with large intercellular spaces which are occupied by the algae (*figs. 4, 5*). The radial elongation of these loosely connected cells induced Schneider to call them palisade tissue. Where large lenticels occur there is a break in the algal zone, and instead of the usual layers the round parenchyma cells extend from the phellogen to the vascular cylinder (*fig. 6*). The round cells with their small intercellular spaces form an effective air-conducting tissue.

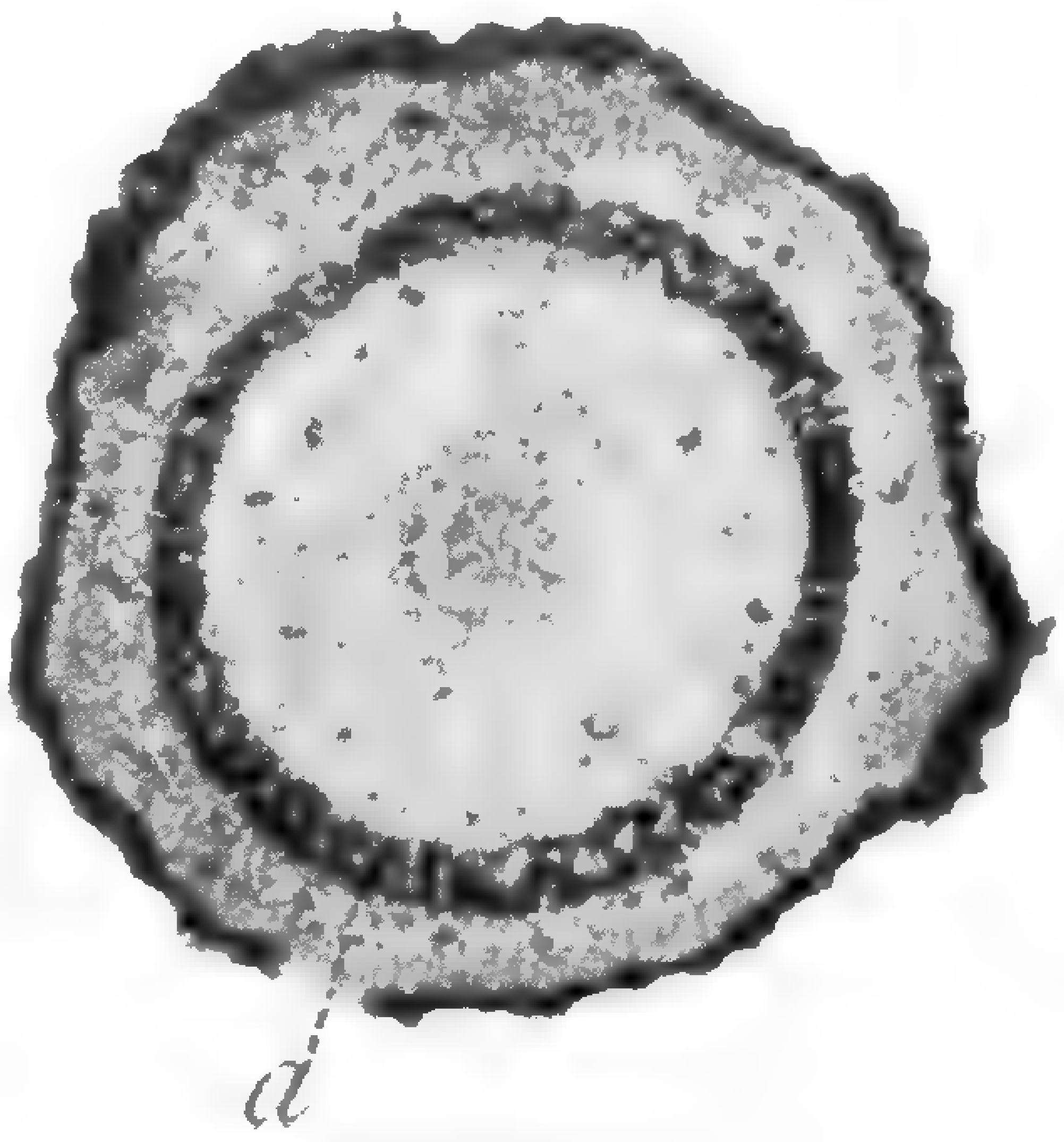

FIG. 2.—Transverse section of a tubercle. × 15. *a*, algal zone.

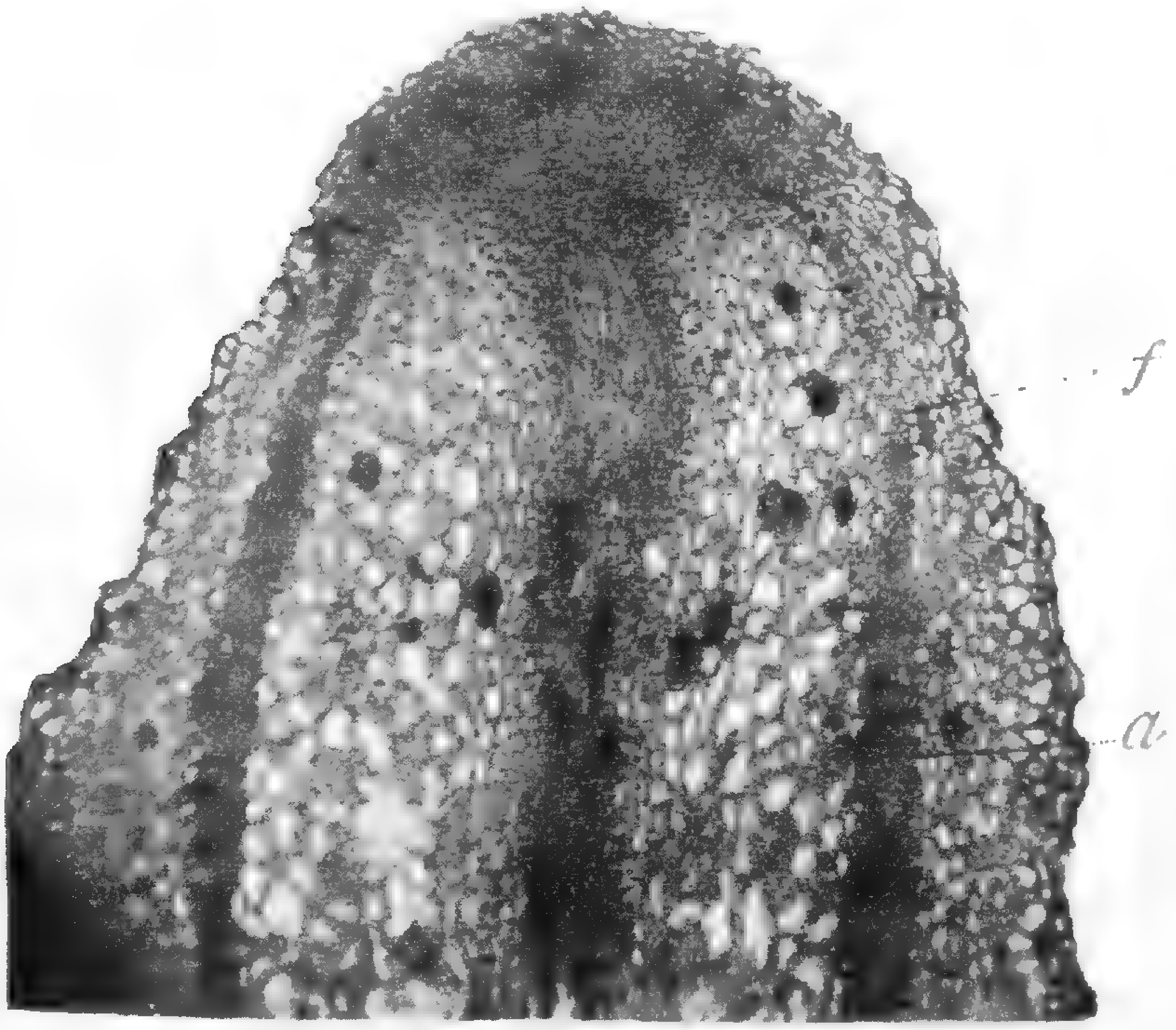

FIG. 3.—Longitudinal section of tubercle. × 40. *a*, algal zone; *f*, tapetum-like layer, with hyphae.

Lenticels occur in abundance upon the tubercles, and are found near the tip of a root upon which young tubercles are growing. They occur also in thickened primary roots which do not bear tubercles. That they are developed very early in the growth of a tubercle is evidenced by the fact that they may be seen forming very near the tip. To determine whether these structures are really lenticels, air was forced through the tubercles under water by means of an aspirator. The streams of air which were given off indicated that the structures are lenticels in function as well as in form. It might be inferred, therefore, that the so-called tubercles are used in aeration, but this would seem to be but an incidental result of their structure. It has been shown by Jost[4] that plants deprived of a sufficient supply of oxygen develop air conducting tissue and abnormal growths, and it is possible that this represents the condition of *Cycas*.

Upon comparing the general structure of the tubercle-like rootlets with those which are normal, it is to be noted that the tubercles have round tips which do not possess a true root cap. Instead of the conical root cap of the normal root they have a sheath of several cell layers extending over the tip and also enveloping the entire tubercle as an outer cortex (*fig. 3*). No such cortex is developed in the normal root.

In studying the fungi and bacteria of the tubercles, cultures were made on agar. From these cultures at least three bacterial forms and an organism resembling the Rhizobium of Schneider[2] were obtained (*figs. 7, 8*). The bacteria included one very large form, a small chain-like form, and a coccus form. The hyphae of fungi were also observed in the cells of the tubercles just in advance of the algal zone (*fig. 9*), but they were not in a condition to be identified. In fact, a zone of differentiated cells extends from the algal zone to the meristem of the tip (*fig. 3*), the cells being shorter than the adjoining cells and their contents more granular.

The fungi and bacteria which are in the cells in advance of the algal zone seem to prepare the way for the algae (*fig. 10*), since their presence seems to result in very much enlarging the small intercellular spaces, which become the relatively large

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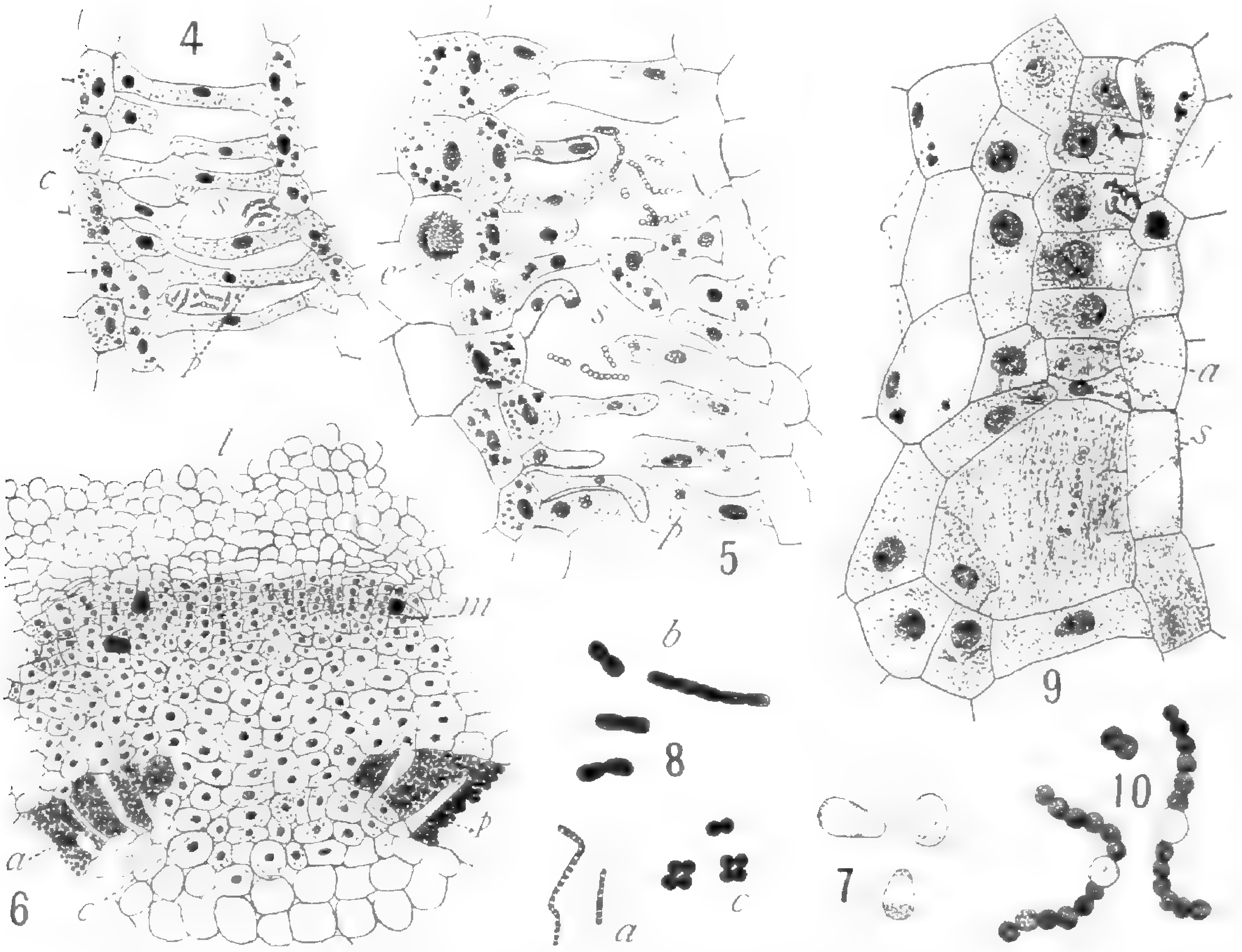
[4] Ein Beitrag zur Kenntniss der Athmungsorgane der Pflanzen. Bot. Zeit. **45**:37–39. 1887.

chambers occupied by the algae. The presence of the fungi and bacteria within the cells seems to retard the nutritive work, so that the cells cannot keep pace with those adjacent. This produces tension which results in a development of spaces, and by means of this tension some of the cells are broken, while others appear to be broken down by the organisms within them. After the algae have gained entrance, their growth and multiplication probably result in still further increasing the size of these



FIGS. 4–10.—*a*, algae of intercellular spaces; *b*, bacteria; *c*, parenchyma; *s*, intercellular spaces of algal zone; *p*, elongated parenchyma; *l*, round corky cells; *m*, cambium of lenticel; *f*, hyphae of fungus; *e*, crystal of calcium oxalate.

FIG. 4. Intercellular spaces of the algal zone. × 120.—FIG. 5. The same. × 190.—FIG. 6. Part of a cross-section, showing a lenticel and a break in the algal zone beneath. × 120.—FIGS. 7 and 8. Bacteria and rhizobia found in cultures from tubercles. × 1425.—FIG. 9. Part of longitudinal section showing beginning of the formation of intercellular spaces of the algal zone, and cells containing hyphae of fungus. × 300.—FIG. 10. Algae found in the tubercle. × 480.

intercellular spaces, since they become larger the further they occur from the region of origin.

In the early stages of the growth of the tubercles, before they contain the algae, numerous lenticular areas may be observed at their bases and also upon the adjacent part of the root which bears them. These peculiar areas have openings in them which appear as crevices, and as the tubercles grow older the whole area frequently breaks away, and it is doubtless through these rents that the algae effect an entrance. Together with the algae the fungi and bacteria also enter, the latter forms penetrating the cells and causing the enlargement of the intercellular spaces.

In reference to the symbiotic relations which exist between these various organisms it is difficult to speak with any certainty. The fungi and bacteria doubtless find congenial conditions of moisture and food in connection with the algae, and are in turn the principal agents in producing the intercellular spaces in which the algae thrive. It is barely possible that there may be some such chemical attraction between the fungi and algae and the cells of the differentiated layer as has been stated by Miyoshi.[5] It has been demonstrated by Vines,[6] Frank,[7] MacDougal,[8] and others that fungi growing upon the surfaces of cells or within them may aid in nutritive work by converting free nitrogen and the simpler nitrogen compounds into the more complex forms used by the plant. The same function has been attributed to certain algae by Prantl,[9] especially including the nostoc forms. This last observation suggests the possibility of the use

[5] Ueber Chemotropismus der Pilze. Bot. Zeit. **52**: 1–28. *pl. 1.* 1894.

[6] On the relation of the formation of tubercles on the roots of Leguminosae and the presence of nitrogen in the soil. Ann. Bot. **2**: 386–389. 1888.

[7] Ueber die auf Wurzelsymbiose beruhende Ernährung gewisser Bäume durch unterirdische Pilze. Ber. deut. bot. Gesell. **3**: 128–145. *pl. 10.* 1885.

[8] Symbiotic saprophytism. Ann. Bot. **13**: 1–47. *pls. 1, 2.* 1899.

[9] Die Assimilation freien Stickstoffes und der Parasitismus von Nostoc. Hedwigia **28**: 135. 1889.

of the nostoc forms within the tubercles of the cycads in assisting nitrogen assimilation.

In conclusion, therefore, the tubercles of cycads may be said to have at least two functions, that of aerating, and that of assisting in nitrogen assimilation.

THE UNIVERSITY OF CHICAGO.

BRIEFER ARTICLES.

WALNUT BACTERIOSIS.

I CHARACTERIZE here briefly a new micro-organism pathogenic to *Juglans regia* and related species, which has been under investigation at this laboratory for several years. Announcements of the isolation of the organism and a demonstration of its pathogenic action on walnuts were contributed several years since to the leading horticultural journals of the Pacific coast. Further communications relative to this disease are in course of preparation, which will enter more fully into the characterization of the organism, its pathogenic powers, its cultural peculiarities, and will give full details as to the nature and treatment of the disease which it causes.

Pseudomonas juglandis, n. sp.—A short, rod-shaped micro-organism with rounded ends, actively motile, bearing a single long polar usually wavy flagellum. Length of organism, taken from colony in acid gelatin, set directly from walnut, and stained with gentian violet, 1–2μ, according to whether the germ has just divided or has elongated but not yet divided. Just before separation a pair of germs will usually average about 2μ in length. Average breadth of organism about 0.5μ. Occurs singly or in pairs, and sometimes in shorter or longer chains. Produces a bright chrome yellow growth on potato and many other media. When growing normally on potato the starch is so acted upon by a diastatic ferment produced by the organism, that it is altered throughout a wide band beyond the margin of the culture of organisms. This band of converted starch may extend 0.5–1$^{\text{cm}}$ or more beyond the margin of the growth or germs, appears white to the eye, fails to show normal starch reaction to iodine, yields marked grape sugar reactions, has an exceedingly sharp and well defined limiting outline, often passing so sharply through a cell as to include only the starch grains on one side of the cell. This broad and distinct ferment band distinguishes this organism at once from *Pseudomonas Stewarti* and *P. hyacinthi*, as well as from the more nearly related *P. campestris*, which occasionally forms a weak but much narrower band, and from all other uniflagellate organisms studied. Organism prefers neutral or acid reaction of culture medium, a moderate degree of alkalinity inhibiting growth; it liquefies neutral and acid gelatin. Produces no gas in fermentation tubes of sugar solutions; growth confined to neck and bulb of tube, hence aerobic, no growth under mica plate. Colonies in malic acid potato gelatin and agar circular; at first clear but soon decidedly yellow, margin sharp. This organism is distinguished from *P. campestris*, the most nearly related species of the genus, aside from the characters already assigned, in producing an abundant and bright yellow pigment on the surface of extracts of the leaves of the following plants, while *P. campestris* produces little or no pigment upon such extracts: walnut (*Juglans regia*), magnolia (*Magnolia macrophylla*), fig (*Ficus Carica*), castor bean (*Ricinus communis*), loquat (*Eriobotrya Japonica*).

Organism strikingly pathogenic to nuts, leaves, and tender branches of *Juglans regia*. In the young walnuts the epicarp and forming shell and kernel are destroyed, in the older nuts the epicarp alone may be affected. The leaves are commonly attacked along the veins and on the petiole, the organism often entering the vessels. The branches become infected near the growing point, and all tissue systems are destroyed, the organism entering and wintering in the pith cavity; it also winters in fallen nuts. An unlimited number of infections may be induced—and thousands have been so induced—by spraying the young nuts with a pure water culture of the organism. This test shows the germ to be one of the most active, self-effective parasitic or pathogenic species of the genus yet known to infect plants.

Pseudomonas campestris has not been found infesting the cabbage fields of the regions where the present disease prevails. Walnut bacteriosis is known to exist over large areas in southern California and to a limited extent in the central and northern portions of the state.—Newton B. Pierce, *U. S. Dept. Agric., Div. Veg. Phys. and Path., Pacific Coast Laboratory, Santa Ana, Cal.*

CURRENT LITERATURE.

BOOK REVIEWS.

Vegetable physiology.

THE NEED of a book of moderate compass to present in clear and succinct form the principles of plant physiology is well met by Professor Green's recent volume.[1] In a handy volume of 450 pages the author has discussed the structure and differentiation of the body (35 pp.); the skeleton (17 pp.); the absorption, transport and loss of water (50 pp.); aeration and respiration (29 pp.); the various processes of nutrition, including absorption and synthesis of foods, translocation, storage, digestion, secretion and waste products (156 pp.); energy relations (17 pp.); growth (15 pp.); temperature and the influence of environment on plants (25 pp.); irritability and movement (39 pp.). These are not the author's chapter headings but fairly represent the various topics. He has "endeavored to present the plant as a living organism, endowed with particular properties and powers, realizing certain needs, and meeting definite dangers," and to keep clearly before the reader the fundamental identity of the activities of plants and animals.

In general the presentation leaves little to be desired. Particularly commendable is the treatment of nutrition. The author not only lays stress upon the true nature of foods, from which category he rightly excludes water and carbon dioxid, but discusses clearly photosynthesis, from which he differentiates, none too strongly, the amylogenic function, and presents, as in his earlier work, an excellent chapter on digestion.

The treatment of respiration and the energy relations of plants, however, is not well arranged. To discuss respiration in connection with aeration and before nutrition seems to be a reversal of the logical sequence and that to no gain. It needs to be brought into intimate relation with nutrition, of which it is a phase, and also with the release of energy, of which it is one method. Aeration, though incidental to respiration, should be treated in connection with gas absorption, just as root hairs are discussed in connection with water absorption.

The handling of osmosis might be much improved by a broader physical treatment, for there is no process whose fundamental principles are so little comprehended by most students. The author seems to overestimate the importance of root pressure in the transport of water through the stems, for

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[1] GREEN, J. REYNOLDS: An introduction to plant physiology. 8vo. pp. xx + 459. *figs. 184*. London: J. and A. Churchill. 1900. 10s. 6d.

it certainly has no effect beyond the cortex of the root when transpiration is active. On the other hand, the presentation of the probable relation of evaporation and osmosis in the mesophyll to water transfer is very satisfactory.

The illustrations are remarkably unequal. Some are excellent; some are crude, but sufficient; some are so diagrammatic, without such remark, as to be misleading; and some disfigure a book which deserves the best possible engravings. We suspect some of the worst of being relics of a long-deceased "botany," resurrected from the publishers' stock-room. Many of the illustrations, though not original, are not credited to their sources, while others are; of this no explanation is given.

No references are made to original papers or to other works; only in a few cases is the proponent of any particular view or theory referred to; and controverted points are scarcely alluded to. The danger from this is that the student may get the too common impression that the book deals out finally settled knowledge. It is difficult to know where to draw the line between the necessary dogmatism of the elementary work and the discussion of the treatise, but we believe in showing up the gaps in a subject fully. While this book only professes to be "an introduction," it is nevertheless so thorough that it would have been improved by a *selected* bibliography following each of the various topics. For though we have Pfeffer's treatise at hand, its citations of literature are too detailed for the student of elementary physiology, and he would have profited greatly by the same judicious sifting of the literature as Professor Green has made of the facts.—C. R. B.

The problems of life.

THE FUNDAMENTAL problem of physiology is the constitution of living matter. But we are so far from a knowledge of the chemistry of proteids, not to mention protoplasm, that the best we can do now is to attempt the framing of logical and consistent hypotheses, in the hope that these will suggest research in fruitful lines. If the true character of such hypotheses is kept clearly in view, they may prove helpful, but there is always a danger that the hypothesis may be held so tenaciously that new facts are distorted to fit our interpretation of other facts.

There is before us the first part of a work by Dr. Giglio-Tos, of the University of Turin, which is an attempt to set forth a logical and consistent hypothesis of the organization of protoplasm and its fundamental functions, notably assimilation, reproduction, respiration, photosynthesis, and cell division.[2] A second part is to discuss ontogeny and its problems.

[2] GIGLIO-TOS, ERMANNO: Les problèmes de la vie: Essai d'une interpretation scientifique des phénomènes vitaux. 1e partie: La substance vivant et la cytodiérèse. 8vo. pp. viii + 286. *figs. 33*. Turin: The author, Palazzo Carignano. 1900. 10 francs.

The general thesis of the book is that vital phenomena are explicable without invoking hypothetical or mysterious forces and are all referable to relatively simple fundamental causes. Since the minutest observable organisms undergo fission, the author makes the assumption that fission occurs also in the molecules of living substance. This he illustrates by the behavior of certain chemical compounds. Methyl-ethyl-ketone, for example, on taking up three atoms of oxygen, cleaves into two molecules of acetic acid. The chemical analogy may be carried further. By treating the acetic acid molecules with phosphorus pentachlorid, and the acetyl chlorid so formed with zinc ethyl, there are finally produced four molecules of methyl-ethyl-ketone and in the course of the process several by-products. Certainly such an analogy, if it be nothing more, renders easily conceivable the author's hypothesis that assimilation of atoms or atomic groups from the medium brings about an increase and a rearrangement of the atoms in each molecule of living substance. When the proper relations within the molecule are reached, it divides into two new ones like the original; or into two (alike) which through a subsequent cycle of development produce molecules like the original; or into two (unlike), only one of which develops and reproduces the original molecule, while the other finally produces again unlike molecules. By assuming this different behavior the author explains the production of nonliving matter by living, and the origin of genetic and somatic plasma.

The respiratory and photosynthetic activities of these living molecules are elucidated in terms of this hypothesis; certainly what we know of them falls in with it easily.

The next assumption is that many unlike biomolecules, to use the author's word for living molecules, are aggregated into living particles, or biomores, in which they have an arrangement determined by the chemical affinity of the various atoms and groups, and shifting as the chemical constitution changes. The life of the biomore, however, does not depend on its constitution but on the life of the biomolecules.

The aggregate of biomores, submerged in water (not of constitution as Nägeli held, but of capillarity), constitutes the bioplasm. Any view as to the morphological structure of the bioplasm, whether the filar structure of Flemming, the reticular of Frommann, the alveolar of Bütschli, or the granular of Maggi and Altmann, is equally consonant with this theory.

The bioplasm is not of indefinite extension but consists of small masses, each a symbiotic system of unlike biomores, constituting a biomonad. A very complex biomonad, especially when biomores constituting a nucleus are present, is a cell.

Cell division is based upon the same fundamental principle as the fission of the biomolecules. In them it is not mere addition of atoms which suffices to bring about division, but their mutual relations and orientation. In the biomores division again depends on the nature, number, *and arrangement* of the biomolecules. In the biomonad, division is possible (1) because the biomores are mobile, being in liquid; (2) because they exercise a mutual attraction (shown by their union into masses giving parts of the cell their definite characters), and consequently assume a determinate arrangement. But division of the cell is completely independent of its structure, though the figures accompanying division, such as the spindle, the equatorial plate, etc., are dependent upon structure. The efficient cause of division is indeed always the same, whether in biomolecule or cell, namely, the mutual orientation of the parts; whatever the number, nature, or structure may be, division is inevitable when the proper arrangement is attained. Assimilation is indispensable to division, but not always sufficient. The discussion of cell division is elaborate and is illustrated by diagrams which make the presentation very clear and the process fascinatingly simple — would that it were so.

Such is a very brief outline of the hypothesis. Of course, it adds nothing to our knowledge, and it would be easy to revile it as an unstable pile of assumptions. But the real questions are, Does it take account of the present facts and coordinate them? Will it suggest fruitful research? That it takes account of all the facts is improbable; that it does fairly coordinate the more important ones (alas, too few) seems evident. That it will stimulate investigation remains to be seen. At any rate it deserves attention for what it purports to be, namely, an attempt to give a scientific interpretation of vital phenomena.— C. R. B.

MINOR NOTICES.

One of the latest of the series of Temple Primers is a little volume on *Plant life and structure* translated from the German of Dr. E. Dennert by Clara L. Skeat.[3] The author seems to recognize no organisms as plants but the seed plants, and continually makes assertions of the most comprehensive sort which are true only of green plants. Indeed he is rather given to generalizations, both regarding structure and function, and to teleology of the Paley type. In many minor matters and in some important ones the book is not up to the times; Goethean metamorphosis, sexual terms for the sporophyll and microspores, and much faulty physiology might have been more easily forgiven in a book dated a decade or two ago. But the best to be said of this booklet is that it is better than many more pretentious works and good enough for one to regret that it is not better.— C. R. B.

Among the plastic products of plants one of the groups most interesting chemically and most valuable commercially is the volatile oils. In their manufacture many firms have been engaged, but none so extensively, so

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[3] Dennert, E.: Plant life and structure. Translated from the German by Clara L. Skeat. 16 mo. pp. viii + 115, *figs. 56*. London: J. M. Dent & Co. (undated). New York: The Macmillan Company. 40 cents.

exclusively, or more scientifically than Schimmel & Co., of Leipzig. Not content with much original work in the chemistry of these substances and costly experimentation with methods of manufacture, this firm commissioned Dr. E. Gildermeister, of Leipzig, and Dr. Fr. Hoffmann, of Berlin (the latter long and honored leader in pharmaceutical affairs in this country), to prepare a work on volatile oils,[4] treating them in an exhaustive and critical manner from the modern standpoint. This work, published about a year ago, has been translated into English by Dr. Edward Kremers, of the University of Wisconsin. The recent rapid development of the knowledge of the volatile oils makes the present volume doubly useful. With the chemistry of these bodies it happily combines much interesting historical matter and a description of the modern processes of distillation. Abundant references to original chemical sources make the work an important aid to the investigator.

Though primarily chemical and technical, the list of plants, arranged according to families, from which volatile oils are obtained will be interesting for the botanist and the whole book is a mine of information. Four hundred and thirty oils are described, the botanical sources, percentage present in various parts, mode of preparation and composition being given.—C. R. B.

NOTES FOR STUDENTS.

HAROLD L. LYON, of the University of Minnesota, has announced[5] that Nelumbo, "both in its anatomy and embryogeny conforms to the type of the monocotyledons." His full paper will be awaited with interest.—J. M. C.

LEWIN[6] contradicts the view of Stahl that raphides are important as a means of protection against herbivorous animals. There is no evidence of mechanical injury to animals, nor of poisonous effects being produced through eating plants that contain these crystals.—H. C. COWLES.

MIYOSHI[7] has performed a number of experiments in order to determine the influence of various substances in the soil or water upon flower colors. His results are not uniform, though he finds in general that aluminium compounds change lilac to blue (as Molisch previously observed), while potash changes lilac to green, and many acids change it to red.—H. C. COWLES.

W. C. WORSDELL[8] has concluded that the Bennettitales are more primitive than the modern cycads, as shown by their stem structure, radial

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[4] GILDERMEISTER, E. and HOFFMANN, FR.: The volatile oils. Written under the auspices of the firm of Schimmel & Co., Leipzig. Authorized translation by EDWARD KREMERS. 8vo. pp. viii + 733, *figs. 83, maps 4.* Milwaukee: Pharmaceutical Review Pub. Co. 1900.

[5] Science **13**: 470. 1901.

[6] Ber. deut. bot. Gesell. **18**: 53–72. 1900. [7] Bot. Centralbl. **83**: 345. 1900.

[8] The affinities of the mesozoic fossil *Bennettites Gibsonianus.* Ann. Bot. **14**: 717–721. 1900.

sporophyll, and terminal ovule. In reference to the radial character of the primitive sporophyll the author accepts Celakovsky's view, and also regards the peculiar ovuliferous stalks as foliar rather than axial structures.—J. M. C.

D. H. SCOTT[9] has described a new genus of lycopods, *Lepidocarpon* by name, which shows features indicated by the title of the paper. It is from the Lower Coal Measures and also from a much lower horizon, the Calciferous sandstone series, and the strobili resemble those of Lepidostrobus. The megasporangia, however, mature and retain a single large megaspore, and each sporangium becomes covered by a definite tegument which is an outgrowth from the sporophyll, and completely encloses it except for a slit-like opening above. So much of the sporophyll persists as is necessary to complete this testa-like covering, and the whole seed-like structure falls off with its retained and germinated megaspore.—J. M. C.

DR. E. O. JORDAN[10] has published recently a paper upon the bacterial self-purification of streams, the observations having been made during a study of the chemical and bacterial condition of the Illinois river and its tributaries, undertaken in behalf of the sanitary district of Chicago. The phase of self-purification considered is that which relates to the disappearance of the sewage bacteria. Although the conclusions are not to be regarded as final, a lessening of the bacterial content seems to admit of no question. In fact, the observations show that the Illinois river at Ottawa had become nearly free from the great mass of sewage bacteria with which it was originally laden. The probable factors in this result seem to have been dilution, sedimentation (leading to exhaustion of food supply), or action of sunlight. The influences of mechanical agitation and aeration, and of plankton, do not seem to be factors which enter into the problem in connection with the Illinois river.—J. M. C.

JOHN WEINZIRL[11] has recently published a paper upon "The bacterial flora of the semi-desert region of New Mexico with especial reference to the bacteria of the air," in which he records the result of a two-year study. Both quantitative and qualitative examinations were made. The quantitative data were obtained by the filter method, sand being used for the filtering substance. Five determinations made in the vicinity of the University of New Mexico gave an average of aboat forty-two bacteria per cubic meter of air. Eleven determinations in the residence district of Albuquerque yielded

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[9] On the occurrence of a seed-like fructification in certain paleozoic lycopods. Ann. Bot. **14**: 713–717. 1900.

[10] Some observations upon the bacterial self-purification of streams. Jour. Exper. Medicine **5**: 271–314. *pl. 20.* 1900.

[11] Jour. Cin. Soc. Nat. Hist. **19**: 211–242. 1900.

an average of one hundred and forty-three per cubic meter. Comparison is made with the Mont-Souris results, but no mention is made of Tucker's observations in Boston. Ten organisms, presumably distinct, are described with some detail. It is not stated whether the "recommended procedures" have been employed. The organisms described are characterized as a whole by their inability to ferment sugar and to peptonize gelatin.—E. O. JORDAN.

MISS ETHEL SARGANT[12] has published an exceedingly interesting paper upon double fertilization, bringing together the contributions to date and discussing the questions that have been raised. The bibliography of the subject is represented now by at least eighteen titles, and the phenomenon has been recorded for about twenty-five species. The author inclines to the view that the triple fusion is a true act of fertilization between a male cell and an egg, interfered with and rendered abortive by the introduction of the non-sexual antipodal nucleus. The result is not a normal embryo, but a small and short-lived mass of tissue. Boveri's experiments with the eggs of sea urchins, in which more than one sperm was forced to unite with egg nucleus, are cited to prove this probable result of more than double fusion. The theory is advanced that the third nucleus is introduced to secure the degeneracy of the resulting tissue. If this is true, the definitive nucleus has descended from one which was the result of true fertilization, and the participation of the third nucleus is an added feature.—J. M. C.

ITEMS OF TAXONOMIC INTEREST are as follows: EDWARD L. GREENE (Pittonia **4**: 242–284. 1901), in continuing his "Studies in the Compositae," has made a special attack upon *Bidens*. After an interesting account of the history of the genus, of *B. frondosa* L., and of *B. cernua* L., he describes twenty new species, thirteen of them being American analogues of *B. cernua*, and seven of them segregates of *B. chrysanthemoides* Mx. *B. Beckii* is given generic rank, and is associated with two new species under the name *Megalodonta*. In the same fascicle new species are described under Conoclinium (3), Eupatorium (8), and Antennaria.—C. S. SARGENT (Rhodora **3**: 19–31. 1901) has described thirteen new species of *Crataegus* from the Champlain valley, remarking that this is one of the richest regions in the world for forms of Crataegus.—P. A. RYDBERG (Bull. Torr. Bot. Club **28**: 20–38. 1901), in the fourth paper of his series entitled "Studies on the Rocky mountain flora," describes new species under Arnica (2), Artemisia, Picradenia, Antennaria, Aster, Townsendia, Erigeron (3), Valeriana, Campanula, Castilleia (3), Mimulus, Pedicularis, Pentstemon (3), Polemonium, Gilia, Phacelia, Lappula, Cryptanthe, Mertensia (4), Mentzelia, Impatiens, Geranium, Lupinus (2), Astragalus, Aragallus, Trifolium, and Lathyrus.—C. V. PIPER (*ibid.* 39–45, in the fifth paper of his series entitled "New and noteworthy northwestern

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[12] Recent work on the results of fertilization in angiosperms. Ann. Bot. **14**: 689–712. 1900.

plants," describes new species under Arabis, Trifolium, Astragalus, Solidago, Erigeron, Antennaria, Artemisia, Crepis, Dodecatheon, Gilia, Phacelia, Lappula, and Mimulus.—L. M. UNDERWOOD (*ibid.* 46–47) has described a new Adiantum from New Mexico.—J. M. C.

BROWN and ESCOMBE have under way one of the most important physical researches of recent years. They have set forth some of their results and have applied them to plant functions in a paper on the "Static diffusion of gases and liquids in relation to the assimilation of carbon and translocation in plants."[13] Blackman's interesting results (1895) concerning the diffusion of CO_2 through stomata are fully substantiated. The authors further find that with small openings *a*) the rate of diffusion varies as the diameter of the orifice; *b*) multiperforate septa do not hinder diffusion when the openings are about ten diameters apart; *c*) decrease in per cent. of area of holes is not followed by proportional decrease in amount of diffusion; *d*) the laws hold for both gases and solutes. Assuming an analogy with lines of force about an electrified disk, they find these results accord with mathematical calculations. Applying these principles to plants the authors conclude that 1) in an ordinary leaf (*Helianthus annuus*) the stomata are sufficient to permit the diffusion of five or six times as much as CO_2 as is actually used by the plant; 2) resistance to the absorption of a greater quantity of CO_2 lies in the relatively slow diffusion of the CO_2 after solution; 3) the stomata are more than sufficient to permit the escape of the observed amounts of water vapor by diffusion without any mass movements; 4) continuity of protoplasm may have more to do with translocation of foods than has been supposed hitherto, since over 60 per cent. of diffusion possible through an orifice the full size of the pit would take place through the many minute perforations, although their area be only 0.84 per cent. of the total membrane of the pit.—T. C. FRYE.

IN A RECENT PAPER by A. H. R. Buller[14] on chemotaxis in fern sperms it is shown that these cells are attracted not only by malic and maleic acids and several of their salts (as was known before), but also by numerous salts of the inorganic acids. Potassium and sodium tartrate and potassium oxalate also attract. Sperms of *Gymnogramme Martensii* were used and were tested by Pfeffer's method of capillary tubes. The concentration necessary for attraction is usually $\frac{1}{100}$ to $\frac{1}{10}$ normal. With malic acid it is $\frac{n}{10000}$ to $\frac{n}{1000}$, and with sodium malate $\frac{n}{1000}$ to $\frac{n}{10}$. Nitrates and chlorids of sodium, ammonium, and calcium do not attract, nor does lithium nitrate. The choice of compounds to be tested was made, apparently, with the aim of making a catalogue of attracting substances rather than of determining the real nature

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[13] Phil. Trans. Roy. Soc., London, B. **193**: 223–292. 1900.

[14] Contributions to our knowledge of the physiology of the spermatozoa of ferns. Ann. Bot. **14**: 543. 1900.

of the attraction. The results are tabulated according to De Vries' obsolete isotonic coefficients, and in order to be studied need to be rearranged by base and acid. The small number of salts of any given acid makes it utterly impossible to draw any conclusion as to the nature of the attraction. The author's propositions in this regard may or may not be substantiated later; several hypotheses might be formulated which would explain equally well the cases cited. It is unfortunate that this paper (following that of Garrey[15] by nearly a year) should carry our knowledge of this important subject of chemotaxis such a little way further than it was carried by that writer. We have tried, with some success, to coordinate the results given in these two papers, but nothing definite can be attained, so far as fern sperms are concerned, until we have more data. Chemical principles must be brought into requisition in the selection of salts to be tested as well as in the interpretation of results. The author makes an interesting observation with regard to starch grains in the vesicle of these sperms. During the swarm period the grains diminish in size and often disappear entirely. The conclusion is drawn that the starch is made use of by the active sperm, being probably oxidized for the production of kinetic energy. Unhappily, no observations on the hydrolysis of these grains were made. We may suppose them to be converted into glucose by an enzyme formed in the vesicle. Thus we might have the non-nucleated cytoplasm of the sperm mother cell doing nutritive work for the moving sperm. This, if shown to be the case, might throw some light on the phenomena occurring in the male cells of the lower gymnosperms.—BURTON EDWARD LIVINGSTON.

AMONG RECENT CONTRIBUTIONS to paleobotany the following papers may be mentioned: LESTER F. WARD (20th Ann. Rep., U. S. Geol. Survey, 1900), with the collaboration of Fontaine, Wanner, and Knowlton, has published an extended account of the Triassic and Jurassic floras of the United States. The various areas are systematically treated, and much new material is incorporated. A large number of plates accompany the work, many of which illustrate Ward's recently described genus Cycadella. A similar report on the Cretaceous is to be expected soon from the same source, and will be heartily welcomed, inasmuch as the literature is considerably scattered. Ward has also published a very interesting popular report on the petrified forests of Arizona, which has been issued by the United States Geological Survey.—F. H. KNOWLTON has published on the flora of the Montana formation (Bull. 163, U. S. Geol. Survey, 1900); this together with his previous papers on fossil plants from Idaho and Yellowstone Park adds greatly to our knowledge of the late Cretaceous and early Tertiary floras of that part of the United States.—DAVID WHITE (20th Ann. Rep., U. S. Geol. Survey, 1900) has worked out

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[15] The effects of ions upon the aggregation of the flagellated infusoria. Am. Jour. Phys. 3:291. 1900.

in great detail the stratigraphic succession of the fossil floras of the Pottsville formation in the Carboniferous of Pennsylvania.—A. C. SEWARD, whose study of the fossil history of Gingko has been briefly noted in this journal (**30**: 139), has published on the Wealden flora of Bernissart (Mem. Mus. Roy. Hist. Nat. Belg., 1900); the ferns dominate in these beds rather than cycads, but there are no angiosperms, although the Wealden is commonly regarded as equivalent to the Potomac beds of our country.—GRAND 'EURY has given some very interesting accounts (Compt. Rend. **130**: 871, 988, 1167, 1366. 1900) of the Carboniferous forests of France. By his study of the plants preserved *in situ*, he concludes that most of the Calamites and some of the tree ferns grew in the water; the herbaceous ferns probably grew largely on hummocks. Even Cordaites seems to have grown in swamps, and Grand 'Eury suggests analogies with Taxodium and the Dismal swamp of today. The prevailing horizontality of the roots strikingly suggests swamp habitats. The author doubts if we have evidence of upland vegetation.—At the last meeting of the British Association (Geol. Mag., Jan. 1901) Seward, Kidston, and others discussed Carboniferous conditions, as indicated by plant fossils. Little new material was added, though Seward suggests that the xerophytic structures of Carboniferous plants may perhaps be accounted for by swamp habitats.—PENHALLOW (Brit. Assoc. Adv. Sci., 1900) has made an interesting report on the flora of the Canadian Pleistocene. Interest was aroused a few years since by Coleman's discovery of the papaw and osage orange in interglacial beds near Toronto, indicating a genial climate between ice-sheets. Over eighty Pleistocene species are now known from Canada. As Knowlton suggests in discussing this report in *Plant World* for January, there is a wide field for work in the study of Pleistocene floras in America. The poverty of our information in this respect is in striking contrast with the wealth of knowledge as to the Pleistocene of Europe.—H. C. COWLES.

THE FORMATION OF TETRADS has lately been investigated by H. O. Juel.[16] The contribution consists of three distinct papers which may be considered separately.

I. *Tetrad formation in the ovule of Larix.*—The general relationships between the reproductive organs of pteridophytes and spermatophytes have long been known, but while it is accepted that the pollen grain arises by a tetrad division, just as the spores of pteridophytes, it is generally believed that the megaspore of spermatophytes is formed without such a division. Dr. Juel studied the ovule of *Larix Sibirica* from an early stage in the development of the mother cell of the megaspore to the beginning of endosperm formation. The paper is of special interest as the first to treat this portion of the life history of a gymnosperm from the standpoint of modern

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[16] Beiträge zur Kenntniss der Tetradenbildung. Jahrb. f. wiss. Bot. **35**: 626–659, *pls. 15, 16.* 1900.

cytology. In material collected about the middle of April, before the snow had disappeared, the mother cell of the megaspore is easily distinguished by its large size, and by the abundance of starch. The first division is heterotypic, and shows the reduced number (12) of chromosomes. At the poles of the spindle are granular masses which may possibly represent centrosomes, although the author is not willing to commit himself to this interpretation. During the anaphase the starch disappears, a cell wall is formed, and each of the two daughter nuclei divides, this time by a homotypic division, giving rise to a row of four megaspores, the lowest of which germinates and produces the gametophyte. By comparing this series with the development of the microspores, which has been thoroughly studied in Larix, the author reaches the conclusion that the two series are homologous, and that the megaspore, like the microspore, arises by a tetrad division. While the conclusion is not new, the evidence supporting it is valuable.

II. *The tetrad formation in a hybrid plant.*— It has long been known that hybrids are inclined to be sterile, and that the pollen of hybrid plants is commonly imperfect. The present paper deals with the formation of the tetrad in *Syringa Rothamagensis*, a hybrid between *S. vulgaris* and *S. Persica*. The form did not prove to be favorable for such a problem, because the pollen of both parents is poor, in *S. vulgaris* about 50 per cent. of the pollen grains appearing to be incapable of functioning, and in *S. Persica* normal pollen being quite rare. The latter form is almost as sterile as the hybrid. In all three forms the development is normal up to the formation of the pollen mother cells. In the hybrid it was found that while most of the divisions in these cells were mitotic, there were also numerous instances of amitotic division, and abnormalities in the chromatin and in the achromatic figure were frequent.

III. *The development of the pollen grain of Carex.*—As a rule, the pollen mother cell of a spermatophyte gives rise to four pollen grains, but it has been reported that in the Asclepiadaceae and Cyperaceae the mother cell gives rise to one pollen grain only. A careful examination of *Carex acuta* showed that the wall of the pollen mother cell becomes the wall of the pollen grain. It also showed that the tetrad divisions take place, but the walls are imperfect and only one cell of the tetrad develops into a pollen grain, the other three being crowded out, just as in the megaspore series three potential megaspores are crowded out by the one that functions.—CHARLES J. CHAMBERLAIN.

OPEN LETTERS.

THE ROCHESTER CODE.

In the course of his article on nomenclatorial principles, published in the March issue of the BOTANICAL GAZETTE, Mr. M. L. Fernald discusses at some length Professor Underwood's recent treatment of the fern genera in this country, making the following statement in that connection:

> In Britton and Brown's *Illustrated Flora*, published in 1896, fifty-nine species of true ferns are recognized, and the names, we are told, are those authorized by the Rochester code. But in Professor Underwood's latest treatment more than *25 per cent.* of those very species appear under different names—still the names authorized by the Rochester code.

Mr. Fernald then presents, in support of this statement, a comparative table of fifteen northeastern ferns, with the names used in Britton and Brown's *Flora* and those in the last edition of Underwood's *Our Native Ferns* given in parallel columns. This table, as an illustration of the remark above quoted, cannot fail to be misleading, since Mr. Fernald evidently wishes the reader to draw the conclusion that the Rochester code is an uncertain guide, and that the same author may interpret it in different ways. In order to ascertain how far such a deduction is to be considered reliable, let us analyze briefly the supposed divergences between Professor Underwood's interpretation of the code in 1896 and in 1900, the dates of the two works mentioned. I follow substantially the same order as that of the table.

1. *Onoclea Struthiopteris,* being regarded by Professor Underwood now as generically distinct from *O. sensibilis,* is separated under the first available generic name, *Matteuccia* since *Struthiopteris* had been earlier applied to *Lomaria.*

2. *Filix* replaces *Cystopteris,* and *Phyllitis* supplants *Scolopendrium* because the first mentioned names have been proven to be the older. This is in strict conformity to the requirements of the code, notwithstanding the fact that conservative botanists would not admit the change.

3. The type of *Dicksonia* being a tropical tree fern, the American herbaceous plant is very properly separated as a genus under the first available name. The various species of *Polystichum* are also segregated from *Dryopteris,* and the latter name is not abandoned, as might be inferred from Mr. Fernald's table. It certainly involves no novel or unusual interpretation of the Rochester code to divide an original aggregate into what later study may prove to be distinct elements; and in the light of numerous new species of

Antennaria of the *plantaginifolia* group that have been proposed from time to time by Mr. Fernald, it is pertinent to inquire whether he does not himself recognize the necessity for occasional segregations. Botanists of the last century, who were familiar with *A. plantaginifolia*, as they supposed, would probably be fully as dismayed over the expansion of this species as modern fern students are likely to be over the division of Dryopteris.

4. *Phegopteris Robertiana* and *Notholaena dealbata* are examples merely of the elevation of varieties to specific rank, an everyday practice among botanists of all shades of opinion.

5. The case of *Pellaea* is analogous to that of Dryopteris.

6. *Cheilanthes gracilis* being a homonym, the first available name, *C. Feei*, is taken up for the species.

Applying the process of exclusion to Mr. Fernald's table in the light of the above remarks, it will be observed that of the fifteen species which he cites, the names of only two are the result of an altered interpretation of the code. These are *Pteridium* for *Pteris aquilina* and its allies, and the restoration of *Asplenium thelypteroides* for *A. acrostichoides*. If we assume the same ratio to hold good throughout Professor Underwood's work, we shall find that all but about 4 per cent. of the changes are the legitimate outgrowth of added research, consisting of corrections of homonyms, division of aggregate genera and species, etc.; and the same changes would probably have been made by the same author under almost any system of nomenclature. On the other hand it may be considered excellent testimony to the soundness of the Rochester principles that after the application to them of Professor Underwood's method of determining generic types so small a percentage of actual changes should occur. The citation of such cases as those discussed above affords no basis whatever for adverse criticism of the code, since, as already explained, the same course might be pursued even by opponents of the Rochester nomenclature.—CHARLES LOUIS POLLARD, *U. S. National Museum.*

NEWS.

THE *Asa Gray Bulletin* has been merged into the *Plant World*. Mr. Cornelius A. Shear becomes one of the editorial staff.

PROFESSOR J. REYNOLDS GREEN'S work on Enzymes has been translated into German by Dr. Wilhelm Windisch, and published by Paul Parey, Berlin.

MR. SAMUEL M. COULTER, fellow in botany at The University of Chicago, has been appointed to an instructorship in the Shaw School of Botany of Washington University.

PROFESSOR DR. EDUARD STRASBURGER has been elected a member of the French Academy of Sciences, and the order of "Rote Adler, III Classe, mit der Schleife" has recently been conferred upon him.

MR. FRANK S. COLLINS, the phycologist, of Malden, Mass., has recently been elected a resident fellow of the American Academy of Arts and Sciences (Boston), and Mr. Cyrus G. Pringle, the veteran collector, of Charlotte, Vermont, has been elected an associate fellow.

THE ALSTEAD School of Natural History is held at Alstead Center, N. H., for five weeks of the summer. In 1901 it offers instruction in general botany by Mr. M. L. Fernald of the Gray Herbarium; and in mycology (fleshy fungi) by Mr. Hollis Webster, of Boston.

MR. L. C. CORBETT, horticulturist of the Agricultural College at Morgantown, West Virginia, has accepted a position in the Bureau of Plant Industry in the United States Department of Agriculture. His work will include investigations in regard to floriculture and gardening.

THE assistant professorship of botany in the University of Tennessee has been made a full professorship, and the present incumbent, Mr. S. M. Bain, has been promoted thereto. The department of botany is said to be thoroughly equipped and to be making satisfactory progress in every way.

A HANDSOME silver loving-cup was presented by a number of teachers to Mr. Thomas Meehan, the veteran horticulturist and botanist of Philadelphia, on the occasion of his seventy-fifth birthday. Mr. Meehan has been a member of one of the sectional school boards in Philadelphia for twenty-three years.

MR. JARED G. SMITH, formerly in charge of the Section of Seed and Plant Introduction in the United States Department of Agriculture, has been selected to organize the territorial Experiment Station in the Hawaiian islands. Mr. Ernst A. Bessey succeeds him as "Assistant in Charge," the Section having been placed under the Bureau of Plant Industry.

THE Botanical Department of Wellesley College has received a gift of $25,000 from Mr. H. H. Hunnewell of Wellesley, who has already manifested his interest in the college by opening his pinetum and orchid conservatories to botanical classes. The money will be used as an endowment for the department, and the income will be used to meet the yearly needs.

MR. A. S. HITCHCOCK, professor of botany at the Kansas Agricultural College, Manhattan, Kansas, has been appointed assistant agrostologist in the United States Department of Agriculture. Mr. H. F. Roberts, instructor in the Shaw School of Botany, and formerly a graduate student at The University of Chicago, has been appointed Professor Hitchcock's successor.

THE DEPARTMENT of botany of Marine Biological Laboratory has issued its announcement for the season of 1901 (to be obtained from Dr. Bradley M. Davis, University of Chicago). A course in cryptogamic botany is offered by Drs. Davis and Moore; phanerogamic botany by Dr. Shaw; plant physiology by Dr. True; and plant cytology by Dr. Davis and Mr. Lawson. An attractive course of open lectures will also be given.

IT IS proposed to establish a quarterly journal of biological statistics under the name *Biometrika*, which may serve as a means not only of collecting under one title biological data of a kind not systematically collected or published in any other periodical, but also of spreading a knowledge of such statistical theory as may be requisite for their scientific treatment. The movement is in charge of Professor Karl Pearson, of University College, London, to whom tenders of support should be sent.

THE Act of Congress, making appropriations for the United States Department of Agriculture for the year beginning July 1, 1991, contains several important items pertaining to investigations in botanical lines conducted by several divisions in that department. The Divisions of Vegetable Physiology and Pathology, Botany, Pomology, Agrostology, and Gardens and Grounds are grouped into a bureau to be known as the Bureau of Plant Industry. The divisions will retain their individual organizations as heretofore and will continue to work along lines similar to those which they have already developed. The total appropriation for the Bureau of Plant Industry is $204,680. The Division of Forestry is also made a bureau for which there is appropriated $185,440.

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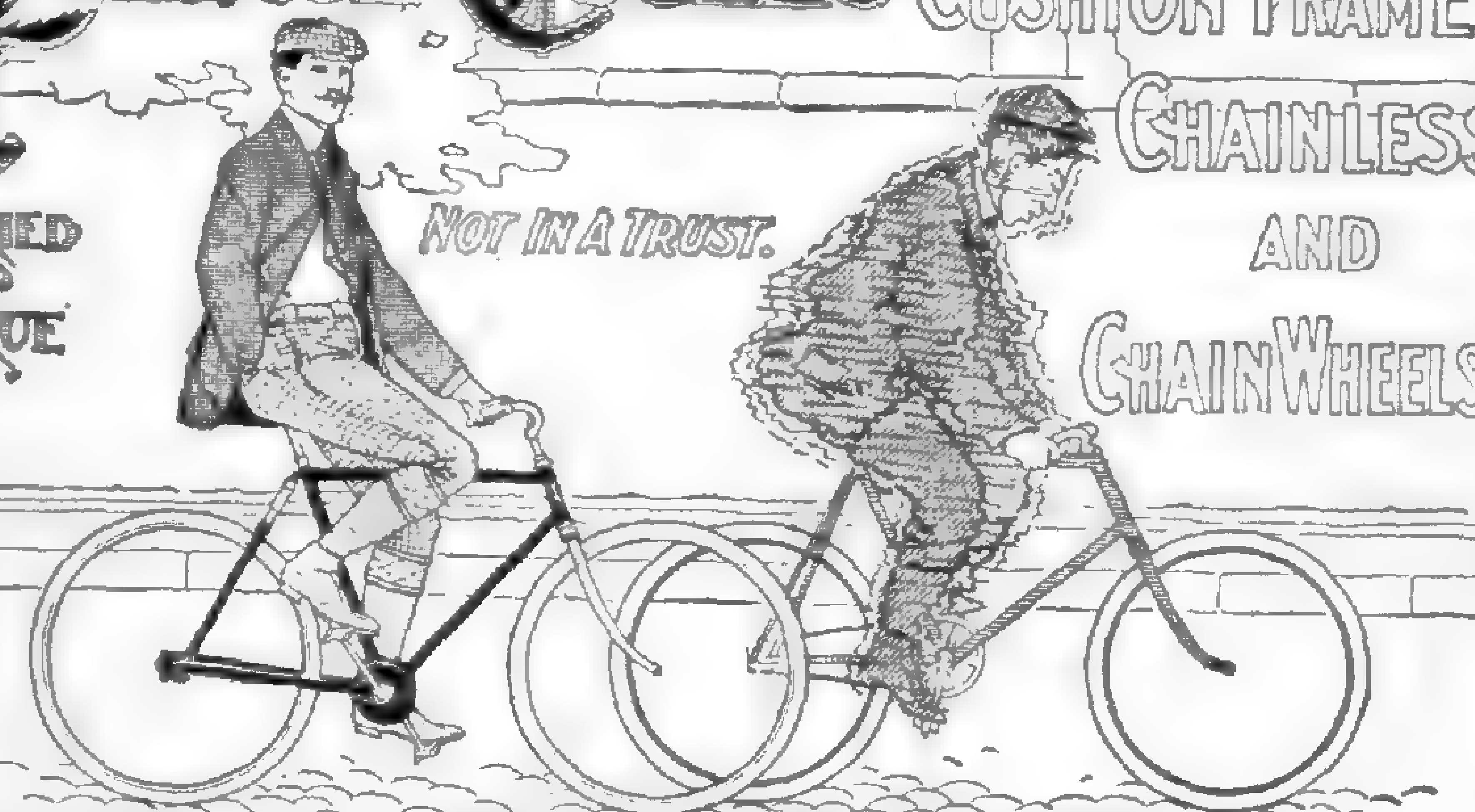

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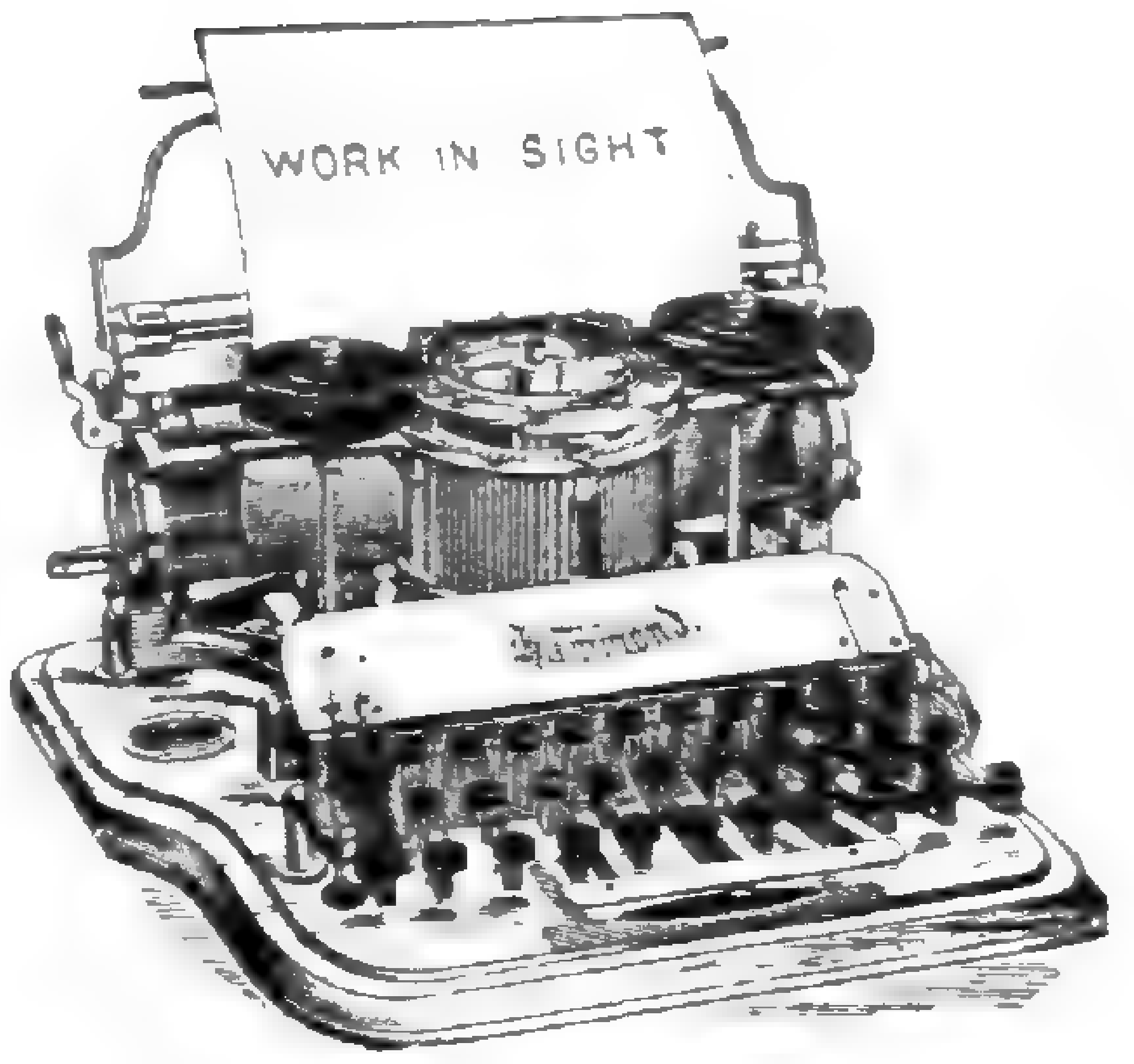

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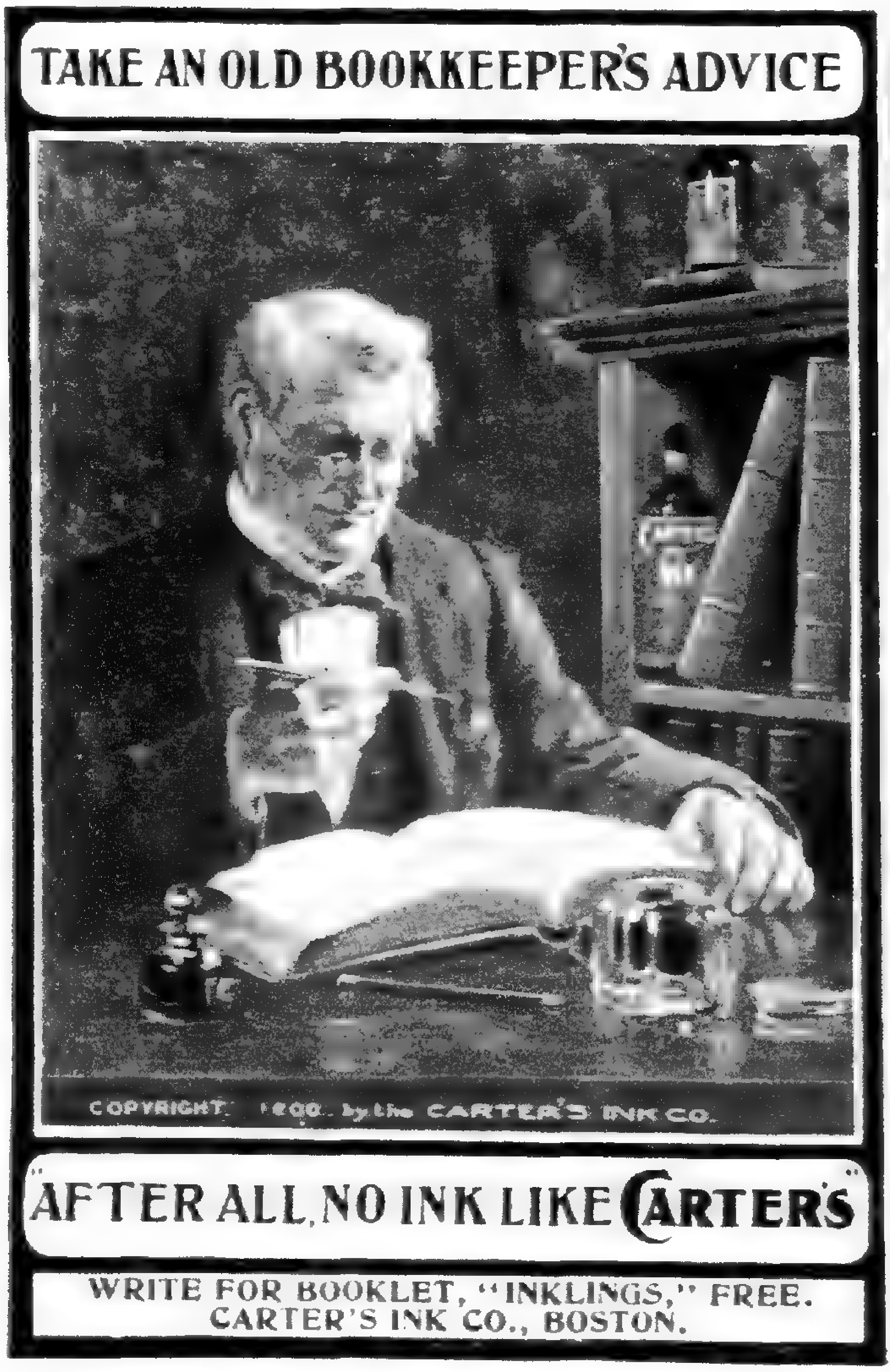

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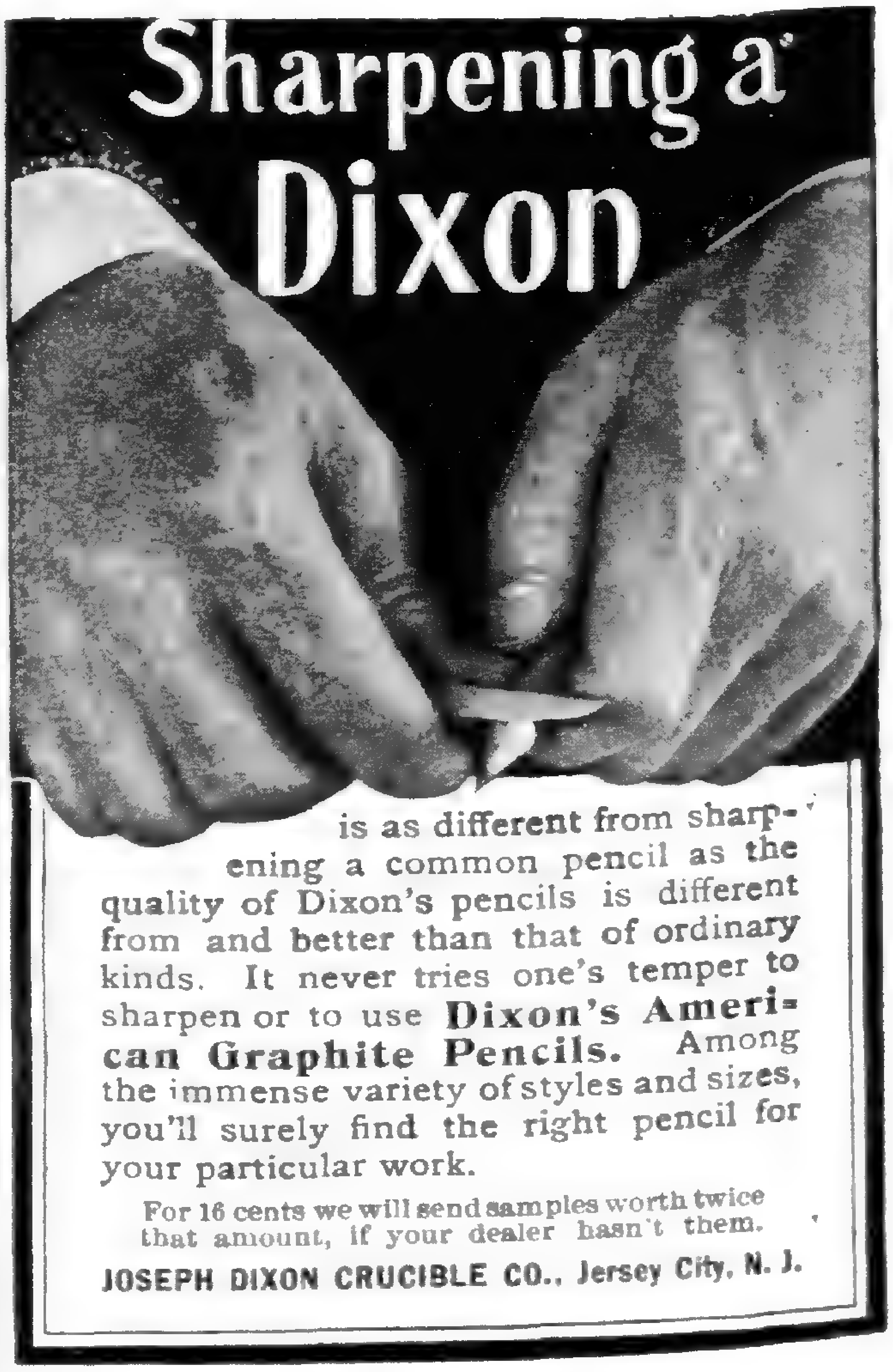

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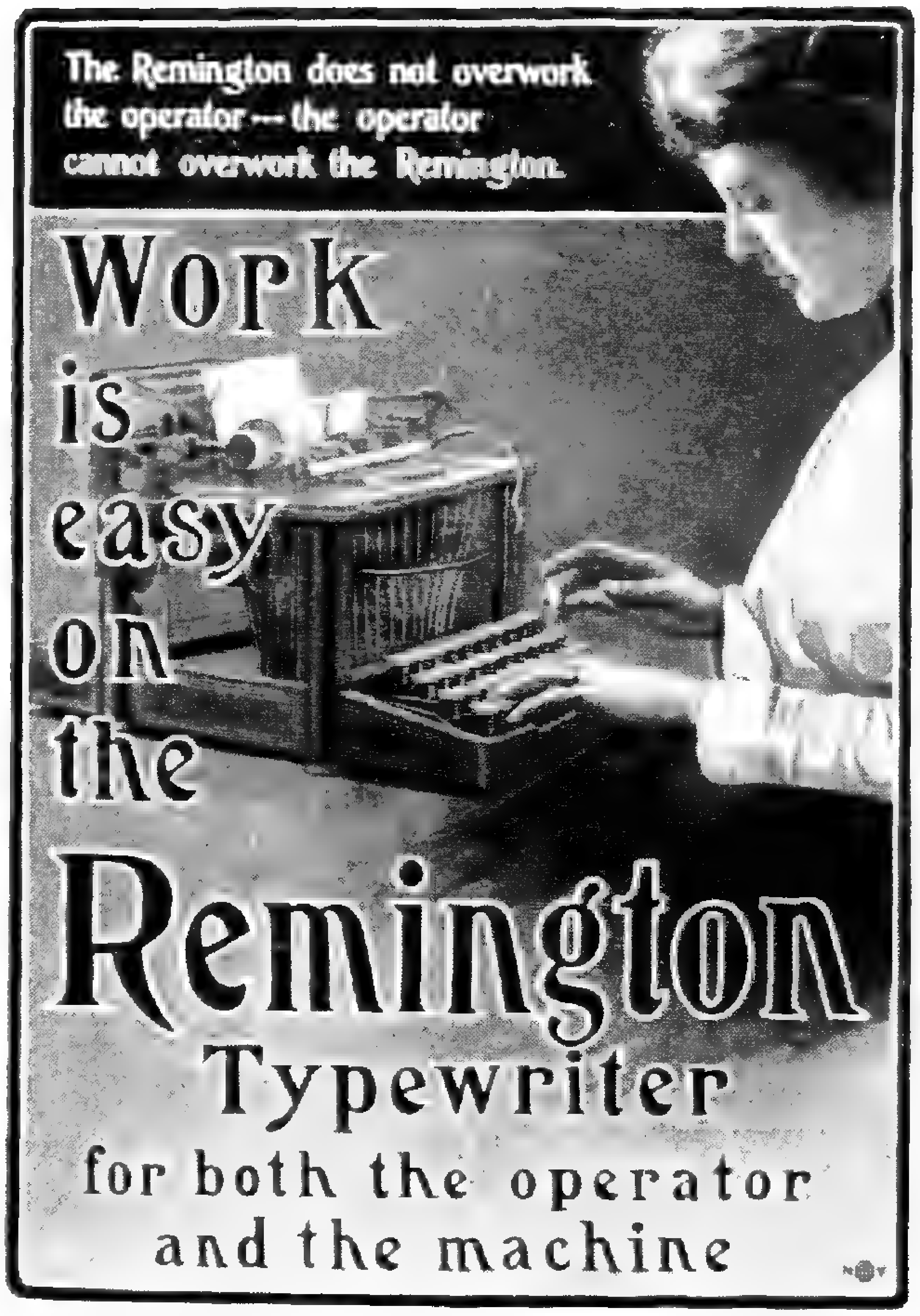

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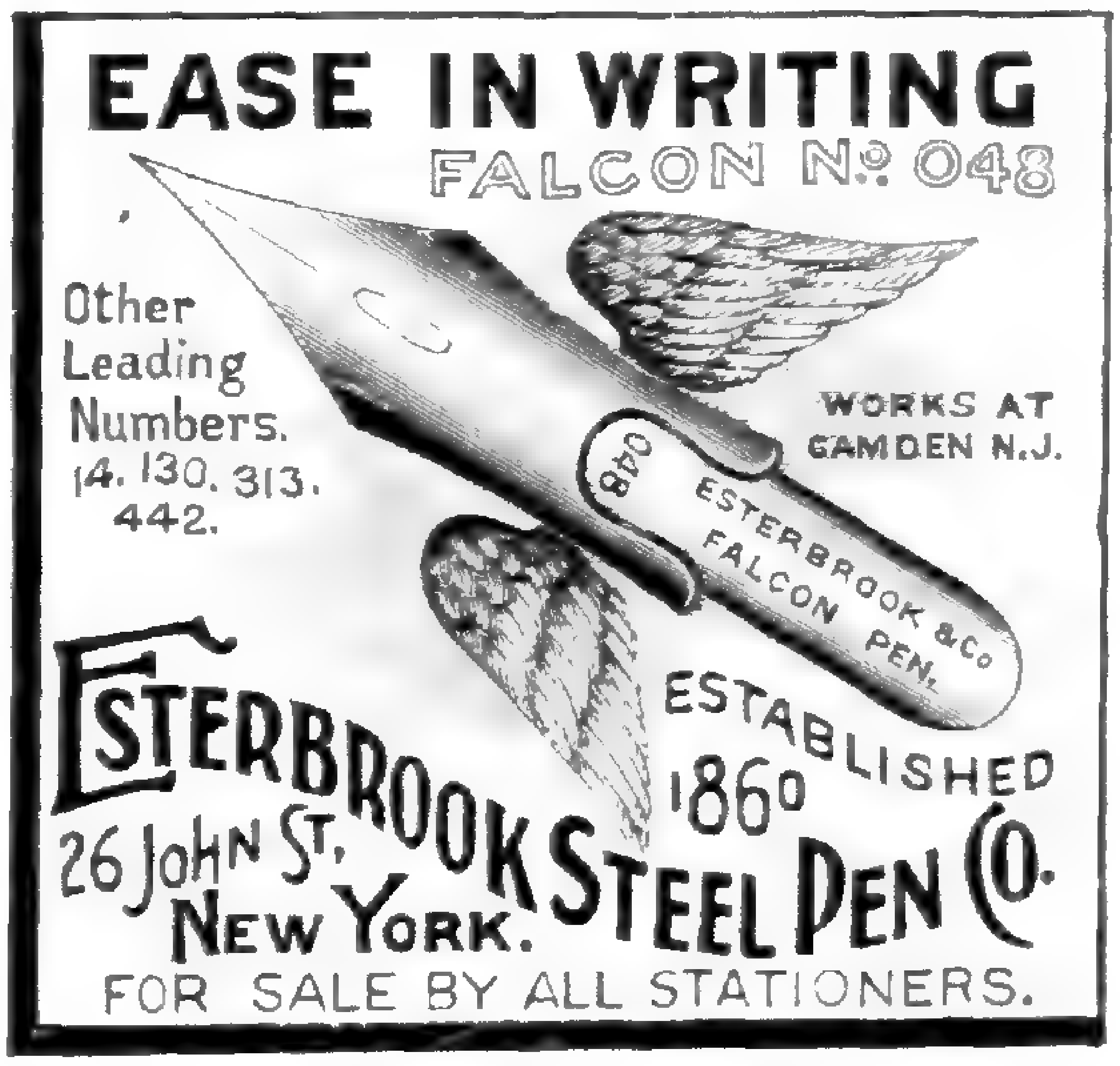

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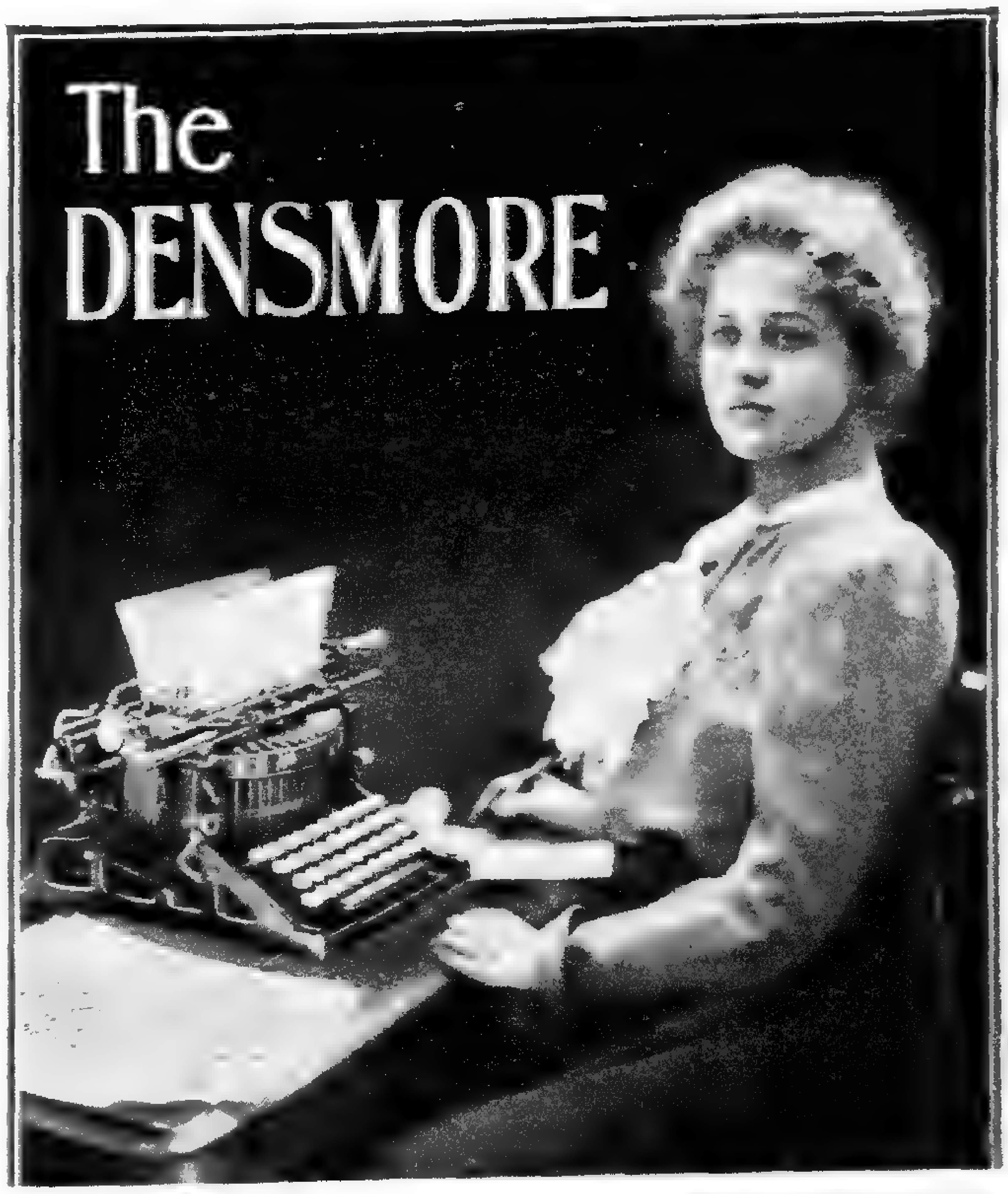

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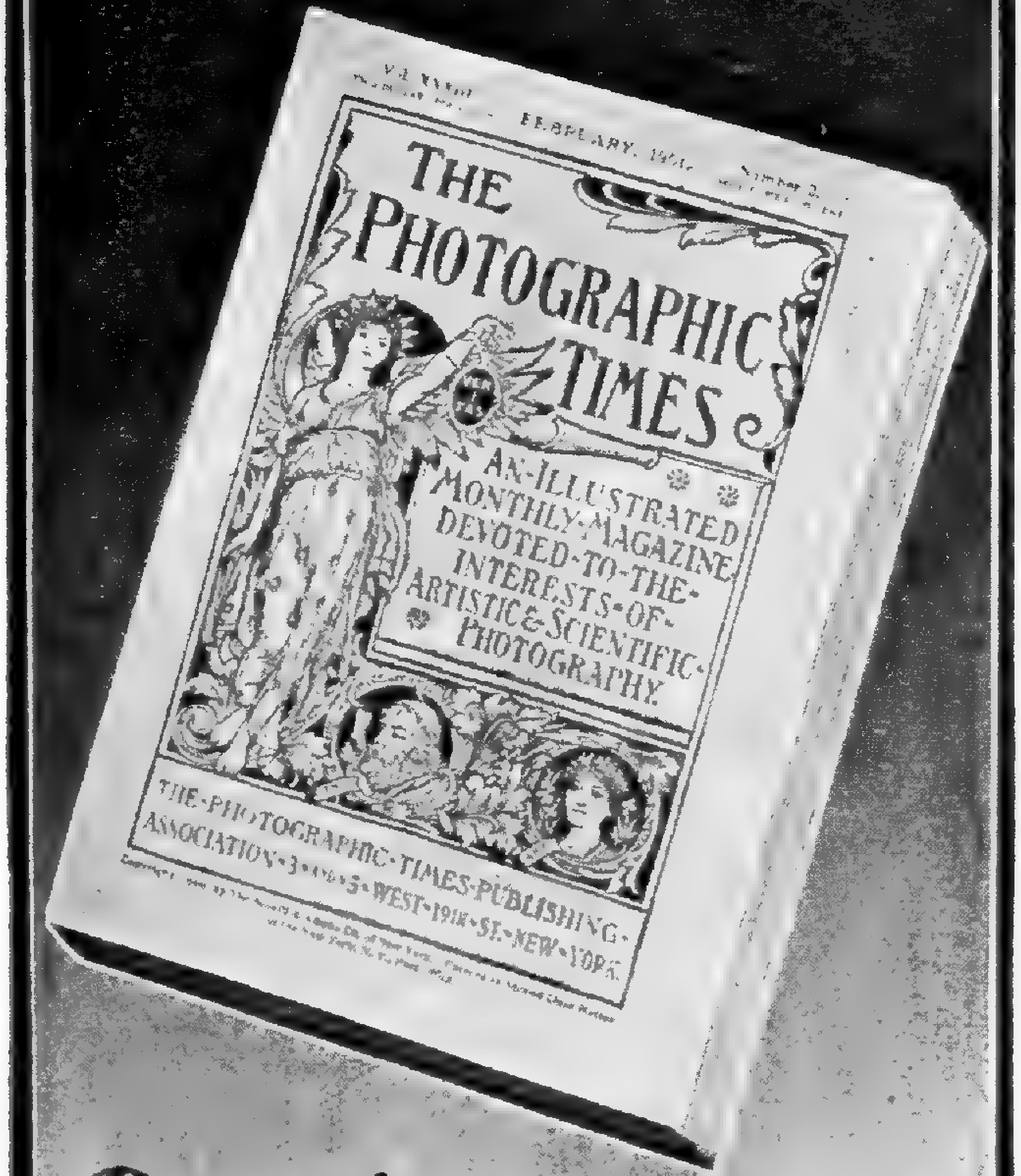

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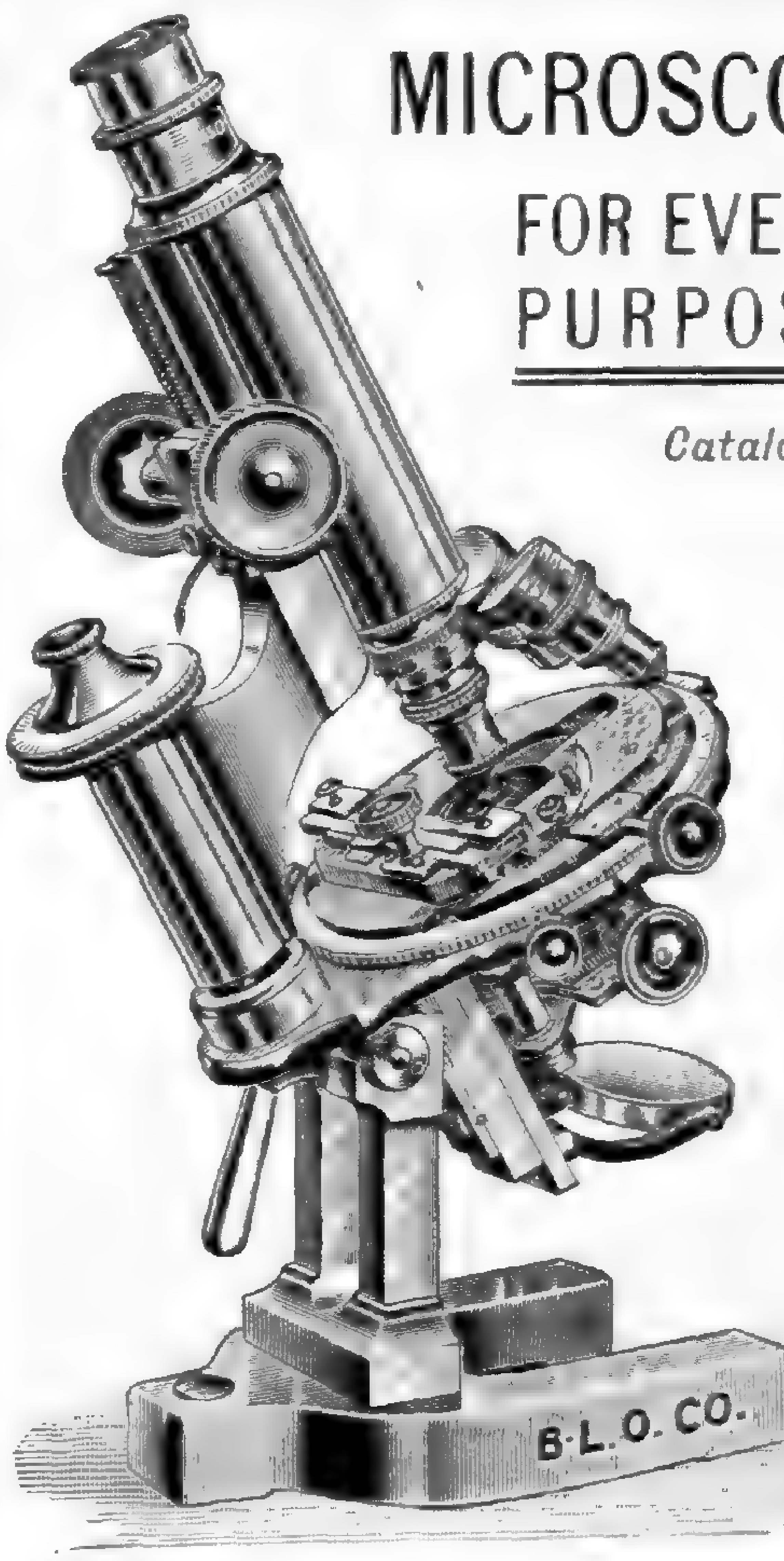
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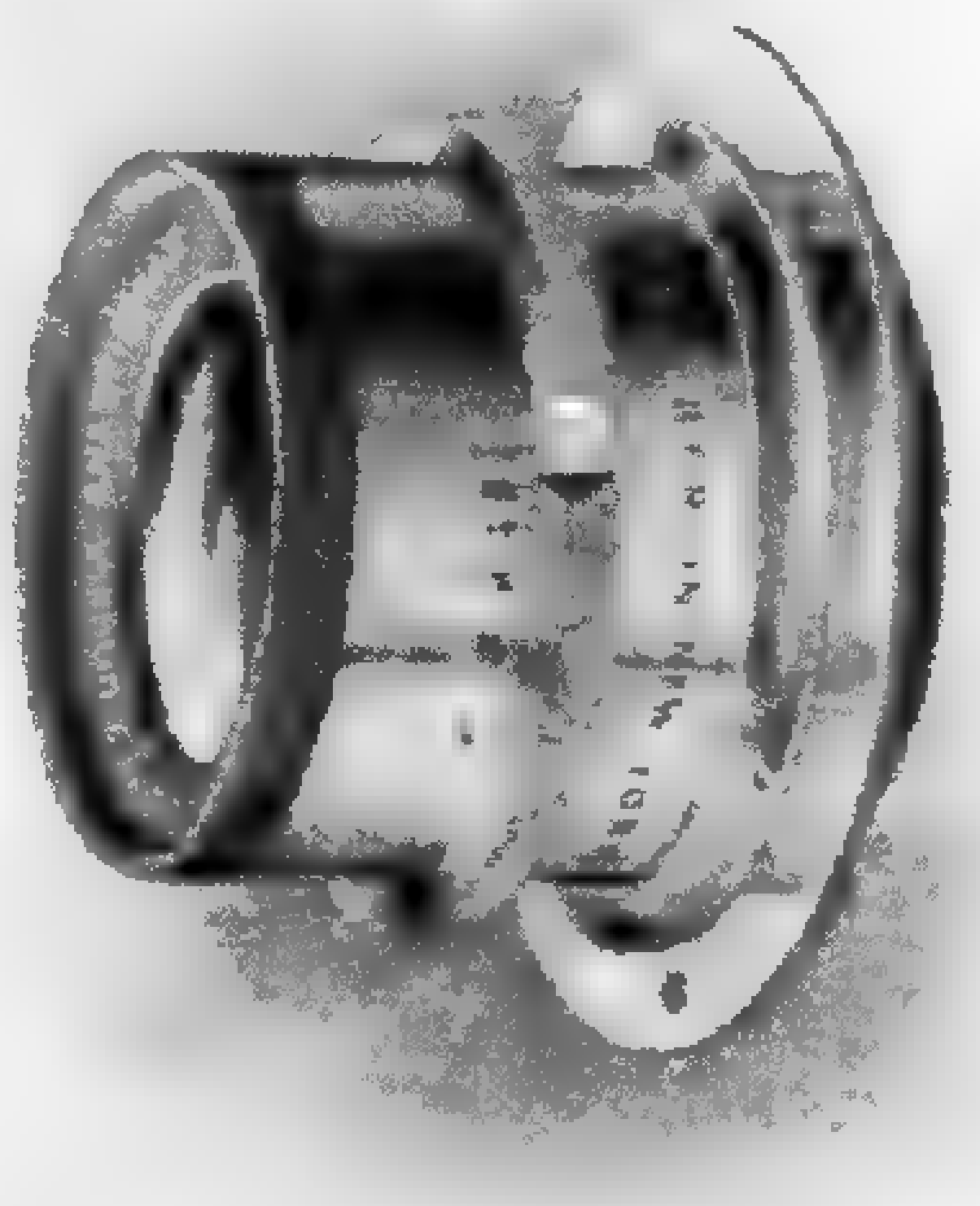

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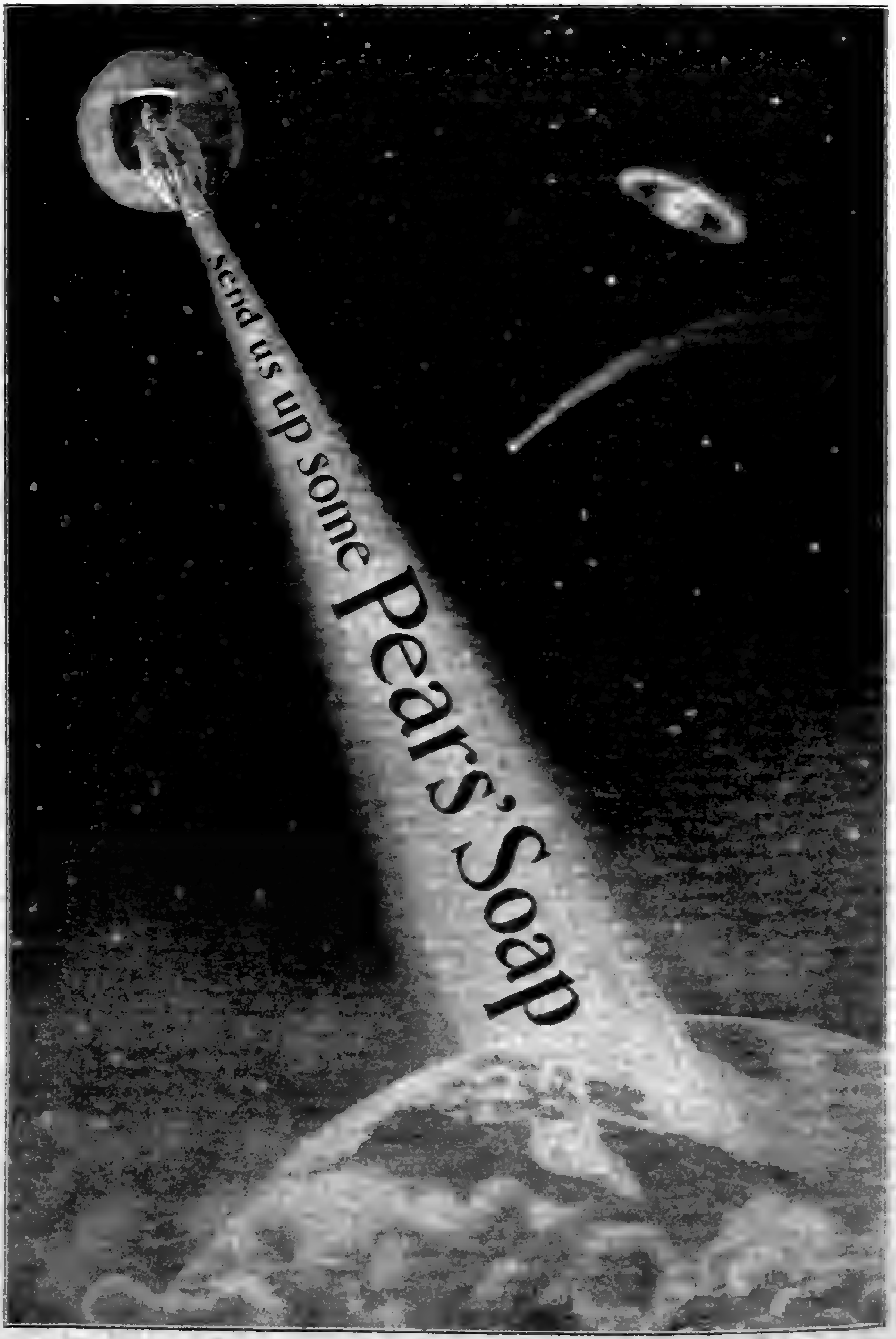

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THE GENETIC DEVELOPMENT OF THE FORESTS OF NORTHERN MICHIGAN; A STUDY IN PHYSIOGRAPHIC ECOLOGY.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. XXVII.

HARRY NICHOLS WHITFORD.

(WITH EIGHTEEN FIGURES)

PORTIONS of the summers of 1898, 1899, and 1900 were spent by the writer in studying physiographic ecology at several points in northern Michigan. The work of the first two summers was under the personal direction of Dr. H. C. Cowles, to whom the writer is indebted for many valuable suggestions. Indeed, the work set forth in the present paper is little more than the testing and working out in detail the ideas on physiographic ecology developed by Dr. Cowles in his lectures at The University of Chicago and in his published papers. Credit is due Mr. W. B. McCallum for the photographs used to illustrate this article, with the exception of *figs. 1* and *4*, which were obtained by Mr. E. N. Transeau.

It should be clearly understood that the conclusions reached are based mainly on observations and are presented tentatively. They are published in the hope that they may be thoroughly tested by other observers, and if necessary modified or discarded altogether. It is the writer's belief that only along lines similar to those advocated here can the problems of forest distribution be successfully solved.

I. FACTORS.

The factors to be taken into account in attempting to explain the relations that exist in different plant associations are so complex that it will be well to consider them in detail. Since the object of this paper is to answer some of the questions involved in the development of forests, special emphasis will be laid upon those factors which appear to be related to tree growth. In order to understand the distribution of trees the subject must be approached from both the negative and affirmative standpoints. In other words, the question is, why are there forests on certain physiographic formations and none on those which lie close by? Also within the forest itself there predominates now one and now another tree type. In some places the coniferous forest is prominent, in others the maple-beech-hemlock type is the chief feature. Indeed, if enough regions are studied an indefinite number of combinations may be observed. Thus not only must the presence or absence of trees be explained, but also where trees are present a reason must be given for the dominance of any particular kind of forest. If these questions can be answered satisfactorily, some light will be thrown on the origin and development of forests. In the answer three sets of factors are involved, climatic, ecological, and historical.

A. **Climatic factors.** The greater part of the eastern half of the United States is a potential forest. Here the two great climatic factors, *temperature* and *moisture*, are favorable to the development of forest trees. When a climate makes possible the development of any predominant type of vegetation that type is called a *climatic formation.*[1] To be specific, the eastern half of the United States has a *forest formation.* But if a bird's-eye view of any portion of this formation be obtained, there will be found within it groups of other plant types. These are designated by Warming[2] *plant societies.* Within this vast forest

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[1] SCHIMPER, A. F. W.: Pflanzengeographie auf physiologischer Grundlage. 1898.

[2] WARMING, E.: Plantesamfund. 1895. German edition, translated by Knoblauch. 1896.

formation there are prairie, beach, dune, heath, swamp, and other plant societies; also the forest itself may be divided into a number of different forest societies. This leads naturally to the consideration of those factors that make up the plant society conditions.

B. **Ecological factors.** For convenience this set of factors may be divided into edaphic, atmospheric, hydrodynamic, and biotic.

EDAPHIC FACTORS. Schimper[3] has regarded the soil and its properties so important that he has given the name *edaphic formations* to those *societies* which owe their existence to the peculiarities of the soil. More than any other form of vegetation trees need a firm anchorage medium, and hence a deep soil. Since the roots are the absorbing as well as the holdfast organs, the water content of the soil is important. Warming's classification of plant societies[4] into xerophytic, hydrophytic, and mesophytic is based upon the amount of water in the soil. More plant societies doubtless owe their characteristic physiognomies to the amount and condition of the water in the soil than to any other one factor. Since trees present a greater transpiration surface than other forms of plants they must occupy those positions where there is sufficient water to maintain the transpiration current. This excludes them from those regions where the water content of the soil approaches the minimum; a stagnant condition of soil water is likewise injurious to trees. Probably here the exclusion of air and the presence of humic acids prevent the healthy growth and activity of the root system. In order that the forest condition may be obtained, therefore, the soil must be well drained, as well as watered.

The physical properties of the soil play an important rôle, for upon them depends the capacity of the soil to hold water. The water-holding properties of the different kinds of soil are too well known to need treatment here. The heat-absorbing and heat-retaining qualities of soils must be taken into account, for they often determine the presence or absence of certain plants.

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[3] *Op. cit.* [4] *Op. cit.*

Again, the soil furnishes the plant certain organic and inorganic compounds, and hence its chemical properties should be considered. As a rule, inorganic salts are present in sufficient quantities in the soil; indeed in salt marshes the presence of too great a quantity of salt in the water excludes trees, except in a few instances. Soils are more often deficient in organic compounds. Organic decay, since it furnishes most of the available nitrates, is of great importance. The amount of *humus* is so essential that it often determines the character of a forest, not only in furnishing the nitrogen to the plants, but also in ameliorating the physical properties of the soil. Nitrifying bacteria are necessary for the conversion of organic matter into nitrates, and if these are excluded the processes of organic decay discontinue, and consequently a condition like that present in sphagnum swamps is developed. Here, generally speaking, trees are excluded, except a few characteristic species.

We must look to the soil factors for an explanation of our most characteristic plant societies. There must be a soil. The water in the soil must be sufficient. The soil must be aerated. The amount of organic and inorganic compounds must not be too great or too little, and usually the soil must contain bacteria or other fungi for organic decay. If all these conditions are present in the right proportions, the soil is capable of supporting a luxuriant tree growth.

ATMOSPHERIC FACTORS. By atmospheric factors are meant those which influence the aerial parts of plants. They include radiant energy in the form of *heat* and *light*, and also the influence of *wind*. Of these light is the most important. The tree by virtue of its many planes of plagiotropic branches gives a greater surface on which the light may fall than is found in any other plant form. Principally because it has worked out this successful light relation, it is ecologically the culminating type of plant body. Once a dense forest is established, all forms of low vegetation, except those species that have special shade adaptations, are driven out. Attention has already been called to the necessity of heat as a climatic factor. Heat may also be an ecological factor. In exposed situations the water and humus contents of the soil may be dried out. For example, a forest may be cleared and thus exposed to the sun's rays to such an extent that the soil factors will be changed considerably. It is obvious that it is difficult to separate the light and heat factors. While it is a benefit for a plant to get as much light as possible up to a certain point, along with the light the plant may absorb too much heat.

The carbon dioxid content of the air is so constant that it plays little or no part as an ecological factor. Those plants nearest the ground are slightly favored by the greater amount of carbon dioxid in the lowest layers of the atmosphere. The effect of winds on trees, however, is often pronounced in exposed situations. Besides destroying trees the wind may injure them to such an extent that in the struggle with disease and with other trees they will be the first to succumb. The wind is of great importance also in that it causes excessive transpiration. The effect of wind on seed distribution is so pronounced that, other things being equal, those plants whose seeds are most easily distributed will stand the best chance in a given area. In conclusion, therefore, the atmospheric factors of light, heat, and wind must be taken into account in trying to explain the presence or absence of certain plant societies.

Hydrodynamic factors. The term hydrodynamic is used here to designate the action of tides and waves upon strand vegetation, and the action of stream and ocean currents in distributing seeds. These factors may play an important part in determining the peculiarities of plant societies, hence the necessity of keeping them in mind.

Biotic factors. Two plants cannot occupy the same soil at the same time. The struggle for a foothold in the soil may take place between species of the same kind or of different kinds. Again, the struggle may be between plant societies, as the forest and heath, or forest and prairie. The line along which two societies meet has been called the tension line. Here it is that the struggle is most pronounced. If the other ecological factors remain constant, the tension line does not change. In that case, for instance, the forest does not advance on the heath nor the heath on the forest. But, as will be shown in the discussion of the historical factors, the conditions as a rule are changing constantly. Not only may the struggle be between the forest on the one hand and some other type of plant society on the other, but it may be between different kinds of forests.

The struggle between plants and animals may have an important bearing on the explanation of any given floral region. In civilized communities man has changed the whole nature of the vegetation. His influence is seen where forests are cleared for timber and fuel, or for purposes of cultivation; also indirectly where forest and prairie fires are active. Again in regions where stock is raised trees are damaged or kept from spreading by the ravages of domestic animals. Insect life may also be an important factor in explaining the floral character of a given region.

In concluding this discussion of the ecological factors, it is well to note again that the three great physical media—soil, air, and water—are all influential in bringing about certain plant physiognomies. These, together with the biotic factors, make that variety in the landscape of any region which is shown in the plant societies that are present.

C. **Historical factors**. The third great set of factors that play a part in the understanding of plant associations has been designated historical, for it involves the element of time. It means simply that the geological and physiographic forces have changed and are changing the factors so far considered as to make absolutely necessary a readjustment of plant formations and plant societies to meet the new conditions. Diastrophic movements may submerge large areas of land and thus destroy all terrestrial vegetation or force it to migrate to unsubmerged parts. On the other hand, when there is an addition to the land area a condition is obtained where there can be noted the successive stages in the reclamation of such an area by vegetation. Again, in the last glacial epoch the ice sheet in its advance destroyed vegetation and modified the climate beyond the limits of its advance, so as to bring about an arctic vegetation where there formerly existed a temperate floral formation.

Erosive forces also come into play. The advance and retreat of the ice sheet changed the physiographic features. Drainage lines were dammed up and lakes were formed. It is the belief of glaciologists that the great lakes, at least in part, were formed in this way. Oscillations in the change of the front of the ice sheet changed the levels of lakes and left old beaches, other sand formations, and cliffs, thus bringing into existence new topographic forms and new soil conditions. With the final retreat of the ice sheet the normal processes of water erosion began again. Drainage lines became reestablished, and with the aid of decaying vegetation the lakes began to be filled up. The longer an area of land has been free from the ice sheet, the more nearly have its drainage lines become firmly established. It is evident then that the edaphic conditions in a region recently vacated by the ice will be decidedly different from those that have been exposed to the erosive force of water. The more nearly a region reaches base level the more stable will be the edaphic conditions. The recent work of Cowles[5] on the Chicago region shows clearly the successive stages in the advance toward the climax condition. He was also the first[6] to bring out clearly the dynamic conditions due to physiographic changes. It is evident that the existing plant societies must not be looked upon as fixed, but rather as changing from year to year; sometimes slowly, as in the case of swamps; or sometimes with rapidity, as in the case of dune societies.

II. THE SAND SOCIETIES.

The islands of North Manitou and Beaver at the northern end of Lake Michigan, the adjoining mainland on the Michigan

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[5] COWLES, H. C.: The physiographic ecology of Chicago and vicinity; a study of the origin, development, and classification of plant societies. BOT. GAZ. **31**: 73–108, 145–182. 1901.

[6] COWLES, H. C.: The ecological relations of the vegetation of the sand dunes of Lake Michigan. BOT. GAZ. **27**: 95–117, 167–202, 281–308, 361–391. 1899. *Idem:* The physiographic ecology of Northern Michigan. Science **12**: 708, 709. 1900.

side of the lake, and the southern shore of Lake Superior in the neighborhood of Marquette, Michigan, offer exceptionally good fields for a study of the stages in the life history of the forest societies. North Manitou island, in general, consists of a clay core covered over and added to by sand formations, principally beach and dune. So complex are these in the interior that it is difficult to trace any definite time relations, and no attempt was made to do this. On the south and southeast ends of the island however, where the beaches and dunes are in the process of formation, it is not so difficult to discover the time relations. The northern portion of Beaver island and the mainland in the vicinity of Charlevoix, Michigan, have similar formations. On the southern shore of Lake Superior, while the beaches are present, the dunes are for the most part absent. The beach and dune societies have been so thoroughly studied by Cowles that attention need only be called to the points in his work essential to the understanding of the various stages in the life history of the forest of these regions.

THE LOWER BEACH. The lower beach is defined as that portion washed by the summer waves. There are a number of factors here, any one of which may exclude vegetation. Since the beach is the shore drift in transit, the very movement of the sand or pebbles may prevent plant life. The mechanical wash of the waves would uproot any plants that had obtained a foothold. Again, the border between the land and water presents at one time a xerophytic and perhaps the next moment a hydrophytic habitat. However, in protected places, or where the water is shallow for a distance from the shore, the breaker line thus being distant from the shore, a condition is obtained which may bring into existence a hydrophytic society. Wherever sand is accumulating along the shores in the region under discussion, the lower beach is prominent. With a further recession of the lake it may pass into the middle beach. It is considered, therefore, the first stage in the life history of the forest, for by the action of the waves a soil is made, the first requisite for any forest society.

THE MIDDLE BEACH. The middle beach is that portion of the shore drift in transit only during the winter months. It is consequently free from the waves during the growing season. Here, therefore, is a new land formation in which all the factors which prevent growth in the lower beach are eliminated for the brief space of one growing season. While the hydrodynamic factors have been eliminated, certain of the atmospheric, edaphic, and historical factors are detrimental. Since the former are considered in the initial stages of the upper beach society, they will be discussed under that head. In the short period that this beach is left untouched by the wave action, no plants of any consequence can obtain a foothold. This, together with the sterile soil of sand or pebbles and the extreme exposure to insolation, often prevents the growth of any species. In a few instances the annuals, *Cakile Americana* and *Corispermum hyssopifolium*, and the first year's growth of the biennial, *Oenothera biennis*, are present. If the new land thus made contained an alluvial soil stocked with seeds, one might expect a more or less abundant growth of annuals, though the insolation would still be very great, and would undoubtedly prevent a rich growth. Since the middle beach, by a further recession of the waters of the lake, may become a fossil beach, and thus reach, as will be shown later, a condition more near the forest, it is regarded as the second stage in the life history of the forest.

FOSSIL BEACH. The fossil beach is that portion of the shore beyond the reach of the hydrodynamic factors. In the initial stages the fossil beach is as barren of vegetation as the middle beach, and if in an exposed situation the wind (*fig. 1*) shifts the sand repeatedly, this condition is maintained for a greater or less length of time. If fairly well protected from winds, successive plant societies appear rather rapidly.

The well-known physical and chemical qualities of sandy soils need not be discussed at length here. While the upper layers of sand dry out rapidly, observations seem to show that the lower layers are moist up to high levels. However, the first few layers are extremely dry after a short period of drouth, due to the rapid evaporation from the loose soil. The soil heats up and cools off rapidly, so that the variation in temperature in a short space of time is great, a condition unfavorable to plant growth. Nevertheless, in spite of the strong insolation and dry soil, if sufficient time elapses a definite fossil beach society is obtained. The enumeration of species is not of any consequence. They are at first mostly herbs, both annual and perennial. By their death, and in some instances by the decay of old logs left by storms when the beach was nearer the lake, humus conditions of the soil are gradually obtained. This is at first slow because of insolation. Nevertheless, each year adds its growth of herbs, and even though a greater part is dried out or blown away, in time the better humus condition will bring about the possibility of a higher type of plant society, so the fossil beach society gradually develops into a heath.

HEATH. The heath society is considered, in the normal development, the fourth stage in the life history of the forest. It will be well to keep in mind the changes that make possible the heath. These are the increase in the amount of humus and the element of time. *Juniperus communis*, *J. Sabina procumbens*, *Arctostaphylos Uva-ursi*, *Pteris aquilina*, *Zygadenus elegans*, *Solidago nemoralis*, *Campanula rotundifolia*, and *Comandra umbellata* are some of the characteristic plants of the heath. *Fig. 1* shows a heath at the foot of a coniferous forest on the lake side of a sand dune.

Now for the first time biotic factors assume some importance, though slight. In the first three stages the struggle of plants against adverse physical conditions gave plenty of room for all able to survive. Although the physical conditions are still unfavorable, in places plants like the junipers and bearberry may occupy considerable areas to the exclusion of others. In the open spaces between the individual shrubby plants, however, there is sufficient room for a large number of herbs. These by decay contribute humus to the soil, and since the insolation is not so great as in previous societies, a larger portion of the decaying vegetation is prevented from drying out. Thus as the vegetation increases there is a gradually increasing increment of humus, and this constitutes a condition favorable to a higher type of plant society.

THE CONIFEROUS FOREST. It is not always easy to determine the conifer that first comes to occupy a place in the heath. If conclusions can be based upon a limited number of observations, the jack pine (*Pinus Banksiana*) is the most xerophytic (*fig. 2*). This is followed closely by the red pine (*P. resinosa*) and the white pine (*P. Strobus*) in the order named. This does not mean that anyone of these always appears to the exclusion of all others, though that is sometimes the case (*fig. 2*). Other things being equal, the more xerophytic the conditions the more likely is it that the jack pine will be the predominant tree, and the less xerophytic the conditions the more abundant the white pine. *Fig. 3* is a photograph of a pine forest in which the red pines form a large proportion of the trees. In this forest are a number of white and jack pines. If the succession as given above be correct, it means that this forest is probably a transition between the jack pine society and a white pine society. In the ideal case, then, the succession of predominant species is in the order named. The drier and perhaps the colder the climate up to a certain point, the more likely is this succession to be realized. Thus, in the Marquette region almost pure jack pine forests are found, while at North Manitou island, where the climate is more uniform, the jack pine stage is almost eliminated. Very often the balsam (*Abies balsamea*) (*fig. 1*) and hemlock (*Tsuga Canadensis*) occupy a prominent place in the coniferous forest.

The first stages of the pine forest society are seen in the appearance of a number of trees in the later stages of the heath. For the first time in the normal development of the plant societies the tree has to be taken into consideration. In the tension zone between the heath and forest the trees are more scattered near the heath, and become gradually thicker as the forest is approached. The territory between the trees, where not shaded, is usually occupied by a growth of the heath plants already named. Thus, gradually the pines advance on the heath, and in time come to occupy its territory. In the young pine forest near the tension zone there are often found scattered trees of the white birch (*Betula papyrifera*), oak, and the poplars (*P. tremuloides* and *P. grandidentata*). As the forest reaches maturity, these are usually crowded out, the birch being the last to disappear.

Thus, with time and with the gradual increase of humus, the pine forest society is established. As a rule, the white pine seems to occupy the tension zone between the coniferous and the deciduous forests. If the climate be unfavorable for a higher type of forest tree, however, a stage beyond the white pine forest is not reached. If the forest be not too open, and if surface fires are absent, the deep shade established by the pines means that the edaphic and atmospheric factors have become favorable for establishing the climax forest of the region.

MAPLE, BEECH, AND HEMLOCK FOREST. Beginning with the middle beach we have seen that in each successive society a gradually increasing quantity of humus has been added to the soil, until a white-red pine forest is established. The pines add their quota of vegetable decay to the humus. The xerophytic soil thus becomes more and more mesophytic, and *pari passu* it has become more and more shaded. The humus means that the almost sterile soil of the beach has become richer in organic compounds, and by the aid of fungi and bacteria more nitrates are added. The capacity of the soil to hold water is likewise increased. The better edaphic and atmospheric conditions make a natural nursery for the growth of beech (*Fagus ferruginea*) and maple (*Acer saccharinum* Wang.) seedlings. The white pine does best in the richer soil conditions, but its seedlings require more light than they can obtain in the shade of the forest. As the maple and beech attain maturity, they come to occupy a prominent place in the forest, and a mixed pine-deciduous forest is the result. The broad-leaved deciduous trees produce a still deeper shade, so that if any pine seedlings are able to survive in the pine forest, the increasing shade will finally make it impossible for a new generation of pine trees. The development of beech and maple seedlings, however, is not affected by the shade of the parent trees. In the midst of the deciduous forest isolated white pines are often seen rising above their neighbors, and thus stand as relics of a previous pine forest. A pine starting from a seedling condition with young deciduous trees as a rule never reaches a height greater than that of the trees among which it is growing. At the same time the girth of such a tree is much greater, owing to the better soil conditions, than it would be were it growing among its kind, where it must necessarily grow taller or be crowded out in the struggle for light.

The place of the hemlock in the pine and deciduous forests is a peculiar one. It often composes 10 per cent. of the trees in a white pine forest, and may reach as high as 50 per cent.[7] It seems to be of about the same age as the trees with which it grows, and hence probably started with them. This probably means that its seedlings are able to develop like those of the pines, without being shaded. Yet it often occupies a prominent place in the deciduous forest (*fig. 4*), even when the shade has become so dense as to exclude any chance for the development of white and red pine seedlings. It apparently occupies this position among the maple and beech because its seedlings can endure shaded conditions, although they do not thrive in such situations. Dwarfed young trees fifteen or more years old are often found in the densest shade possible. These develop slowly, until an open place is made by the death of the older trees around them, when they spring rapidly into prominence and occupy a position equal to that of the maple and beech. Like the white pine, the hemlock will flourish in the more xerophytic places, but prefers the deciduous woods and does best in them. The balsam also occupies a position similar to that of the hemlock, although it is seldom present in a mature climax forest. The yellow birch (*Betula lutea*) has a constant place with the beech, maple, and hemlock. It is more plentiful in the Marquette region than farther south, but seldom constitutes more than a small percentage

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[7] SPALDING, V. M., and FERNOW, B. E.: The White Pine Bull. 22. U. S. Department of Agric., Div. of Forestry. 1899.

of the total number of trees. The beech is absent in the Marquette region, and the significance of this is not clear. It may be due to the fact that the climate is not favorable for its development. It is present, however, in the northern peninsula east of Marquette.

The whole interior of North Manitou island (*fig. 4*), except in clearings and undrained areas, is covered with a mature maple-beech-hemlock forest. The presence of seedlings and young trees of these three in abundance and the absence of all other young trees in their shade indicate that the future forest growth will be the same as the present. The climax forest in places reaches nearly to the shore of Lake Michigan, restricting the coniferous and heath societies to very narrow belts. If the present shore line should remain constant, and if the natural succession of plant societies were not interfered with by man, undoubtedly the whole island would in time become completely covered with a deciduous forest save a narrow strip, the last remnants of a coniferous forest, next the water's edge.

The undergrowth in the dense shade of the maples, beeches, and hemlock is scanty. *Taxus Canadensis* and *Mitchella repens* are usually the most abundant. The spring plants are characteristic, but their vegetative period is confined to the leafing time of the trees under which they grow, so that by midsummer only traces of the many forms survive. The loose sandy soil is favorable for creeping underground stems. Lianas are entirely wanting. This is probably due to the lack of sufficient light and heat, for in the open woods farther south the liana habit is common, and as one approaches the tropics the increasing warmth, even in dense shade, favors a luxuriant growth of lianas. Epiphytes, except mosses, liverworts, and lichens growing on the bark of trees, are also absent.

Aspidium spinulosum intermedium, *A. marginale*, *Lycopodium lucidulum*, *L. inundatum*, *Actaea alba*, *Goodyera pubescens*, *Osmorrhiza brevistylis*, *Maianthemum Canadense*, *Monotropa uniflora*, *Corallorhiza odontorhiza*, and *Epiphegus Virginiana* are among the most common plants that occupy a place in these forests.

The humus in the soil is usually variable in amount, but is most plentiful where fallen logs have decayed. Hummocks of soil rich in humus mark places where dead trees when uprooted brought with them quantities of earth. The decaying logs are covered with fungi and mosses. Indeed the soil itself is full of a living mass of hyphæ. The recent researches of Stahl[8] show that mycorhiza is the exception rather than the rule. The rôle that mycorhiza plays is problematic. Some plants, the European beech among them, are entirely dependent upon these root-fungi, for when grown in sterile soil they perish. This seems to indicate that the beech cannot thrive in soil without humus, for its root-fungus is dependent upon organic decay for its existence. In other words, the absence of humus means the absence of mycorhiza, and its absence excludes the beech. Indeed, future investigation may show that a large majority of forest trees and other forest plants have established an obligate mutualistic relation with root-fungi.

THE DUNE SOCIETIES. In discussing the sand societies the conditions favorable to the formation of dunes have been disregarded. Where the wind sweeps across the fossil beach the succession of plant societies is retarded. The extreme exposure to the xerophytic influence of the wind often prevents the presence of plants. Nevertheless, when not too severe, a definite beach society is finally attained. The origin and development of dunes and dune societies have been clearly shown by Cowles.[9] It is only necessary to emphasize the fact here that the plant succession on dunes is similar to that on the beaches, and that in time the climax maple-beech society is reached. *Fig. 1* is from a photograph, showing a fossil beach society in the foreground. On the right is a dune clothed with a coniferous forest. At the base of the dune is a heath encroaching upon the beach. On the landward side of this dune there are indications of the beginnings of a maple-beech forest, and farther inland are dunes

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[8] STAHL, E.: Der Sinn der Mycorhizenbildung. Jahrb. f. wiss. Bot. **34**: 539–668. 1900.

[9] Sand dunes of Lake Michigan, BOT. GAZ. **27**: 95 ff.

which have passed through the first stages into mature climax societies. Dunes clothed with maple-beech forests are also found along the Michigan coast in a number of localities. It is difficult to understand how such a mesophytic plant society is attained, unless it be assumed, as observation seems to indicate, that by capillarity, water may rise from the ground water level to considerable heights in sandy soils.

III. THE CLAY SOCIETIES.

There are greater difficulties in tracing the life-history of clay societies than of sand societies, principally because there is not such a perfect sequence of clay formations at the present time as of sand formations. With the exception of sea-cliffs and clearings, clay soil formations free from vegetation date back to the time of the retreat of the last ice sheet. Sea-cliffs, however, formed by the action of the waves on glacial clay, are a common feature along the shores of Lake Michigan. Here the waves are constantly undermining the cliff, and thus prevent anything more than a transient vegetation. But should the débris at the foot of the cliff become too great for the shore current to transport, or should a recession of the waters of the lake leave a cliff beyond the reach of the waves, the undermining would cease. Here then at the outset is a clay bluff almost free from vegetation.

The reclamation by plant growth begins at once. The first stage in the life-history is represented by herbaceous plants like *Solidago humilis*, *Aster laevis*, *Elymus Canadensis*, *Prenanthes alba*, etc. Later on xerophytic shrubs like *Shepherdia Canadensis* and *Juniperus communis* give a heath-like physiognomy to the bluff. Again, a third stage is reached in the appearance of conifers, poplars, and white birch. These stages are more rapid, for clay soil retains moisture more readily than the sandy soils. The action of humus on clay is exactly the reverse of its effect on sand, for it loosens up the soil and renders it much less soggy than it would be were it free from organic decay. Where the cliff has been long enough freed from the action of the waves, in due time a maple-beech-hemlock condition is the result. Thus, starting with an herbaceous vegetation similar to that on the fossil beach, there is a transition through the heath and coniferous forest to the climax society. Making due allowance for difference in climate, it is probable that all the glacial clay

FIG. 1.—The lakeward slope of a sand dune on North Manitou island covered by a forest. Balsam is the most common tree. The undergrowth is very dense, and the deep shade furnishes favorable conditions for the development of maple and beech. The evergreen forest is encroaching on the evergreen heath seen at the foot of the slope, and the latter, in turn, is encroaching on the fossil beach society situated in the foreground.

lands in the region under discussion have passed through somewhat similar stages, since they were formed by the action of the last ice sheet. As a rule, where the vegetation has not been disturbed by man, they are clothed with maple-beech-hemlock forests. Where clearings are made, as will be shown subsequently, they rapidly attain the same forest condition if let alone.

IV. THE ROCK SOCIETIES.

The pre-Cambrian rocks of the Marquette region furnish an excellent field for the study of the succession of plant societies. The rocks are mostly granites and quartzites. The chemical nature of the rocks seems to have little influence on the ultimate plant society that is obtained, but the ease with which they disintegrate is different, therefore the rapidity of the succession of plant growth is influenced. Other things being equal, granites, because of their heterogeneous structure and consequently differential weathering, will furnish a soil more quickly than the homogeneous quartzite. In the region under discussion the rocks have not only been worn and polished smooth by the action of the last ice sheet, but since then have lain beneath the waters of the former extension of Lake Superior. Indeed, some of them have only recently emerged from the lake. Thus just as there are beach lines of different ages, so there are rock areas of different ages. Other things being equal,

FIG. 2.—Jack pine forest on a fossil beach near Marquette. The absence of undergrowth is due to repeated surface fires.

the longer the rocks have been subject to sub-aerial influences the more nearly they approach the condition of the climax plant society.

On the sand formations at the contact of the lake with the shore the hydrodynamic factors absolutely prevent plant growth.

FIG. 3.—Norway pine forest on an old beach near Marquette. This forest also contains a few white and jack pines.

Here likewise, where the rocks dip beneath the lake, there is a zone of no vegetation. However, often within the reach of not too active waves lichens are found. Many lichens need no soil; such are essentially lithophytes and are soil makers. They are fastened firmly to the rocks by holdfasts which secrete acids that aid in disintegrating the rocks on which the lichens grow. Lichens receive moisture from the rain that falls on them, or, when near the water's edge, from the wash of the waves. Between rains they dry and curl up, but are uninjured, for after the next rain they are as fresh as ever. Nitrogen compounds are obtained from the rain water or from particles of dust which lodge around them and other requisite inorganic compounds come from the rocks. Thus these pioneers of vegetation, as has been shown by various writers, are able to flourish in the most xerophytic situations. They not only aid in disintegrating the rocks, but by decay furnish humus constituents to the soil, and in these ways, *pari passu*, both organic and inorganic soil is made.

FIG. 4.—A maple-beech-hemlock forest in sandy soil on North Manitou island. The undergrowth consists principally of maple, beech, and helmlock seedlings and young trees; also *Taxus Canadensis* and *Mitchella repens*. The young trees indicate that the next generation of trees will be the same as the present.

If the lichens be on not too steep a slope they will in themselves furnish soil enough to maintain a higher form of plant life. Xerophytic mosses gain a foothold as soon as a slight soil is made. These, too, by decay aid the lichens in forming a soil that will support still higher forms. *Fig. 5* shows such a society. It is even possible, in time, without the aid of inorganic processes of weathering to establish a soil capable of supporting a tree vegetation. However, inorganic processes of weathering are going on continually. Changes of temperature, etc., crumble the rocks and form crevices in which soil lodges. Since most of

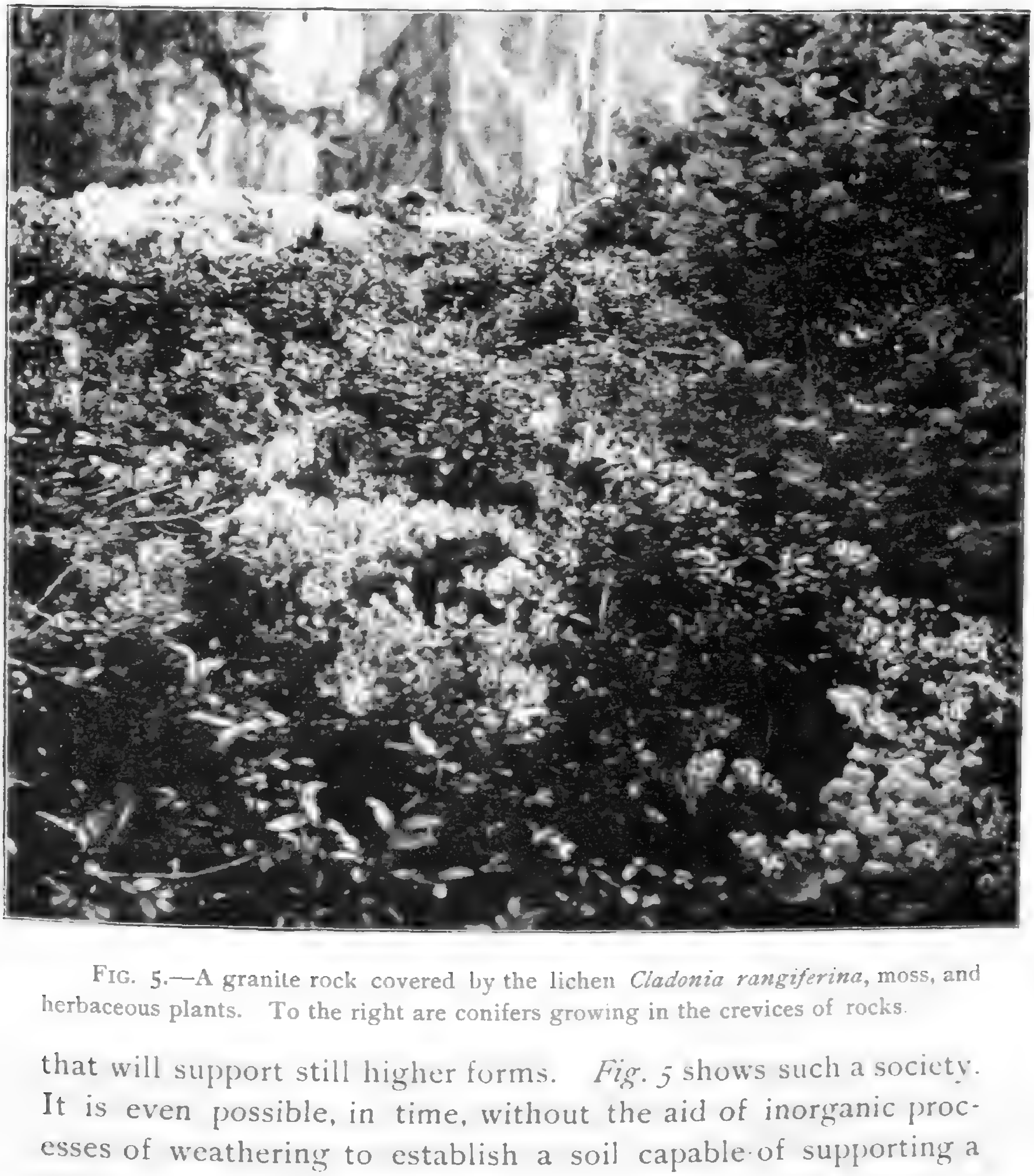

FIG. 5.—A granite rock covered by the lichen *Cladonia rangiferina*, moss, and herbaceous plants. To the right are conifers growing in the crevices of rocks.

the rock surfaces are not level, the soil made by lichens and mosses is washed into the crevices or into hollows made by the action of ice or water erosion. At once a herbaceous and shrubby vegetation springs up. Plants like huckleberries, goldenrods, *Potentilla tridentata*, *Campanula rotundifolia*, and the bearberry gain a foothold in the crevices. These are followed by arbor vitae (*Thuja occidentalis*), the junipers, and the pines. *Fig. 6* shows a rocky island in a bay near Marquette. At a distance it looks barren of vegetation, but a closer view (*fig. 7*) shows that it is not altogether destitute of plant life. *Fig. 8* is from a photograph of a larger island near by which shows a much higher type of vegetation, for here are found red and white pines. The weathering process is greatly aided by the prying action of roots. *Fig. 9* shows a red pine whose roots have split and raised a granite rock.

FIG. 6.—A granite island in Lake Superior near Marquette. At a distance it appears destitute of plant growth.

One of the noticeable features of rock vegetation is its variety. Within the limits of a few square rods miniature representations of all the great plant societies are found. Near a *roche moutonnée*, as smooth and as barren of vegetation as the day the ice sheet left it, is a small depression containing a swamp, in which sphagnum moss and the cranberry are found growing. Near by is a lichen society; this may grade into a heath such as is shown in *fig. 5*, and this in turn may border on a small group of pines.

As in the sand and clay series, the mesophytic forest is not reached until first preceded by a coniferous forest. The coniferous forests on the rocks are at first very open, but ultimately the gaps are filled up, sometimes with birch and poplars, and thus a condition is obtained for the maple-hemlock forests. Some rock hills near Marquette illustrate these points. *Fig. 10* is a view from Sugar Loaf. The top of this hill is almost barren of vegetation. Obviously this would be the case, for the soil that is formed descends to lower levels; in the case of steep

FIG. 7.—A near view of a portion of the island shown in *fig. 6*. On the faces of the rock are shown lichens and mosses. In the crevices are a number of herbaceous and woody plants; among them are goldenrods, poplar, arbor vitae, huckleberry, ninebark, Juneberry, wild red cherry, *Campanula rotundifolia*, and *Potentilla tridendata*.

slopes gravity alone is sufficient, while on all slopes the transporting power of rain water comes into play. Usually at the foot of the hill and sometimes well up the slope the conditions are favorable for the climax society. Other hills (*fig. 17*) farther in the interior are completely covered with pine and deciduous forests.

FIG. 8.—Portion of an island near the one shown in *figs. 6* and *7*. Here the vegetation is further advanced. Besides lichens, etc., white and Norway pines are found.

V. THE SWAMP SOCIETIES.

One of the most characteristic features of a young glacial topography is the large number of lakes. In general these may be divided into two classes according to their mode of origin. One class is due to the action of the ice sheet. Depressions may be made directly by the moving ice, or glacial deposits may dam up drainage lines. A second and subsequent class of lakes is made by bars cutting off lagoons from the larger lakes, or by spits formed across their embayments. Both classes have a similar life-history. Some find outlets and ultimately pass out of existence through the normal stages in the life-history of a river. A larger number, however, never find outlets, but are silted up by the wash of the surrounding soil, and by the accumulation of vegetation. Thus swamps are formed, and since they may represent a stage in the life-history of the forest they deserve treatment here.

The zonal distribution of plants in swamps is one of the stock illustrations of ecologists, so that development of the various zones need only be mentioned briefly. Most swamps start as ponds or lakes, in which water lilies and other pond plants dominate. On the borders of the pond sedges appear; these, by their decay,

FIG. 9.—A Norway pine growing from a crevice in granite; the rock has been cracked and uplifted by the growth of a root.

build up a soil, and thus prepare the way for the next zone, the Cassandra-sphagnum vegetation. The sedges encroach farther on the original lake. The Cassandra-sphagnum zone makes conditions possible for a tamarack-spruce zone (*fig. 11*). Thus each successive zone is pushed farther and farther toward the center. Finally the lily center disappears, and then successively the sedge and Cassandra zones, until a tamarack forest may come to occupy the whole territory.

FIG. 10.—A general view of granite rock vegetation as seen from a granite hill (Sugar Loaf) near Marquette. On the margin of the lake the rocks show the first stages in the life-history of a forest. As the foot of the hill is approached the vegetation becomes more and more mesophytic until a mixed conifer and deciduous forest is attained. Probably in places this condition is reached more rapidly because of the presence of glacial drift. At the top of the slopes the xerophytic condition of the lake border is again attained.

Attention has already been called to the probable factors unfavorable to a high development of plant life in these swamps. These are due in the main to undrained conditions. The accumulation of humic acids may cause, osmotically, a drying-up effect. Insufficient aeration of the soil prevents a healthy growth of the root system of highly organized land plants, and also bars the presence of nitrifying bacteria. These probably bring about the xerophytic structures of plants so commonly seen in hydrophytic habitats.

The areas around the swamp, whether clay, sand, or rock, have been undergoing their normal changes, so that the swamp is eventually surrounded by a forest. The swamp is finally built up high enough above the water level to permit a higher type of tree to occupy the area. Thus the tamarack is gradually crowded out, and a climax forest is the final stage.

FIG. 11.—A lagoon cut off from Lake Superior by a beach line, resulting in an undrained swamp. In the foreground is seen a portion of the original lagoon; back of this is the sedge vegetation, and near the conifers is a Cassandra zone. The conifers are mostly tamaracks (*Larix Americana*).

The life-history is not always as indicated above. The swamp may become partially drained, but still be too wet to support the highest tree society. In that case the abor vitae gradually replaces the tamarack. Associated with the arbor vitae are the ash (*Fraxinus* sp.), the balsam, the white pine, and the yellow birch. Gradually, however, the arbor vitae swamps give away before the encroaching mesophytic forests. *Fig. 12* shows a hemlock-maple forest bordering an arbor vitae swamp. In wet springy soils the arbor vitae forest is also found. *Fig. 13* shows a young forest in such a situation.

VI. CLEARING SOCIETIES.

Thus far what has been called the normal life-history has been traced. The influence of human agencies, with few exceptions, has been disregarded. By far the greater number of areas studied show unmistakable signs of the devastating influence of man, though less so on the islands visited than on the mainland. These clearing areas cannot be disregarded if a complete history of forest development is to be written. At first the difficulties of getting any order out of the tangle seemed insurmountable, and the notes were usually headed "clearings, conditions artificial." The literature on the subject of plant succession in clearings is confusing. It consists, as a rule, of records of isolated observations without any attempt at correlation. That there is some solution to the problem was the writer's firm belief, and after collecting a large number of notes the study began to yield results.

If the factors controlling the normal development as given above are correct, they ought to dominate in the clearing societies. With two exceptions, the stages observed in the development of these clearing societies are represented in the normal history. These exceptions are the "fireweed" and the poplar-birch societies. To explain these it was found necessary to give prominence to the fact that some plants migrate more easily than others.

If a deciduous forest be destroyed and burned over so that the surface débris is partially reduced to ashes, it will usually be found that the humus conditions of the soil are then reduced toward, but not necessarily to the conditions obtained in the heath. The equilibrium that had been established has been disturbed, and other things being equal all plants will have an equal chance provided their seeds are present. Shade plants, however, including young plants of beech and maple, are excluded because the insolation is great. Some few plants that seem to prefer more xerophytic conditions likewise will not thrive. Then the struggle is narrowed to those plants that can endure strong insolation, that prefer tolerably good edaphic conditions, and whose seeds are present. It is obvious that those plants in the neighborhood that have the lightest seeds will have the largest representation of seeds on the ground first, and of these the most rapid growers will prevail the first year or two. The so-called "fire-weeds" meet the requirements best. *Epilobium angustifolium*, *Erigeron Canadensis*, and certain goldenrods spring at once into an occupancy of the field. and there is given a "fire-weed" physiognomy to the clearing (*fig. 14*).

FIG. 12.—A hemlock-maple forest bordering on an arbor vitae swamp. The tangled growth of the arbor vitae swamp is seen in the foreground. The hemlocks are encroaching on the arbor vitae.

The poplars (*P. tremuloides* and *P. grandidentata*) and the white birch are the trees which have seeds adapted for rapid migrations, and are also rapid growers. Because they are perennial, and can thus get an early start each year after the first, they soon overtop the fireweeds and gradually shade them out. *Ostrya Virginica*, *Prunus Pennsylvanica*, *P. serotina*, and *Quercus rubra* are in some places associated with the poplars and birches.

FIG. 13.—A spring hillside with young growth of arbor vitae. The hill in the background has been cleared of a maple-hemlock forest and is used for a pasture.

In the absence of pine trees in the vicinity to furnish pine seeds, this poplar-birch society is maintained until deep shade conditions are again obtained for the growth of the maple-beech seedlings. Then, just as in the normal development the pines are replaced by the maples and beeches, so in the clearing development the poplar and birches are likewise replaced. The poplars go first, then usually the birch and hornbeam, and finally the cherry trees drop out.

If, however, pine trees in the vicinity of a clearing can furnish seeds, the pines occupy a place in the life history. The more unfavorable the humus conditions up to a certain limit, the more likely is the clearing to have a pine aspect. The humus in the soil may be so reduced as to be incapable of supporting a poplar-birch growth. *Fig. 15* shows a young jack pine growth.

FIG. 14.—A hemlock-maple forest destroyed by fire. The rich growth of fireweed (*Epilobium angustifolium*) indicates the first stage in the life-history of a second-growth forest.

In this repeated fires have probably so reduced the humus conditions of the soil that the most xerophytic of the pines alone is able to gain a foothold. If favorable for the presence of both pine and poplar-birch growth (*fig. 16*), the pines in time overtop the poplars and birch, until a condition corresponding to the normal life-history is attained, viz., a pine society preceding the maple-beech society.

It can be seen readily that it is possible to obtain all stages of reduction between mesophytic and xerophytic conditions. This depends on what stage in the normal life-history is attacked by the fire, and on the intensity or entire absence of subsequent fires. Thus all possible combinations are represented. *Fig. 17* shows a maple-hemlock forest that has been nearly destroyed by fire. This is situated on the slope of a quartzite hill, and had probably reached the climax condition. In places the fire has left remnants of the forest, and even where the trees are destroyed certain geophilous forest herbs like *Clintonia borealis* have maintained themselves in the shade of half burned logs, while near by fireweeds, poplars, and pines are found. *Fig. 18* shows an almost pure birch forest. Not far away, however, are

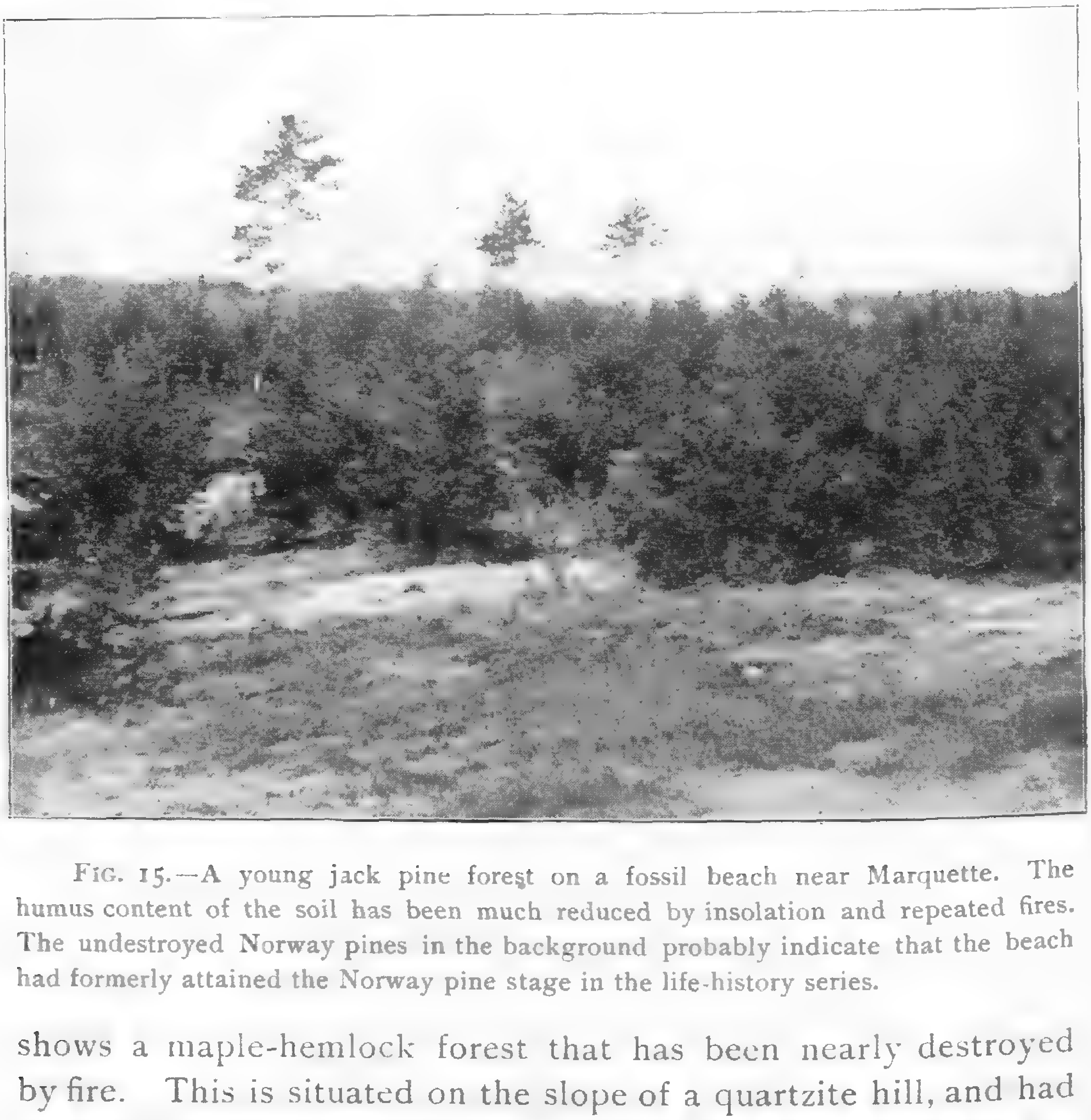

FIG. 15.—A young jack pine forest on a fossil beach near Marquette. The humus content of the soil has been much reduced by insolation and repeated fires. The undestroyed Norway pines in the background probably indicate that the beach had formerly attained the Norway pine stage in the life-history series.

found poplars mixed with the birch. In this neighborhood stumps of pines indicate the former forest. In places repeated fires have reduced the area to heath conditions. This is shown by a number of heath plants like *Pteris aquilina*, *Gaultheria procumbens*, *Cladonia rangiferina*, etc. The presence of few seed-producing pines in the neighborhood will probably account for the absence of many pine seedlings.

FIG. 16.—A second-growth forest of pines and poplars on a fossil beach near Marquette. The pines are slowly gaining ascendancy over the short-lived poplars and these will in time disappear.

Thus, no matter how far toward the first stage in the life-history a forest is reduced, if not interfered with by human agencies, ultimately the climax forest society is reached, but not without first having passed through a pine or a poplar-birch stage. A maple forest was never observed to follow a maple forest except when the stools of a cleared forest are capable of producing sprouts. These may in time reach tree dimensions, though usually not before a considerable number of pines, birch, or poplars spring up between them.

Thus it will be seen that if human agencies should cease to operate, all classes of topographic forms will ultimately come to be clothed with the climax forest growth. There is no reason why even the jack pine barrens may not in time reach this state. It must be remembered that these are late topographic features, or are reduced by repeated burnings to a soil poor in humus.

FIG. 17.—A partially destroyed hemlock-maple forest on the slope of a quartzite hill (Mt. Mesnard) near Marquette. The forest had attained the climax stage in the life-history series.

VII. CONCLUSIONS.

The life-history of the vegetation of four sets of physiographic formations has thus been traced. It has been shown that in each series the climax plant growth is a deciduous-hemlock combination. These physiographic formations have been treated separately because usually they are distinct from one another. In some instances, however, clay is mixed with rock débris or underlies the sand. The only effect such a mixture has is to hasten the succession of stages, for the advance toward the climax is more rapid on clay than on other soils. Principally for this reason the clay soils on the whole are already covered with the climax forest. In many instances the sandy soils have likewise attained the last stage in the life-history. Especially is this so where free from the influence of man as on

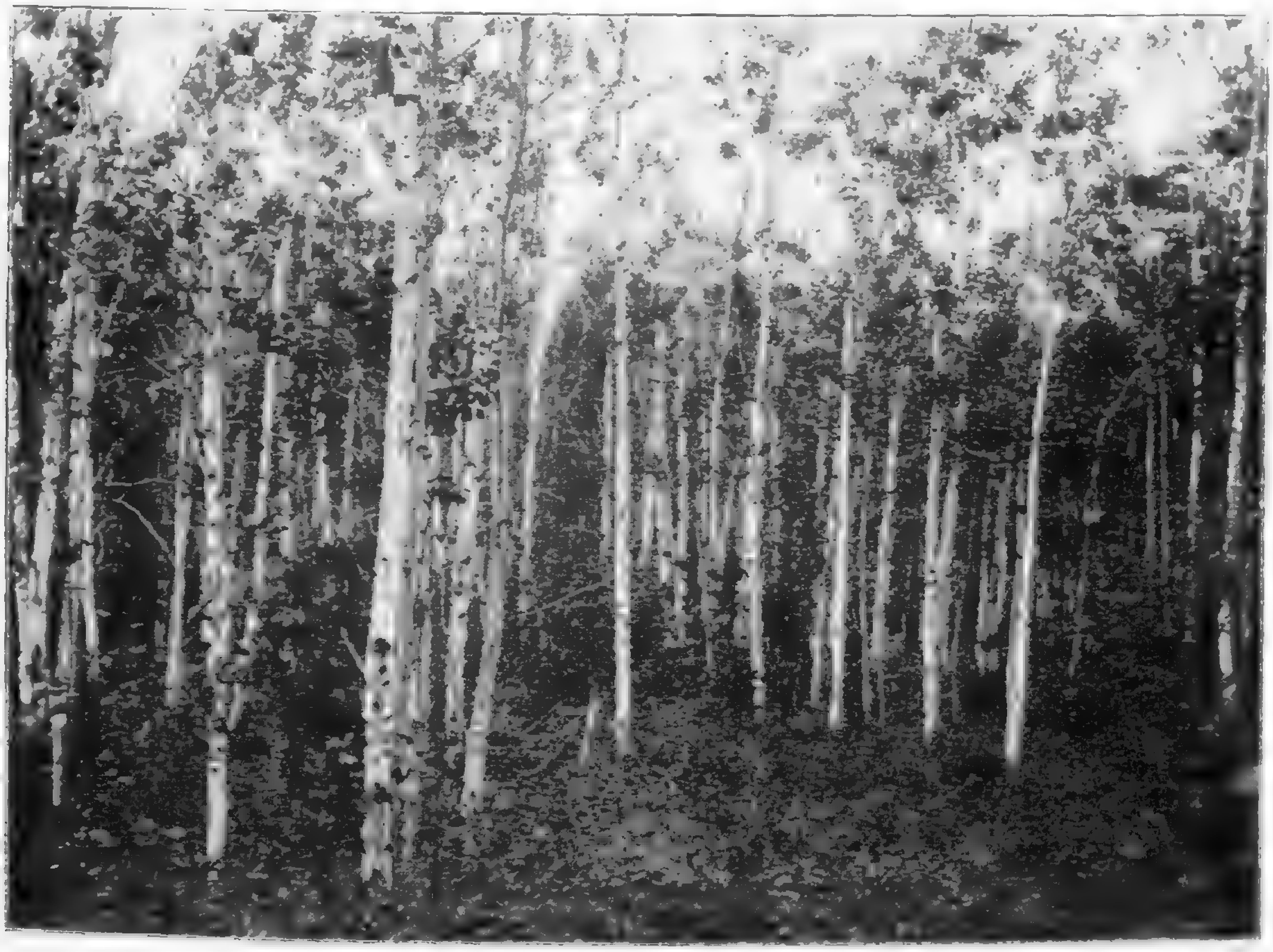

FIG. 18.—A white birch clearing growth on a fossil beach near Marquette. The undergrowth consists of *Pteris aquilina*, *Diervilla trifida*, etc.

North Manitou island. But the succession of plant societies is much slower on sand than on clay soil, hence the prevalence of pine forests on the former. The reasons for believing that ultimately these pine forests will give way to the deciduous have already been given.

It is the belief of the writer that with some modifications the principles brought out in the foregoing pages will hold for all regions climatically capable of supporting a tree vegetation. The region under discussion is physiographically young. If the terms of physiography be adopted for ecology, a region having scanty vegetation may be considered young, while from this there will be all stages through maturity to old age, viz., a mesophytic climax forest. It would appear to the casual observer that northern Michigan is a region physiographically young and ecologically old. But no inconsiderable portion of the area of both Michigan and Wisconsin is occupied by swamps and lakes (including the great lakes). These will remain hydrophytic and hence ecologically young until filled up or drained. This condition is not attained until the region reaches maturity. The whole region, from an ecological standpoint, therefore, cannot reach maturity until it does so physiographically. Thus the development of the forest is in a measure held back until the normal physiographic processes extinguish the swamps and lakes. When these are eliminated, the region will reach old age from the vegetation standpoint much sooner than it does physiographically, because the climate is favorable for the extension of mesophytic forests into altitudes which would otherwise support only a xerophytic society.

In an area where the climate is more severe for tree growth the life-history stages are less rapid, for even though the region may be nearer base level the climax stages are more restricted. For example, Cowles[10] has shown that in the Chicago region, as a rule, the river bottoms contain the mesophytic plant societies, while the clay hills have only attained a semi-mesophytic forest

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[10] Bot. Gaz. **31** : 88 ff. 1901.

of oaks and hickories. Such clay hills in northern Michigan are usually covered with the climax forest.

Again, as one approaches the semi-arid regions of the West, he will observe that the forest growth on the hills becomes less and less mesophytic until finally it gives way altogether to the prairie society. At the same time, the river bottom forests also become less mesophytic and more restricted to the banks of the streams. Ultimately, they, too, in the region of the great plains pass from existence and the prairie reaches to the very margin of the drainage lines. The writer has made some studies at various places in Kansas in reference to these points, and it is his intention to discuss them in full in a future paper on the ecological relations of prairie and forest.

THE UNIVERSITY OF CHICAGO.

MEXICAN FUNGI. III.

E. W. D. HOLWAY.

THE descriptions of the following new species were sent to me in German by Dr. Dietel. I am under many obligations to Professor Robinson of the Gray Herbarium, and to C. G. Pringle for the determination of the host plants. A large collection of Uredineae yet remains to be studied.

Uromyces Celosiae Diet. & Holw., n. sp.—Sori hypophyllous, sometimes on indistinct yellow spots, small or medium-sized, scattered or often thickly covering the leaf; uredosori cinnamon-brown; uredospores elliptical or globose, sometimes obovate, 27–34×24–26μ; epispore thick, thinly covered with strong spines, with two germ-pores, brown; teleutosori dark brown; teleutospores elliptical or globose, coarsely verrucose, chestnut-brown, apex with a light colored rounded cucullate or papilla-like thickening, 28–38×22–30μ; pedicel hyaline, as long as the spore, or a little longer, easily separating at the base from the host-plant, swelling in water.

On *Celosia latifolia*, Oaxaca, October 17, 1899, no. 3641.

Uromyces venustus Diet. & Holw., n. sp.—Aecidia hypophyllous, single or in small groups, hemispherical, opening at apex by a small pore; aecidiospores globose or elliptical, 20–25×29μ, finely verrucose, teleutosori epiphyllous, opposite the aecidia, often in a circle, the center of which is the aecidium on the opposite side of the leaf, variable in size, sometimes confluent, naked, pulverulent, dark brown; teleutospores ovate or elliptical, sometimes almost globose, 32–40×20–28μ, chestnut-brown, apex light brown, beak-like; epispore thick, with longitudinal lines; pedicel about the length of the spore, thin, hyaline, easily breaking at the base from the host-plant.

On *Cestrum nitidum*, Amecameca, October 31, 1899, no. 3759. Easily distinguished from *U. Cestri* Mont. by the papilla at apex, and by the lines on the epispore.

Uromyces Oaxacanus Diet. & Holw., n. sp.—Sori epiphyllous, irregularly scattered (occasionally a sorus on the under side of the leaf), small, pulverulent, black; teleutospores ovate, elliptical or almost globose, frequently angular and irregular, 25–35 × 18–24μ; epispore chestnut-brown, not thickened at apex, verrucose; pedicel hyaline, hollow, somewhat longer than the spore.

On *Jatropha urens*, Oaxaca, October 21, 1899, no. 3690.

Uromyces dolichosporus Diet. & Holw., n. sp.—Uredosori mostly hypophyllous, scattered, dark brown, partly with spermogonia on the upper surface of the leaves; uredospores obovate, dark brown, 33–47 × 23–27μ; epispore thickened at apex and often at the base, echinulate, with three germ-pores; teleutosori of medium size, hypophyllous, rarely epiphyllous, scattered or in small circular groups, orange-yellow when fresh, becoming white and felt-like; teleutospores long-fusiform or long-clavate, 45–65 × 12–18μ; with a thin hyaline smooth epispore, and germinating as soon as mature; pedicel firm, about the length of the spore.

On *Tournefortia velutina*, Oaxaca, October 18, 1899, no. 3655.

Uromyces Rubi Diet. & Holw., n. sp.—Spots circular, about 5^{mm} in diameter, occasionally confluent, yellow; sori epiphyllous, small, white when dry; uredospores elliptical, obovate, or globose, 23–35 × 18–25μ; epispore hyaline, with stout spines; teleutospores elliptical or clavate, 26–35 × 17–24μ, with a very thin hyaline epispore; pedicel short; spores germinating at once.

On *Rubus*, Cuernavaca, May 17, 1898, *C. G. Pringle.*

UROMYCES POLYMNIAE (P. Henn.) Diet. & Holw.—Uredo is *U. Polymniae* P. Henn. Teleutosori scattered, hypophyllous, single sori here and there on the upper surface, brownish black, naked; teleutospores elliptical or almost globose to pyriform, sometimes truncate at apex, 30–45 × 20–30μ; epispore smooth, strongly thickened at apex, brown; pedicel firm, tinted, up to 75μ long.

On *Polymnia maculata* ?, Rio Hondo cañon, near city of Mexico, October 4, 1899, no. 3562; October 30, 1899, no. 3562B. On *Polymnia maculata*, Patzcuaro, October 10, 1899. The latter host shrubby, 10–15 feet high; the former herbaceous only, 4–5 feet high.

Uromyces Indigoferae Diet. & Holw., n. sp.—Sori epiphyllous, sparingly hypophyllous, scattered or in little groups on dead brown spots, and also on the petioles and young fruit, small, naked, surrounded by the ruptured epidermis, dark brown; uredospores globose or elliptical with short spines and three germpores, brown, 20–25 × 18–23μ; teleutospores elliptical or globose, smooth, chestnut-brown, strongly thickened at apex, 22–30 × 18–25μ; pedicel long and firm, hyaline.

On *Indigofera Mexicana*, Oaxaca, October 23, 1899, no. 3722.

UROMYCES GALPHIMIAE Diet. & Holw.—Uredo on *G. Humboltiana*, Guadalajara, September 14, 1899, no. 3409.

UROMYCES VIGNAE Barclay ?—On *Vigna stroboliphora*, Guadalajara, September 15, 1899, no. 3424.

UROMYCES TRIFOLIAE (Hedw.) Lev.—On *Trifolium*, Pachuca, October 6, 1899, no. 3588.

UROMYCES GLOBOSUS Diet. & Holw.—On *Sapium biglandolosum*, Cuernavaca, September 28, 1899, no. 3517. This is the host plant of the original collection.

UROMYCES CALADII (Schw.) Farl.—On *Arisaema macrospathum*, Cuernavaca, September 29, 1899, no. 3522. The 1896 specimens are on this host, and not on *A. Dracontium*.

UROMYCES SOLANI Diet. & Holw.—On *S. appendiculatum*, Amecameca, October 31, 1899, no. 3761.

UROMYCES AEGOPOGINIS Diet. & Holw.—On *Aegopogon cenchroides*, Tizapan, Valley of Mexico, September 27, 1899, no. 3506.

Puccinia Berberidis-trifoliae Diet. & Holw., n. sp.—Spots brown, or blackish-purple; sori hypophyllous, firm, strongly pulvinate, black, about 1–3^{mm} in diameter, linear on the petioles; teleutospores brown, quite variable in form and size, elliptical, oblong or fusiform, rounded at apex, or conical, or often prolonged into a point, mostly rounded at base, little constricted, 24–45 × 14–24µ, smooth, variously thickened at apex according to the form of the spore; pedicel rather longer than the spore, tinted, firm; one-celled teleutospores rather common.

On *Berberis trifolia*, Rio Hondo, near City of Mexico, October 4, 1899, no. 3570. The Aecidium of *Puccinia graminis* occurs on some of the leaves.

Puccinia Aniscanthii Diet. & Holw., n. sp.—Sori on both sides of the leaf, scattered, small; uredosori brown; teleutosori black, naked; uredospores elliptical or obovate, 22–28 × 18–22µ, light brown, with distant short spines, and two germ-pores; teleutospores elliptical, rounded at both ends, slightly constricted, 38–48 × 25–31µ, chestnut-brown, at the apex and often on the lower cell a cucullate or papilla-like light-colored thickening, verrucose; pedicel longer than the spore, hyaline, easily separating at the base, sometimes laterally inserted.

On *Anisacanthus*, probably *A. Wrightii*, near Acamboro, October 8, 1899, no. 3595. This species is much like *Puccinia Ruelliae-Bourgaei* Diet. & Holw., but that has almost all the pedicels laterally inserted, and the membrane is not thickened over the germ-pores. *Puccinia Blechi* Lagerheim appears to be very similar, but according to the description the teleutospores are differently colored, and also without the thickening over the germ-pores.

Puccinia Ruelliae-Bourgaei Diet. & Holw., n. sp.—Aecidia in irregular groups along the veins; cells of the pseudosporidia oblong; aecidiospores elliptical or globose, often angular, 25–38 × 20–26µ, yellowish, strongly verrucose, much thickened at apex; uredospores in these specimens few, with the teleutospores, brown, echinulate, 20–25µ; teleutosori hypophyllous on yellow spots, sparingly epiphyllous, scattered, 0.5–2^{mm} in diameter, black, pulverulent, naked; teleutospores elliptical, rounded at both ends, not at all or only slightly constricted, 35–41 × 27–32µ, dark chestnut brown, with large tubercles; pedicel as long or longer than the spore, hyaline, rough, inserted at one side.

On *Ruellia Bourgaei*, Chapala, September 20, 1899, no. 3471. Closely resembles *Puccinia lateripes* B. & R., but has much larger and darker teleutospores; the aecidiospores are also larger and remarkable for their strong apical thickening.

PUCCINIA HETEROSPORA B. & C.—On *Abutilon crispum*, Oaxaca, October 20, 1899, no. 3684; on *Anoda hastata*, near Tula, September 21, 1898, no. 3186; Cuernavaca, September 28, 1898, no. 3098; on *Anoda*, Patzcuaro, October 17, 1898, no. 3004; Orizaba, October 6, 1898, no. 3194; Chapala, September 22, 1899, no. 3477; on *Anoda acerifolia*, Oaxaca, October 18, 1899, no. 3656; Cuautla, October 12, 1898, no. 3044; on *Sida Holwayi*, Cuautla, October 12, 1898, no. 3043.

PUCCINIA GALII (Pers.).—On *Galium uncinulatum* var. *obstipum*, Oaxaca, October 18, 1899, no. 3654.

PUCCINIA SEYMERIAE Burrill.—On *Seymeria virgata*, Oaxaca, October 22, 1899, no. 3721.

PUCCINIA PITCAIRNIAE Lagerh.—On *Pitcairnia Palmeri*, Chapala, September 1899, no. A; Uruapam, October 11, 1899, no. 3619. These two specimens are not exactly alike, the latter having somewhat smaller more regular spores less thickened at apex.

PUCCINIA MENTHAE Pers.—On *Monarda?*, Jalapa, October 3, 1898, no. 3211.

PUCCINIA PHILIBERTIAE E. & E.—Tizapan, Valley of Meixco, October 28, 1899, no. 3749, on *Metalstelma angustifolium*.

Puccinia Marsdeniae Diet. & Holw., n. sp.—Sori on yellow or brownish spots, medium-sized or small; uredosori scattered, cinnamon-brown, on both sides of the leaves; uredospores broadly elliptical, almost globose, 28–33 × 25–29μ, light brown; epispore thick, with widely separated short spines and numerous germ-pores; teleutosori epiphyllous, scattered, naked, black, pulverulent; teleutospores elliptical, rounded at both ends, very little constricted, 33–45 × 28–32μ, dark chestnut-brown, with large tubercles; pedicel up to 75μ long, easily breaking off at the base, often inserted at the side of the spore.

On *Marsdenia Mexicana*, Cuernavaca, September 29, 1899, no. 3529.

PUCCINIA XANTHII Schw.—On *Xanthium*, Chapala, September 17, 1899, no. 3440; Cuautla, October 12, 1898, no. 3042; Oaxaca, October 17, 1899, no. 3644; Cuernavaca, September 28, 1899, no. 3516; on *Zinnia tenuiflora*, Chapala, September 17, 1899, no. 3441; Oaxaca, October 17, 1899, no. 3646.

PUCCINIA KUHNIAE Schw.—On *Barroetea sabuligera*, Aguas Calientes, September 12, 1899, no. 3400.

Puccinia Oaxacana Diet. & Holw. n. sp.—Sori hypophyllous, small, scattered, brown; uredospores elliptical or ovate, 23–29×23μ, with echinulate epispore; teleutospores oblong or elliptical, rounded at both ends or narrowed to the base, little constricted, 31–50×18–25μ, smooth, pale brown, slightly thickened at apex, germinating at once; pedicel the length of the spore or a little longer.

On *Baccharis hirtella* DC., Oaxaca, October 18, 1899, no. 3673. *Aecidium fragile*, n. sp., occurs with this, but it is doubtful whether it is a stage of the Puccinia.

Puccinia Baccharidis-multiflorae Diet. & Holw., n. sp.—Sori hypophyllous, small, scattered; uredosori light chestnut-brown; uredospores obovate, 32–42×22–28μ, yellowish-brown, echinulate, apex with a cucullate thickening (up to 7μ) and with 3 germ-pores, which are covered with a convex hyaline thickening; teleutosori dark brown; teleutospores oblong, apex rounded or conical, mostly narrowed to the base, somewhat constricted, 38–60×21–30μ; epispore smooth, yellowish-brown, apex strongly thickened, and mostly somewhat paler; pedicel short, or up to 60μ long, hyaline, rather fragile. The spores germinate soon after maturity.

On *Baccaris multiflora*, Amecameca, October 31, 1899, no. 3757.

Caeoma punctato-striatum Diet. & Neg.—On *Baccharis*, Guadalajara, September 16, 1899, no. 3435, with *Puccinia Baccharidis*, Diet & Holw.

Puccinia Baccharidis Diet & Holw.—On *Baccharis*, Patzcuaro, October 17, 1898, no. 3003; Guadalajara, September 16, 1899, no. 3435.

Puccinia Baccharidis-hirtellae Diet. & Holw., n. sp.—Sori hypophyllous, scattered, punctiform, pulvinate, chestnut-brown; uredospores (mixed with the teleutospores) elliptical to globose, or obovate, 22–27×19–25μ, with a thin light brown echinulate epispore; teleutospores elliptical, rounded at both ends, slightly constricted, 32–46×20–30μ; epispore yellowish-brown, slightly or not at all thickened at apex, finely punctate; pedicel long, thin, hyaline.

On *Baccharis hirtella*, Amecameca, October 31, 1899, no. 3756.

Puccinia subglobosa Diet. & Holw., n. sp.—Sori on both sides of the leaves, particularly on the under side, scattered, punctiform, naked; uredosori chestnut-brown; teleutosori black, pulverulent; uredospores elliptical or obovate, sometimes almost globose, 18–25 × 17–20μ brown, with short spines; teleutospores broadly ellipsoidal, often almost globose, rounded at both ends, not at all or only slightly constricted, apical thickening slight, smooth, dark chestnut-brown, 29–38 × 24–29μ; pedicel hyaline, easily breaking from the host plant.

On *Viguiera Palmeri*, Chapala, September 23, 1899, no. 3488.

Puccinia praemorsa Diet. & Holw., n. sp.—Sori on the under side of brown roundish spots, which are somewhat depressed, solitary, medium-sized, dark brown, pulvinate, mostly made up of several small sori which have crowded together; teleutospores oblong-clavate, apex truncate, conical, or very irregular, narrowed at the base, somewhat constricted, 40–73μ long, upper cell 15–30μ wide, smooth, brown, thickened at apex; pedicel short, firm, brownish. The spores germinate, at least in part, as soon as mature.

On *Brickellia veronicaefolia*, Oaxaca, October 20, 1899, no. 3686. This is like *Puccinia Asteris*, but differs in several particulars.

Puccinia inanipes Diet. & Holw., n. sp.—Sori on both sides of the leaf, particularly on the upper, scattered, punctiform; uredosori brown; uredospores elliptical, rounded at both ends and when dry both ends depressed, scarcely constricted, apex with a very slight cucullate thickening, smooth, dark chestnut-brown, 34–42 × 28–31μ, with long hyaline hollow pedicels which easily break from the host plant.

On *Eupatorium brevipes*, Oaxaca, October 18, 1899, no. 3677.

Puccinia espinosarum Diet. & Holw., n. sp.—Sori on both sides of the leaf, scattered, small or medium sized, naked; uredosori brown; uredospores ovate, epispore light brown, with short spines, 30–36 × 20–23μ; teleutosori black; teleutospores broadly elliptical, rounded at both ends, apex with a slight cucullate thickening, smooth, dark chestnut-brown, 40–50×32–36μ; pedicel long (up to 125μ), 10μ thick, hollow at the base only, easily breaking from the leaf.

On *Eupatorium espinosarum*, Oaxaca, October 17, 1899, no. 3651.

PUCCINIA VIGUIERAE Peck.—On *V. picta*, near Tula, September 20, 1898, no. 3136; on *V. excelsa*, Rio Hondo cañon, near City of Mexico, September 22, 1898, no. 3160; City of Mexico, October 9, 1898; no. 3039; on *Gymnolomia Ghiesbreghtii*, Oaxaca, October 21, 1899, no. 3700; on *Viguiera*, Toluca, September 20, 1898, no. 3178; on *Gymnolomia subflexuosa*, Oaxaca, October 17, 1899, no. 3645; on *Verbesina trilobata*, Oaxaca, October 24, 1899, no. 3731; on *Verbesina virgata*, Rio Hondo cañon, near City of Mexico, October 30, 1899, no. 3751; on *Verbesina montanifolia*, Patzcuaro, October 10, 1899, no. 3604; on *Viguiera*, Chapala, September 20, 1899, no. 3469; on *Calea Zacetechichi* var. *rugosa*, Cuernavaca, September 30, 1899, no. 3534; September 28, 1899, no. 3512; on *Calea hypoleuca*, Oaxaca, October 17, 1899, no. 3648.

Puccinia ferox Diet. & Holw., n. sp.—Sori pulverulent, large, irregular, brown, attacking the upper leaves and occasionally the flowers, often destroying the plants, the leaves being much thickened and deformed and often entirely covered with the spores on both sides; teleutospores rounded at both ends, strongly constricted, with epispore uniform in thickness, pale brown, finely verrucose, 33–43×20–26μ; pedicel short, fragile. The spores germinate at once.

On *Verbesina diversifolia*, Oaxaca, October 21, 1899, no. 3704. A very destructive species.

Puccinia Electrae Diet. & Holw., n. sp.—Sori on various colored spots on the upper side of the leaf, less numerous on the lower side, small, scattered; uredosori dark brown; uredospores obovate or elliptical, 28–35×21–25μ, echinulate, brown; teleutosori naked, black; teleutospores elliptical, rounded at both ends, scarcely constricted, verrucose, apex not thickened, 36–48×24–31μ; pedicel long, hyaline, or next the spore somewhat tinted, easily separating at the base from the host plant.

On *Electra Galeottii*, Oaxaca, October 18, 1899, no. 3664.

Puccinia Desmanthodii Diet. & Holw., n. sp.—Sori on the under side of large irregularly limited violet or yellow spots, small, but closely crowded into large groups in a kind of stroma formed of dark brown firm united paraphyses; teleutospores oblong or mostly fusiform, narrowed to both ends or truncate at apex, not at all or only slightly constricted, 40–60 × 10–17 μ, smooth, thickening at apex conical or cucullate, light brown; pedicel short or up to 40 μ long, firm, tinted.

On *Desmanthodium ovatum*, Oaxaca, October 18, 1899, no. 3665. Aecidia occur on some of the leaves but are too old to describe.

Puccinia Iostephanes Diet. & Holw., n. sp.—Sori mostly epiphyllous on small purple spots, less numerous on the under side of the leaf, scattered, black; teleutospores elliptical, rounded at both ends, scarcely constricted, chestnut-brown, verrucose, a light-colored cucullate thickening at the apex and on the side of the lower cell, 37–50 × 25–35 μ; pedicel long, hyaline, easily breaking at the base from the host plant, often laterally inserted.

On *Iostephane heterophylla?* Cuernavaca, September 30, 1899, no. 3543; on *Viguiera dentata*, Oaxaca, October 21, 1899, no. 3543, and October 25, 1899, no. 3744. Type is on no. 3543, the host being an Iostephane which is probably *I. heterophylla*, although it differs somewhat from other Mexican specimens.

Puccinia Guardiolae Diet. & Holw., n. sp.—Sori on purple spots, hypophyllous, rarely single sori epiphyllous, punctiform, scattered; uredosori dark brown; uredospores nearly globose, elliptical or obovate, 24–32 × 22–25 μ, dark brown, echinulate, with two germ-pores; teleutosori blackish, strongly convex, firm, small; teleutospores clavate, rounded at apex, or more rarely truncate, with a hyaline cucullate thickening, narrowed to the base or rounded, constricted, 45–60 × 18–25 μ, smooth, pale brown, germinating at once, whitening the sori; pedicel hyaline, firm, mostly shorter than the spore.

On *Guardiola Mexicana*, Cuernavaca, September 28, 1899, no. 3513.

Puccinia conjuncta Diet. & Holw., n. sp.—Sori epiphyllous, a few scattered ones epiphyllous, of medium size, except on the petioles and stems, where they break through the epidermis in large patches, pulverulent, dark brown; teleutospores strongly constricted, of two almost globose cells, 34–45 × 22–28μ, brown, echinulate, apex with a slight cucullate thickening; pedicel short, deciduous.

On *Lippia Pringlei*, Oaxaca, October 23, 1899, no. 3719B. Collected at about 10,000 feet, where there were no specimens of *Uredo Lippiae* D. & H. to be found. The latter occurred at about 6000 feet.

Puccinia Coulterophyti Diet. & Holw., n. sp.—Spots yellow or wanting; sori hypophyllous, small, scattered; uredosori light ochre color; uredospores obovate, 29–36 × 22–29μ; epispore hyaline, apex very strongly thickened, covered with distant, globose warts; teleutosori blackish-brown, naked, pulverulent; teleutospores long elliptical or irregular, rounded at both ends, scarcely constricted, 33–50 × 23–30μ; epispore chestnut-brown, verrucose, sometimes irregularly rugose; pedicel deciduous. One-celled teleutospores are not uncommon.

On *Coulterophytum laxum* Rob., Chapala, September 19, no. 3463; Uruapam, October 11, no. 3621. These hosts were determined for me at the Gray Herbarium. The leaflets differ, however, the former being smooth, while the latter are densely white-tomentose.

Uredo Lippiae Diet. & Holw., n. sp.—Sori hypophyllous, scattered, dark brown, pulverulent; uredospores globose or broadly elliptical, 25–32 × 25–28μ; epispore dark brown, closely echinulate, to 3μ thick, with two germ pores. Hyaline ampullaceous paraphyses are found in the sori.

On *Lippia Pringlei*, Oaxaca, October 23, 1899, no. 3719. Collected at about 6000 feet. No trace of *Puccinia conjuncta* D. & H. could be found at this elevation.

UREDO ARBUTI Diet. & Holw.—On *Arbutus diversiflora*, Oaxaca, October 18, 1899, no. 3662.

RAVENELIA EPIPHYLLA Schw.—On *Brongniartia*, Guadalajara, September

14, 1899 no. 3415; on *Tephrosia Talpa*, Oaxaca, October 19, 1899, no. 3679.

RAVENELIA INDICA Berk.—On *Cassia Absus*, Tequila, September 29, 1893, *C. G. Pringle.*

RAVENELIA BRONGNIARTIAE Diet. & Holw.—On *B. sericea*, Oaxaca, October 18, 1899, no. 3663; on *Brongniartia*, Cuernavaca, September 28, 1898, nos. 3170 and 3022; September 29, 1899, no. 3519; on *B. intermedia*, Tizapan, Valley of Mexico, September 27, 1899, no. 3504½.

RAVENELIA INDIGOFERAE Tranzschel.—On *Indigofera Palmeri*, Oaxaca, October 19, 1899, no. 3682, forming swellings on the stems, and apparently quite destructive; on *Indigofera Cuernavacana*, Cuernavaca, September 22, 1898, no. 3120.

Ravenelia spinulosa Diet. & Holw., n. sp.—Sori on both sides of the leaf, breaking forth from beneath the epidermis, of irregular shape and size; uredosori ochre-colored; uredospores elliptical or almost globose, $18–23 \times 16–19\mu$, light brown, with short spines, germ pores numerous, paraphyses sparingly intermixed; teleutosori black, heads hemispherical, $75–110\mu$ in diameter, with 7–9 spores in cross-section, chestnut-brown, with numerous globose hyaline cysts on the under side; spores $11–17\mu$ broad, one-celled, each with a long (up to 8μ) pale brown point at the apex.

On *Cassia multiflora*, Oaxaca, October 18, 1899, no. 3675. This species is much like the African *R. Stuhmanni* P. Henn., but has smaller uredospores.

PUCCINIOSIRA PALLIDULA (Speg.) Lagerh. (*P. triumfetta* Lagerh.).—On malvaceous plant, Jalapa, April 22, 1899, *C. G. Pringle.* Is probably on *Triumfetta* sp.

PUCCINIOSIRA BRICKELLIAE Diet. & Holw.—On *Brickellia tomentella*, Amecameca, October 31, 1899, no. 3767. These specimens show that the fungus also occurs on the under side of the leaves in various sized groups, sometimes annular, or elongated along the veins, and that the spores are not smooth, as originally described, but finely verrucose.

Endophyllum singulare Diet. & Holw., n. sp.—Sori covering large areas of the stems and leaves, with pseudosporidia strongly developed, conical, up to 2^{mm} long, irregularly splitting; spores ochre-colored in mass, elliptical or oblong, not rarely pointed at apex, 40–55 × 24–30μ; epispore pale brown, strongly thickened at apex, closely verrucose.

On ericaceous plant, Jalisco, *Marcus E. Jones.*

Stichospora Mentzeliae Diet. & Holw., n. sp.—Sori hypophyllous, scattered, small; uredosori orange-yellow when fresh, white when dry; uredospores formed in short chains, 20–28 × 20–24μ; epispore verrucose, hyaline; teleutosori waxy, blood-red, 100–120μ high; teleutospores formed in a few series, one over the other, cylindrical clavate or elliptical, 24–45 × 14–20μ, at first one-celled, shortly before germination divided by vertical septa into four cells; epispore of the upper spore of each series with a hyaline thickening (up to 8μ); sporidia elliptical, often narrowed to one end, 15 × 10–13μ.

On *Mentzelia hispida*, Chapala, September 18, 1899, no. 3452.

Coleosporium Verbesinae Diet. & Holw., n. sp.—Sori scattered or in irregular groups, hypophyllous; uredosori golden-yellow; teleutosori bright red; uredospores elliptical to globose, 26–33 × 23–26μ, with colorless verrucose epispore; teleutospores cylindrical, up to 130μ long, 12 × 18μ thick, strongly thickened at apex.

On *Verbesina virgata*, with *Puccinia Viguierae*, Rio Hondo cañon, near City of Mexico, October 30, 1899, no. 3751; on *Verbesina*, Cuernavaca, September 30, 1899, no. 3542.

Coleosporium paraphysatum Diet. & Holw., n. sp.—Sori hypophyllous, on yellow or chestnut-brown spots, small, scattered; uredospores long-elliptical to clavate, with sharply projecting warts, 26–43 × 17–24μ; teleutospores at first ellipsoidal and one-celled, at length cylindrical or clavate, and divided by horizontal septa into four cells, 45–65 × 17–22μ; in many teleutosori there were numerous filiform paraphyses.

On *Liabum discolor*, Chapala, September 23, 1899, no. 3483.

Coleosporium anceps Diet. & Howl., n. sp.—Uredosori punctate, scattered or in circular groups, hypophyllous, white when dry; uredospores elliptical, oblong, or almost globose, 17–25×15–20μ, with long cylindrical tubercles; teleutosori hypophyllous, on yellow or brown dead spots, single, or often in annular or irregular groups, honey-colored, waxy; teleutospores cylindrical or clavate, 90μ long, 18–25μ wide, 4-celled; pedicel hollow, 60–70μ long; sporidia mostly cylindrical, 24–30×12–15μ.

On *Verbesina sphaerocephala,* Chapala, September 24, 1899, no. 3492, mostly Uredo, and September 25, 1899, no. 3501, only teleutospores.

DECORAH, IOWA.

OVULE AND EMBRYO OF POTAMOGETON NATANS.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. XXVIII.

G. M. HOLFERTY.

(WITH PLATES II AND III AND ONE FIGURE)

THIS investigation was begun several years ago, and was continued as time permitted. Material from a number of stations in the vicinity of Chicago was collected, and other collections have been added. From this material about seven hundred slides of microtome sections have been prepared and studied. The work was done under the direction of Professor John M. Coulter and Dr. Charles J. Chamberlain.

MATERIAL AND METHODS.

The collections were made in June, July, and August. Those made in June show some young spikes still within the cone-shaped spathe, while others are just issuing from it. Early in July the flowers open and pollination is effected, while in August the seed comes to maturity.

The spikes were cut off with a sharp scalpel and dropped at once into the 1 per cent. solution of chrom-acetic acid. After remaining in the solution from 36 to 48 hours, the material was washed in warm water, and then allowed to remain in running tap water 20 to 24 hours. After imbedding in paraffin the material was cut on a Minot microtome, the sections being from 6–13μ in thickness.

Combination stains were used for all work, cyanin and erythrosin proving most satisfactory, particularly for sporogenous tissues. The safranin gentian-violet orange G combination gave very satisfactory results for chromosomes and all phases of mitosis. The length of time sections should be left in each stain became a matter of some experimentation. In general, 30 to 40 minutes in cyanin and 30 to 40 seconds in erythrosin gave the bests results. The use of turpentine between absolute alcohol and xylol was found to be of decided advantage in many cases.

FLOWERS AND SPIKES.

The flower consists of four similar cup-shaped sepals, four opposite stamens, and four alternate carpels. In early stages the sepals completely overlap the other organs, but later they spread sufficiently to allow the protruding styles to expose the stigmas for pollination. Each stamen branches, bearing an anther on each branch. The anthers are biloculate, and hence the group of four carpels is surrounded by sixteen pollen-sacs. The flowers are nearly sessile on the vertical spike, alternating in such a way that the spiral arrangement is clearly seen (*fig. 1*).

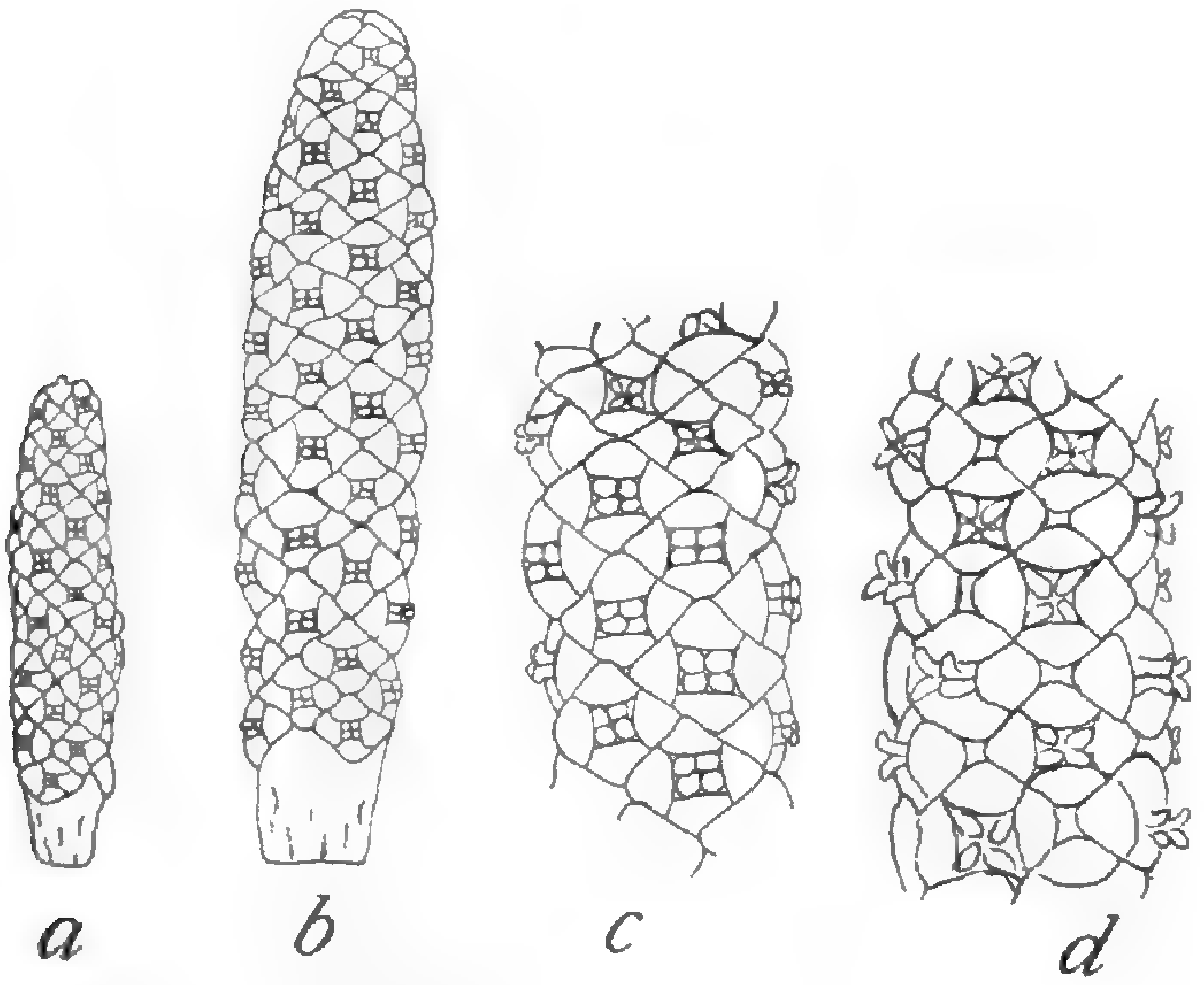

FIG. 1.—Illustrations of spikes: *a*, × $\frac{2}{3}$ size; *b*, × $\frac{1}{3}$; *c*, × $\frac{5}{8}$; *d*, × 2.

From these spikes longitudinal and transverse sections were cut. It can be seen that the first and last longitudinal sections from such a cylindrical spike would give cross-sections of stigmas, styles, and ovaries; while those cut from the center would give two rows of longitudinal sections. Cross-sections of the spike would of course give longitudinal sections of ovaries, styles, and stigmas, but in a plane at right angles to the longitudinal sections mentioned above.

THE OVULE.

The embryo sac is much more deep-seated than in many other plants, occurring in the center of the nucellus, and surrounded on all sides by a mass of tissue from five to eight cells in depth. This deep-seated position may bring added protection of some sort, or it may have no such significance. In the earliest stages of the nucellus no differentiation of cells can be distinguished. Its growth appears to be due almost entirely to divisions of nucellar tissue other than epidermal, since after the formation of the epidermis no layers were observed cut from it by periclinal walls. In fact, the occurrence of periclinal walls in the epidermis is exceedingly rare.

The archesporial cell and its two daughter cells.—Longitudinal sections of the nucellus, about the time the primordium of the inner integument makes its appearance, show a single hypodermal cell having archesporial characters. This cell is larger than the others and has a larger nucleus, and its protoplasm is usually less dense (*fig. 1*). When this hypodermal cell is barely distinguishable from the surrounding tissue, it divides by a periclinal wall. The outer cell is the so-called "tapetal cell" (*figs. 2, 3*), from the progeny of which an extensive region of sterile tissue is subsequently formed. The inner cell is the primary sporogenous cell or megaspore mother cell, its sporogenous character being plainly shown by the rapid changes which soon take place in both its nucleus and cytoplasm.

The sterile tissue.—The subsequent history of the tapetal cell is as follows. The increase in size is followed at once by a periclinal division (*fig. 4*), and this by an anticlinal wall (*fig. 5*). Doubtless an anticlinal wall follows in each of these cells, making a plate of four cells lying next to the epidermis. Wiegand[1] says that the anticlinal walls may precede or follow the periclinals, usually preceding, but this was not verified in *P. natans*. Anticlinal walls now follow in the second layer, thus completing a two-layered tapetum. In *fig. 7* a three-layered tapetum is shown; in *fig. 13* one that is five-layered. The process continues until in some cases eight layers lie between the embryo sac and the epidermal layer. As mentioned before, the embryo sac now lies in the very heart of the nucellus.

[1] WIEGAND KARL M.: The development of the embryo sac in some monocotyledonous plants. BOT. GAZ. **30**: 25–47. *pls. 6–7.* 1900.

The primary sporogenous cell.—At the same time the primary sporogenous cell is undergoing important changes. It increases very much in size, its contents becoming less and less dense, until in some cases vacuoles make their appearance (*fig. 6*). The nucleus also increases in size, and is often surrounded by an area of hyaline cytoplasm (kinoplasm), while radiating strands of granular protoplasm extend from the nucleolus to the periphery of nucleus (*figs. 2, 3*). The chromatin of the nucleus now collects in a closely compacted mass, with a dense non-granular nucleolus by its side (*figs. 4, 5, 6*), the cell having passed into the synapsis stage so characteristic of mother cells.

That the development of the primary sporogenous cell has been simultaneous with the formation of tapetal tissue is shown by the fact that in many cases the former cell has been found in early synapsis with only a two-layered tapetum (*fig. 4*). As the nucleus of the mother cell passes to the spirem stage, the chromatin threads are usually more on one side than on the other. The nucleoli never appeared granular, though often one to several very large granules or black grains could be seen. The cytoplasm was never uniform in appearance, at times having a reticulated appearance (*fig. 5*), and again a stringy appearance (*fig. 6*).

It may be stated that if the manipulation of the stains has been fortunate, one finds in all phases of synapsis an excellent illustration of the value of cyanin and erythrosin as differential stains, the chromatin being always a deep red and the nucleolus a deep blue. There was in the case of Potamogeton no difference in the way in which the stains were taken up by nuclei of the megaspore and microspore mother cells, thousands of the latter showing the highly erythrophilous chromatin and the highly cyanophilous nucleoli seen in the former.

Development of potential megaspores.—It was some time before any positive evidence of an axial row could be found; but the presence of a cap of densely staining protoplasm at the micropylar end of the sac was a strong indication of its presence.

Wiegand[2] demonstrated a two-celled row for *P. foliosus*, but found the fate of the two cells somewhat unusual. He says, "the first division of the archesporial cell is immediately followed by a second nuclear division in each of the daughter cells, but without the formation of a wall between the two nuclei. The upper of these two cells soon perishes, while the lower goes on through various phases forming at last the complete embryo sac."

In *P. natans* some irregularity appears in the number of cells of the axial row, but it is always more than two, brought about by the division of one or both daughter cells of the primary sporogenous cell. The early stages of the division of the sporogenous cell are shown in *figs. 4–7*. In the stage shown in *fig. 8*, the chromosomes have passed to the poles, the spindle fibers are still intact, and the cell plate is clearly marked. A spindle is also formed in each daughter cell (*fig. 9*). It is at this point that the irregularity mentioned above appears. That a spindle is not always formed in each cell may be inferred from *fig. 11*, where the lower cell shows by its size, age, and nucleus that it is the functioning megaspore. The middle cell, its sister cell, is being resorbed along with the upper cell. The spindle shown in *fig. 10* indicates that the two resulting potential megaspores will lie side by side. The preparations referred to thus far do not show any completed four-celled axial row, but they do show several three-celled rows, with spindles to indicate four potential megaspores. The spindle in the upper cell of the axial row, in both cases shown, is transverse rather than longitudinal.

The germination of the megaspore.—The divisions leading to the ante-fertilization stage of the gametophyte appeared perfectly regular and normal, although Wiegand[3] states that in *P. pauciflorus* both egg-apparatus and antipodals were somewhat abnormal. He says, "although the normal number of cells in each was present, they were formed irregularly. The polar nucleus and

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[2] WIEGAND, KARL M.: *loc. cit.* 32.

[3] WIEGAND, KARL M.: Notes on the embryology of Potamogeton. BOT. GAZ. 25: 116–117. 1888.

first and second synergids seem to have been cut off successively from the mother nucleus of the egg. The synergids disappear almost immediately. A similar irregularity was found in the antipodals." This could not be verified in *P. natans*, in which the process seems quite normal (*figs. 13, 14, 17*). At this time there is considerable plasmolysis even when great care is taken in the fixing and subsequent processes (*figs. 15, 16, 17*). In *fig. 14* traces of the first spindle of the megaspore can still be seen connecting the recently formed daughter nuclei, but there is no trace of a wall. By the growth of the sac the antipodals are left in a small pocket, and are of short duration (*figs. 16, 17*); but no traces of a wall shutting them off from the rest of the sac at any time could be found. Nor could a wall be found cutting off the egg-apparatus from the opposite end of the sac. The polar nuclei never meet in the center of the sac, but always nearer the antipodal end (*figs. 16, 17*). The endosperm develops as a parietal layer of cytoplasm in which free nuclei are imbedded, and no walls were observed in the most advanced stages studied (*figs. 19, 21d*).

THE EMBRYO.

The first division of the oospore is transverse, resulting in a large vesicular suspensor cell and the first cell of the embryo proper (*fig. 18*). The three-celled embryo shown (*fig. 19*) has probably resulted from the division of the embryo cell. The single suspensor cell becomes remarkably large and vesicular, and its nucleus and nucleolus correspond in size. The first division of the terminal cell in the row of three is longitudinal (*fig. 20*), and this is followed by a second longitudinal division at right angles to the first (*fig. 21*). This quadrant stage is also shown in transverse section in *fig. 21d.* Further views of the embryo at this period are shown in *figs. 21a–21d*, which are consecutive transverse sections from such an embryo as that shown in *fig. 21*, in which figure the points at which the sections are made are lettered *a, b, c, d.* It is seen from the sections that the young embryo is cylindrical rather than flattened.

In two or three cases a very large nucleus was found near the antipodal end of the embryo sac, the embryo being in the stage just described. Its origin could not be determined, but it seems reasonable to consider it a derivative of the primary endosperm nucleus, and possibly the lower nucleus of the first division, as in *Sagittaria*[4] and *Potamogeton pauciflorus*.[5]

THE UNIVERSITY OF CHICAGO.

EXPLANATION OF PLATES II AND III.

FIG. 1. Micropylar end of nucellus, showing the archesporial cell.

FIG. 2. Primary sporogenous and tapetal cells.

FIG. 3. The same at a later stage; nucleus with radiating strands of protoplasm, and surrounded by a hyaline area.

FIG. 4. Tip of a young nucellus; inner integument and primordium of outer integument; sporogenous cell with nucleus in early synapsis stage; chromatin massed, dense (deeply erythophilous); nucleolus non-granular (deeply cyanophilous); two-layered tapetum.

FIG. 5. Primary sporogenous cell; nucleus in synapsis; a two-layered tapetum with an anticlinal wall recently formed.

FIG. 6. Same with two-layered tapetum; nucleus in synapsis.

FIG. 7. Same with three-layered tapetum.

FIG. 8. Same with spindle and cell-plate; epidermis with double layer but taking no part in tapetal structure.

FIG. 9. Same with two spindles; upper one nearly transverse; beginning of axial row.

FIG. 10. Axial row showing two potential megaspores, and the upper daughter cell with a spindle.

FIG. 11. Functioning megaspore more advanced, but no sign of further division in either middle or upper cells.

FIG. 12. Functioning megaspore resorbing the potential megaspores.

FIG. 13. Embryo sac after the first division; daughter nuclei widely separated, with large vacuole between them; six-layered tapetum.

FIG. 14. Embryo sac after second division; remnants of the spindle between the nuclei at antipodal end of sac; eight-layered tapetum not all shown.

FIG. 15. Micropylar end of embryo sac, showing cells of the egg-apparatus; from section adjacent to *fig. 16*.

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[4] SCHAFFNER, JOHN H.: Contribution to the life history of *Sagittaria variabilis*. BOT. GAZ. **23**: 252–273. *pls. 20–26*. 1897.

[5] WIEGAND, KARL M.: BOT. GAZ. **25**: 117. 1898.

FIG. 16. Antipodal end of embryo sac; antipodals in pocket, and polar nuclei meeting in lower end of sac; from section adjacent to *fig. 15*.

Fig. 17. Embryo sac after third division, showing the eight-celled stage; synergids with vacuoles, egg cell beneath; antipodals in pocket, two with nuclei, remnant only of the third one; polar nuclei meeting below the center.

FIG. 18. A two-celled embryo, showing the large vesicular cell and first cell of embryo proper.

FIG. 19. A three-celled embryo imbedded in endosperm and suspended from the large vesicular cell; endosperm of free nuclei embedded in cytoplasm; each nucleus with two nucleoli.

FIG. 20. A four-celled embryo; the end cell divided longitudinally; very large vesicular cell with correspondingly large nucleus and nucleolus.

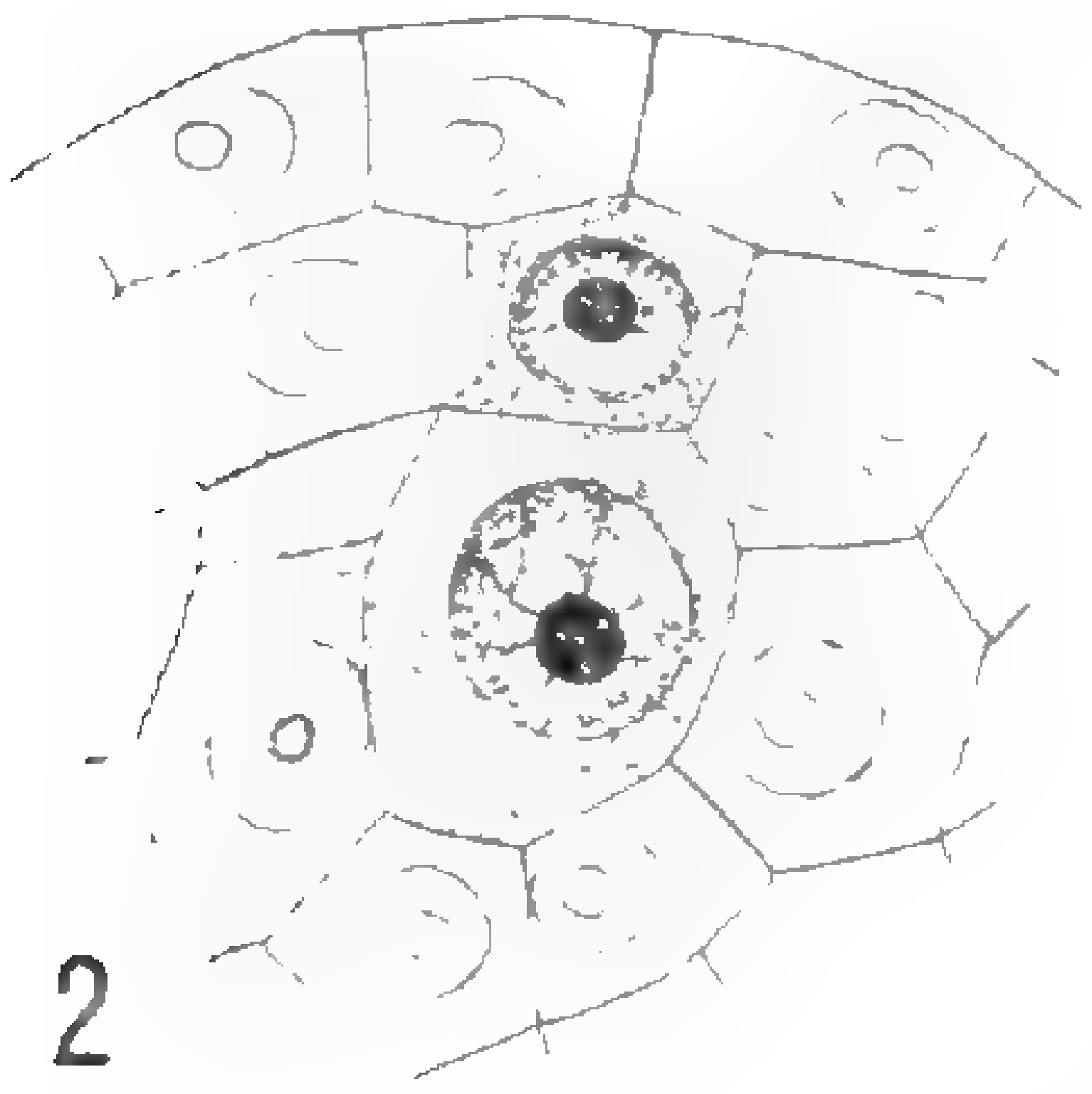
FIG. 21. An eight-celled embryo; end-cell divided into four cells; very large vesicular cell; letters denote points of cross-sections shown in following figures.

FIG. 21*d*. Cross-section of end cell through *d* in *fig. 21*.

FIG. 21*c*. Cross-section through *c* in *fig. 21*.

FIG. 21*b*. Cross-section through *b* in *fig. 21*.

FIG. 21*a*. Cross-section through *a* in *fig. 21*.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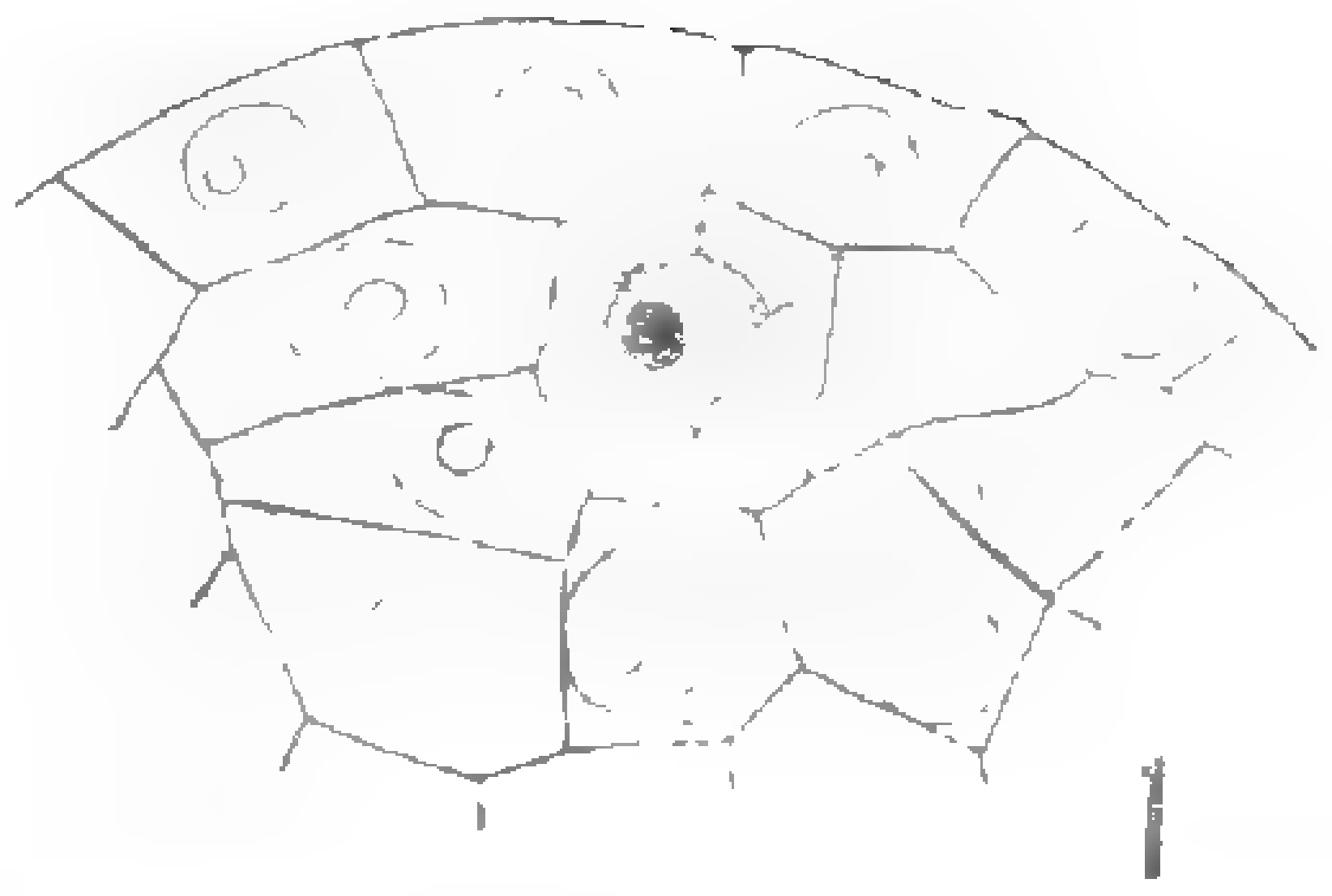
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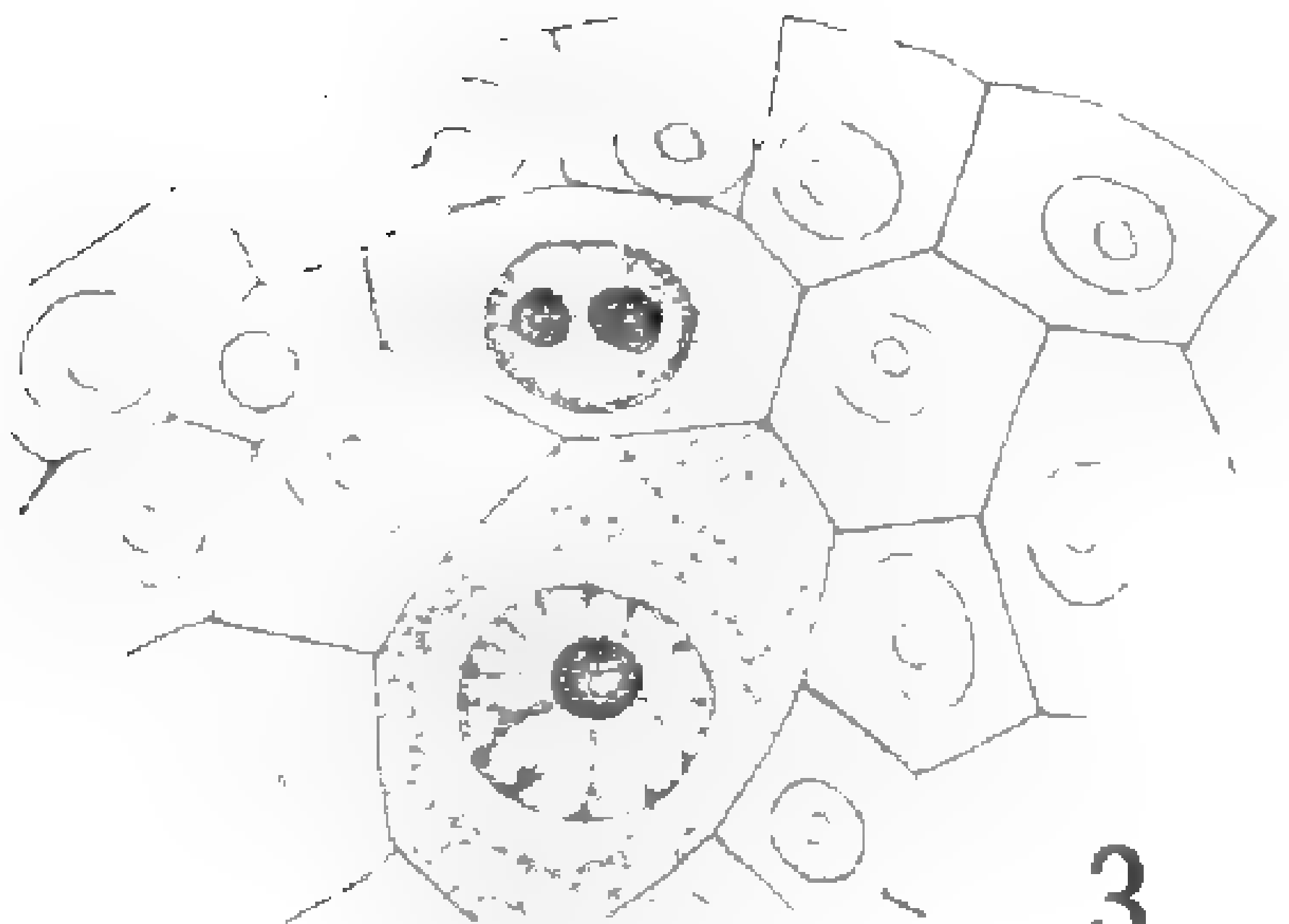
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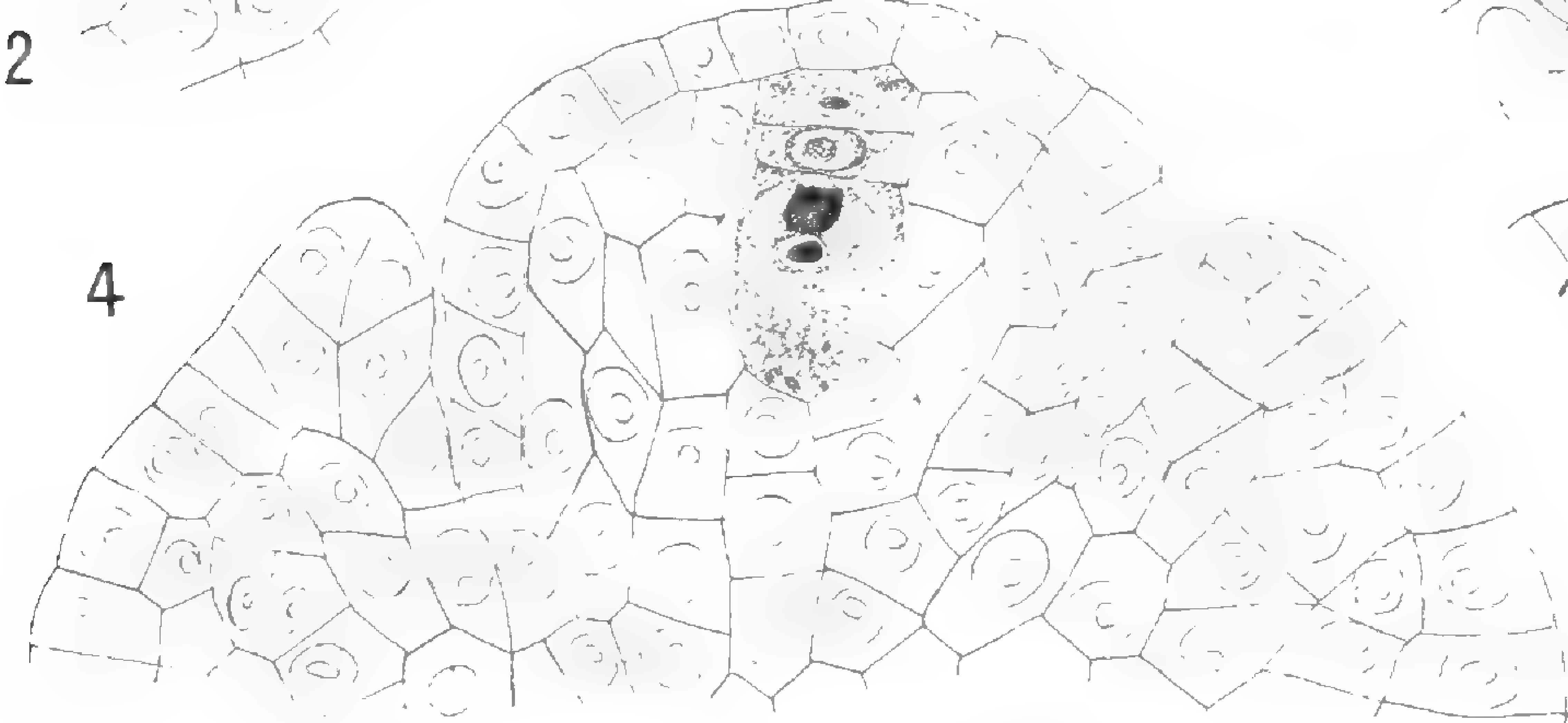
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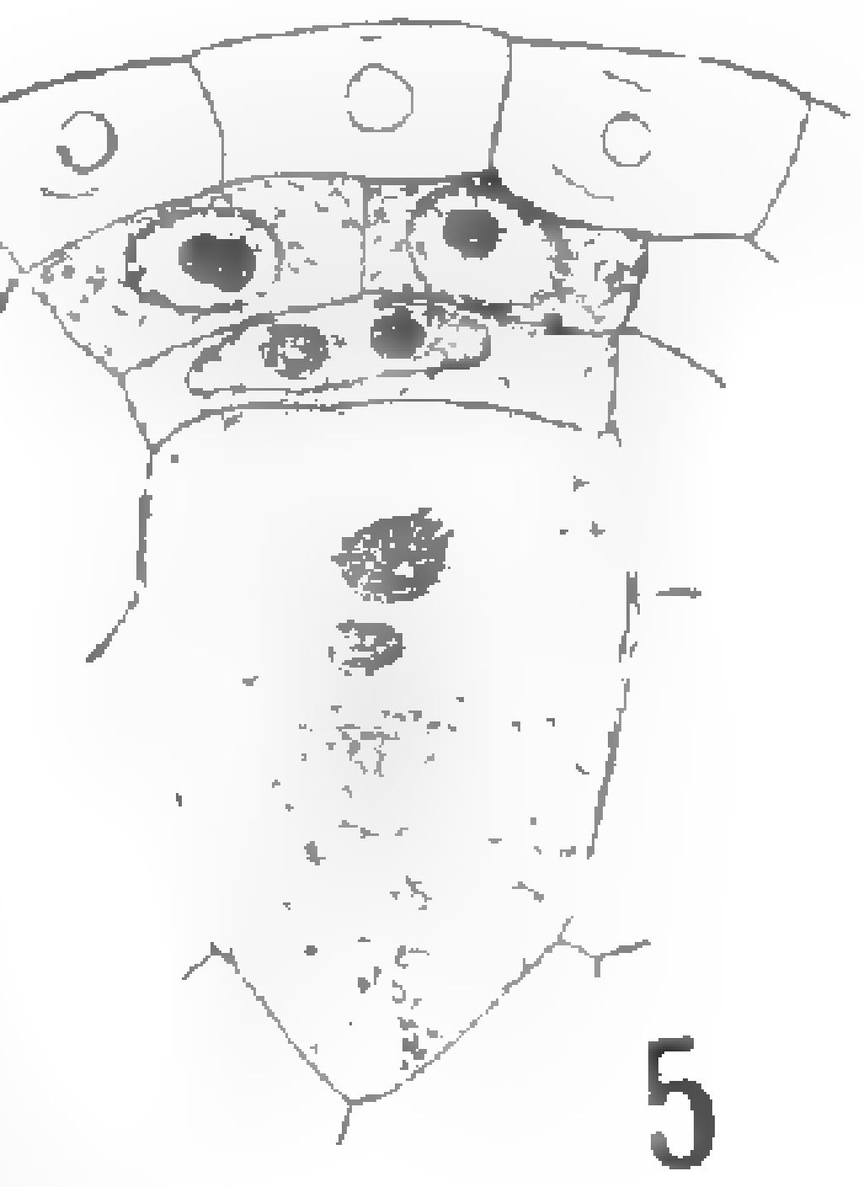
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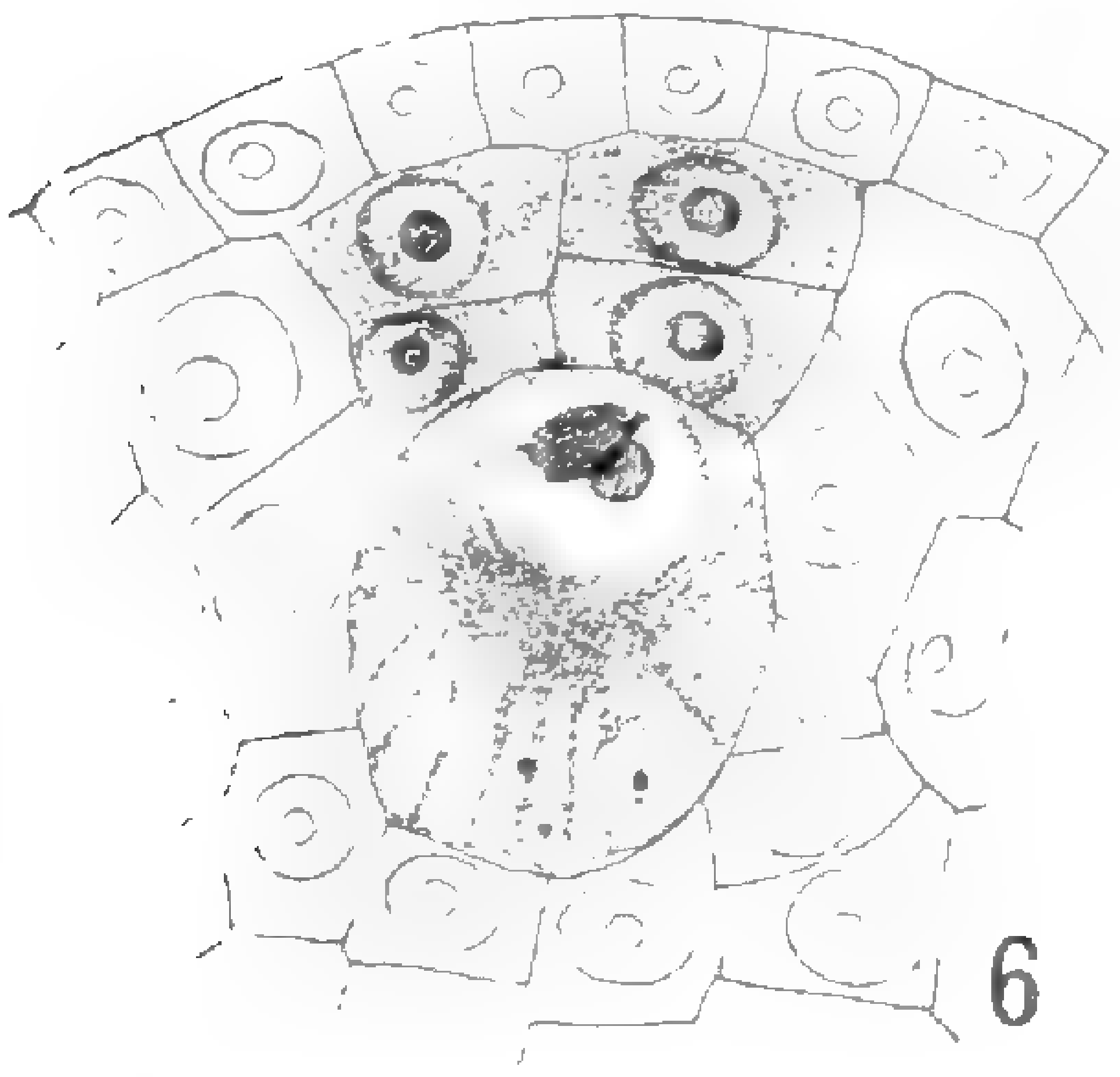
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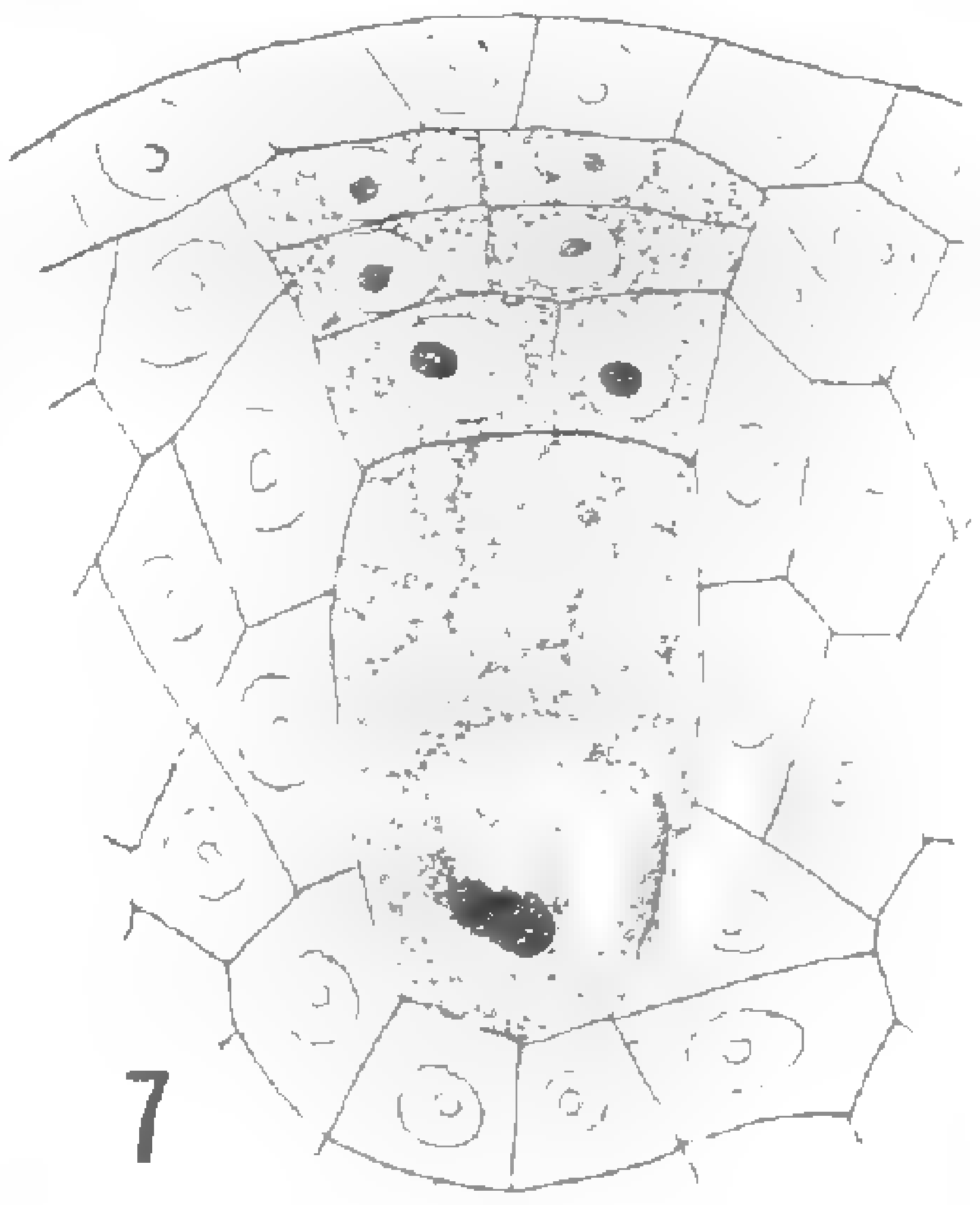
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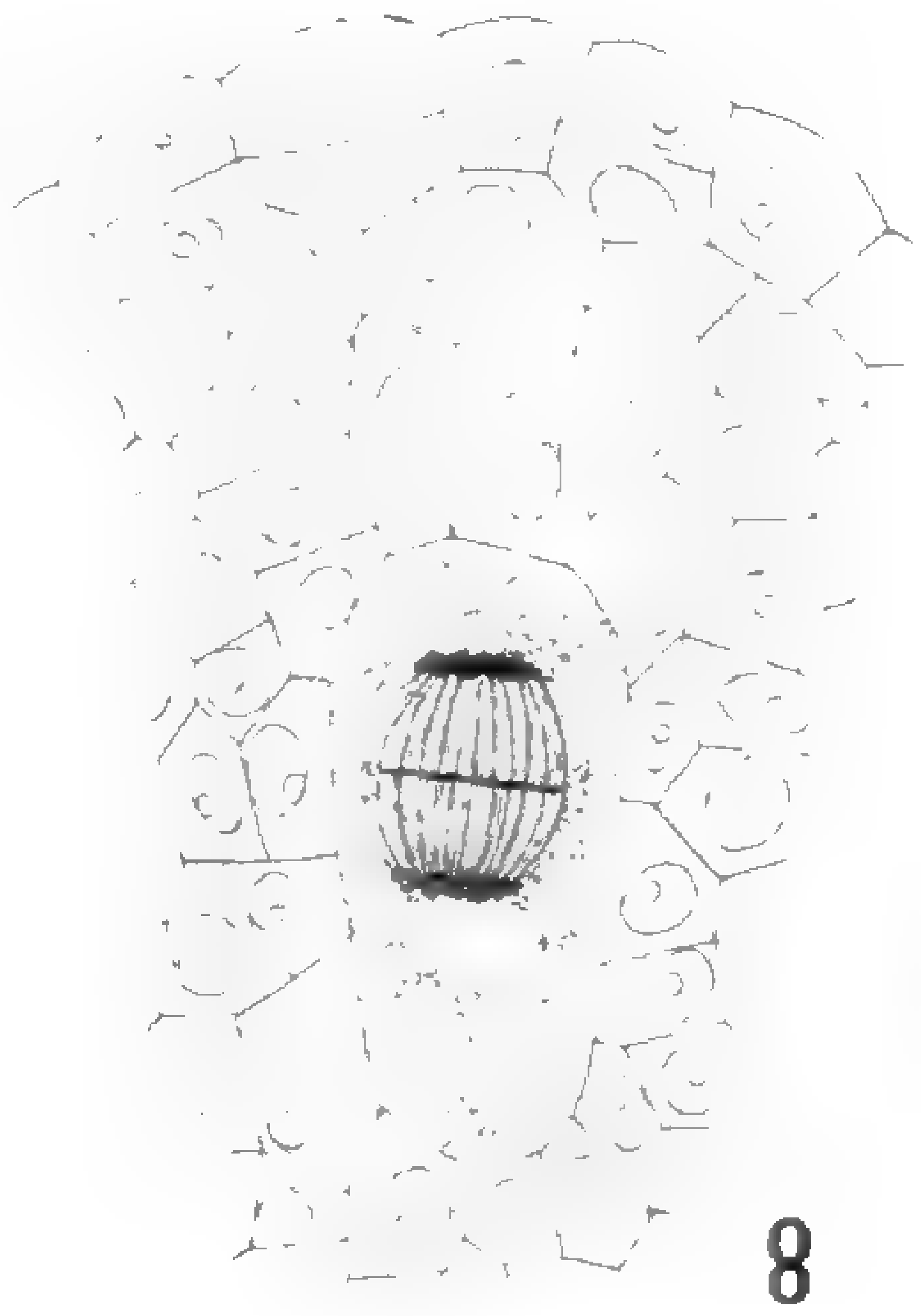
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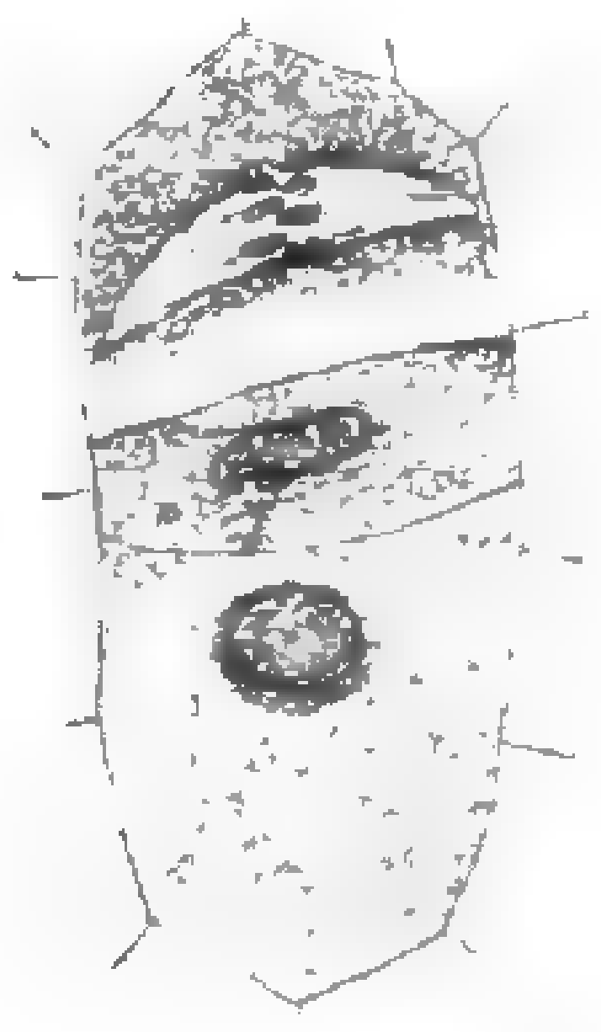
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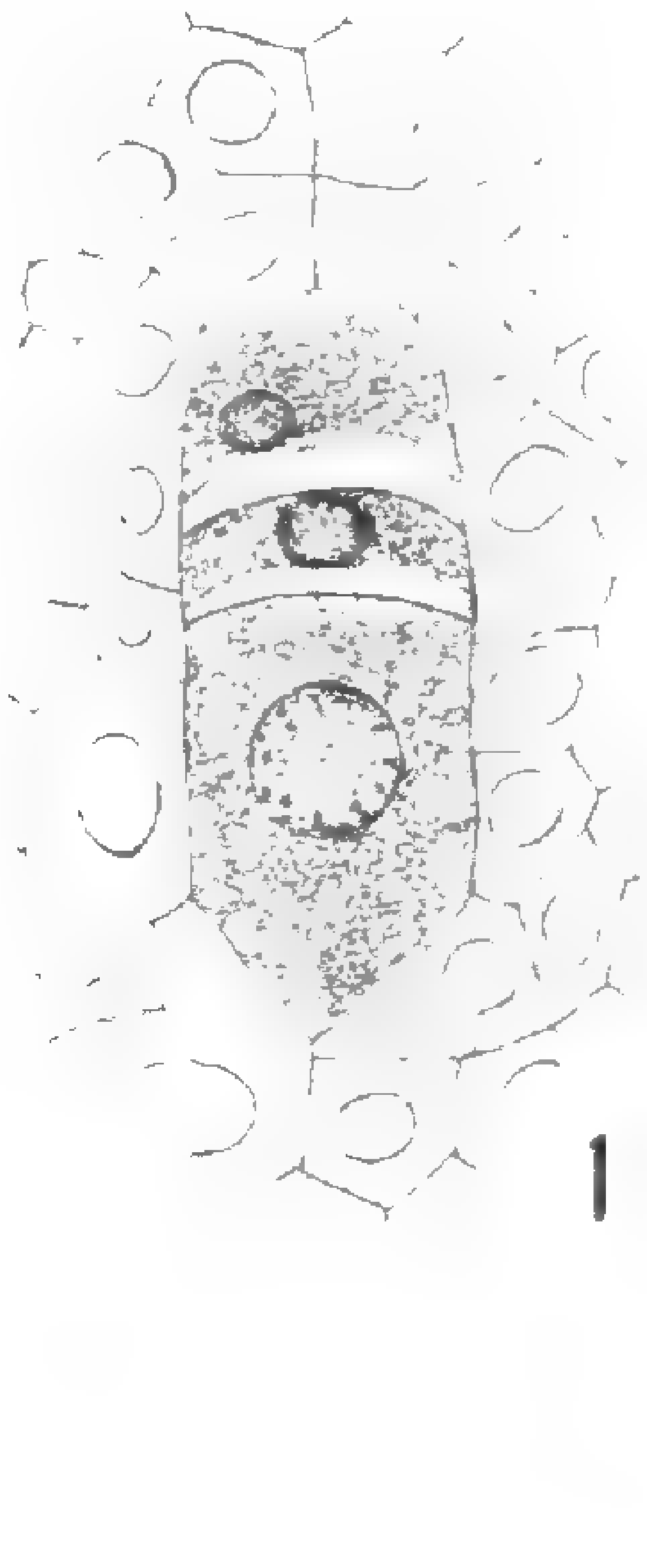
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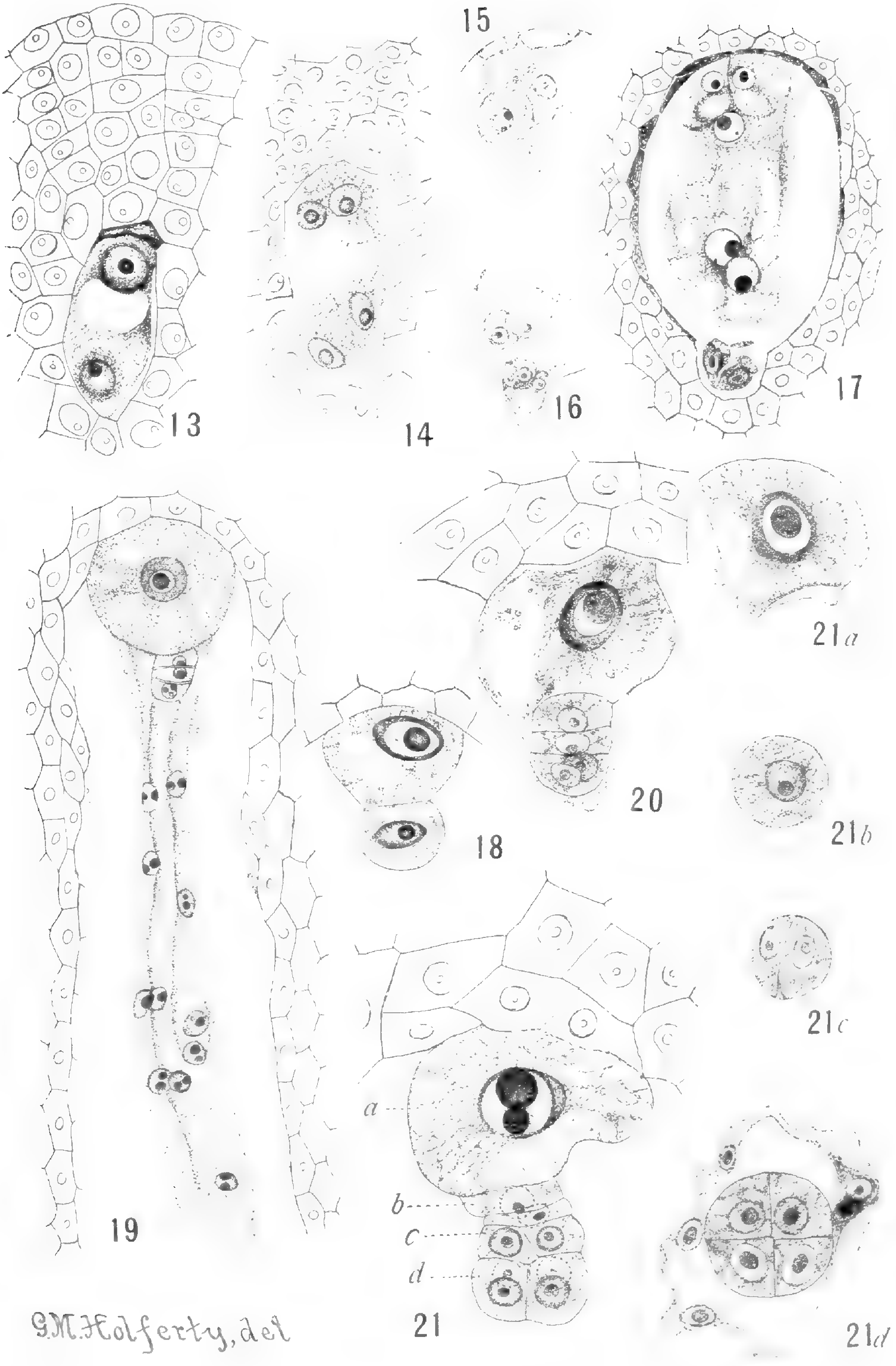
G.M.Holferty, del.

HOLFERTY on POTAMOGETON



HOLFERTY on POTAMOGETON

BRIEFER ARTICLES.

FERN VARIATION IN GREAT BRITAIN.

Up to a comparatively recent date, the departures from the normal type of ferns which were found growing wild under perfectly natural conditions received little or no attention from professional botanists, but were simply dubbed "monstrosities" and left to amateurs to collect, cultivate, and observe. Eventually, however, the discovery that these "sports" did not always merely involve a superficial change of form, but also that this change was in some cases correlated with hitherto unknown modifications and abridgments of the normal life cycle, led to a greater interest being taken, with the result that theories as to the origin of alternation of generations were seriously affected. Before these investigations and discoveries, it was assumed that the life cycle was necessarily spore, prothallus, fertilized egg, and finally the sporophyte or fern proper. Apogamy, however, discovered by Professor Farlow, eliminated the sexual act, a vascular structure originating in the prothallus which resulted in an asexual bud, whence at once arose the sporophyte, the life cycle then being spore, prothallus, sporophyte. This, though first remarked in a normal *Pteris cretica*, was subsequently found by DeBary to occur with seeming constancy in an abnormal tasselled form of Lastrea (*L. pseudo-mas cristata*) and several other species normal and abnormal. The next discovery was that of soral apospory by the writer, on a form of *Athyrium filix-foemina*, which shortened the life cycle in another way altogether, by eliminating the spore, masses of prothalli being produced, as Professor F. O. Bower subsequently ascertained, from the stalks of aborted sporangia, on the ordinary soral sites.[1] Here the life cycle runs thus, sporophyte, sorus, prothallus, fertilized egg, sporophyte. No sooner was this phenomenon announced than Mr. G. B. Wollaston reported the still more remarkable case of apical apospory in a form of *Polystichum angulare* (*P. ang. pulcherrimum*), in which the abnormally long sickle-shaped pinnules

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[1] DRUERY, C. T.: Jour. Linn. Soc. **21**: 354. 1884; **22**: 427–440. 1885. BOWER, F. O.: Trans. Linn. Soc. **2**: 301–326. 1887.

had their terminal and segmental apices dilated into prothalli, which when layered ran the normal course, with the exception that resulting plants were invariably defective and depauperate. Here the sorus is eliminated, and the prothalli are produced altogether independently of the usual reproductive sites, by a modification of the tissue of the sporophyte. Several quite independent finds of the *pulcherrimum* type existed, and in every case apical apospory was found to be correlated with it, and furthermore soral apospory existed on the fertile fronds. The modifications of the life cycle, however, were not even yet exhausted, for curiously enough a sporeling of the apogamous variety of Lastrea above mentioned was found by the writer to bear a well developed prothallus at the tip of its first frond, and the second and third bore prothalli, even profusely, on their surfaces, a sort of prothallic rash as it were.[2] These produced a brood of plantlets, but one and all lost this aposporous character and assumed the merely crested type of the parent as their later fronds arose. Here as we have apogamy and apospory associated, the life cycle dwindles down to sporophyte, prothallus, sporophyte, the shortest possible cut except the bulbils on the fronds of viviparous ferns, which have no intermediate stage at all. Subsequently, the writer found both soral and apical apospory on another variety of Athyrium, and apical on a fimbriate form of Scolopendrium.[3] Curiously enough, subsequent to the discovery of the aposporous Lastrea, a sporeling of the same parentage originated in Mr. Cropper's collection, which was and is profusely prothalliferous from all apices, the smallest piece of frond forming a mass of prothalli when layered, which creeps about Marchantia-like and yields a perennial crop of typical plants. Finally, in this connection, Professor Farlow found an aposporous (soral) type of *Pteris aquilina*. Subsequently, at Professor F. O. Bower's suggestion, Mr. W. H. Lang commenced a series of investigations in connection with the prothalli produced from spores of abnormal varieties, and thereby practically completed the series of abnormal modifications of the life cycle, by finding in more than one species prothalli bearing developed sporangia and spores,[4] thus cutting out the sporophyte, and reducing the life cycle to spore, prothallus, spore, an absolute minimum. I must refer to Mr. Lang's

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[2] DRUERY, C. T.: Jour. Linn. Soc. **29**: 480–482. 1892.

[3] DRUERY, C. T.: Jour. Linn. Soc. **30**: 281–284. 1892.

[4] LANG, W. H.: Proc. Roy. Soc. **63**: 56–61. Phil. Trans. Roy. Soc. Ser. B. **190**: 187–238. 1898

papers for the most interesting details of these and other vagaries, and will merely add that on one and the same prothallus several different modes of reproduction were found, namely, asexual bulbils, some producing fronds and others merely roots; other prothalli budding out from the surface; and sporophytes sexually developed; all these on prothalli which themselves were thick cylindrical fleshy masses instead of the normal flat cordate thallus, while archegonia, antheridia, and sporangia were indiscriminately dotted about among the other varied growths.

The above facts are cited merely as a prelude and justification for the suggestion that in the study of American species the varieties should have due attention and not be labeled "monstrosities," and ignored as they were in Great Britain for a very long period. The writer has repeatedly urged and urges once more that it is quite as much, if not more, in the direction of nature's exceptions that we should seek the key to many of her secrets. Certainly in the study of the abnormal fern types alluded to, a number of new and unexpected facts have cropped up, which largely modify previous ideas regarding fern reproduction, not one of the links in the normal life cycle being absolutely essential. Spore, prothallus, egg, sporophyte, have all in turn been shown to be superfluous, the fern in one shape or another reproducing itself without them.

As regards the great number of varietal forms which have originated in Great Britain, there is little doubt that it is due far more to the continued existence of a coterie of persistent variety hunters than to any predisposing elements in the environment. The traveling botanist is rarely a variety hunter, but a species hunter, hence he does not in a habitat full of known species examine them plant by plant, or scan them with a peculiarly trained eye, as would the hunter for sports. If he have such an eye and a taste for varieties, we have the evidence that "finds" will crop up abroad as well as at home. Witness Mr. George Brown, who found *Woodwardia radicans cristata*, two finely crested forms of *Lastrea dilatata*, and two tasseled forms of *Aspidium hemionitis* in the Azores; while the writer, hunting in all for about two hours recently in Fayal (Azores), found a clump of *Aspidium hemionitis* beautifully tasseled throughout, and a fine pendulous polydactylous variety of *Pteris aquilina* which lined the high road for fifty yards. This being so I would advocate variety hunting in the United States as a pursuit likely to reward its votaries not merely with very beautiful types for their collections, but also with material well worthy scientific attention. Thanks to some short notes sent to the *Fern Bulletin*, I have received already fronds of a crested Athyrium found by a lady, and plants of *Denstaedtia punctilobula cristata* and *Phegopteris hexagonoptera truncata*, the latter found by Mr. W. R. Maxon on the Potomac, which have originated in the United States as wild sports, a proof that such sports exist. At the same time, however, I note that much stress is laid upon doubtful subvarieties, which a wider knowledge of marked ones would probably minimize considerably. In my own fern hunting expeditions I invariably come across subvarieties in which the cutting is more or less modified; but with the abundance of really marked types in mind, these are simply noted and left. As exemplifying this abundance the figures from Mr. G. I. Lowe's *British Ferns*, a descriptive list published in 1891, may be appropriately quoted.

	No. of vars.
Pteris aquilina	17
Adiantum capillus-Veneris	34
Asplenium adiantum nigrum	16
trichomanes	27
maximum	28
Athyrium filix-foemina	313
Scolopendrium vulgare	450
Polystichum aculeatum	34
angulare	394
Lastrea filix-mas	54
pseudo-mas	42
propinqua	28
montana (oreopteris)	77
dilatata and others	57
Polypodium vulgare	74
Other varieties of sundry species	214
Total	1859

Upon analysis it is found that 1119 of these were wild finds, without reckoning additional independent finds of forms too similar to differentiate. This list cannot be regarded as exhaustive, and we may safely reckon the distinct varieties at over 2000, and the wild finds at 1500. As a concrete example of what one man can do in a single district, Mr. J. Moly, of Langmoor in Dorset, is credited with no less than 600 distinct finds in that and adjoining counties. His near neighbor, Dr. Wills at Chard, found several hundred more. The numbers, however, represent the outcome of many years of persistent search, which, however, could not have been exhaustive, as it is recorded that Mr. Patey, visiting Mr. Moly, found one of the finest of all types (*P. ang. plumosum* Patey) in Mr. Moly's own hedge, while Dr. Wills was indebted to a farm laborer for that unique fern *P. ac. pulcherrimum*, also found in a hedge close to his house, and thought to have a funny look about it by the finder. Finally as an inducement to fern hunting, we have the incontrovertible fact that many of these wild sports are far more beautiful than the normal forms, and as such constitute decorative foliage plants of highest merit.

A word may be added in reference to the soral bulbils, as these occurrences should afford good material for the morphological study of the sporangium. Professor Bowers' monograph on apospory and allied phenomena, already cited, gives some illustration of this, and the writer's previous paper[5] also alluded thereto. Since then, however, such soral bulbils have been recorded as occurring on *Adiantum capillus-Veneris* vars. *daphnites* and *imbricatum*, and on *Polypodium vulgare elegantissimum*, while most of the *superbum* section of plumose Athyria have inherited the capacity from the original wild Axminster find. In all these cases the bulbils are seated on the soral sites, and are usually accompanied by sporangia grading from imperfect and aborted ones to perfect ones with full complement of perfect spores which germinate freely and yield fairly typical plants. In the case of the Polypodium, such bulbils occur only on the most highly developed fronds, and on pinnules of extremely fine cutting, the terminals of which run out into nearly inch long lingual extensions, pointing I think to aposporal tendencies. The sori are massive and consist of filamentous processes some of which lengthen out into fronds, while others form perfect sporangia of normal golden yellow color. Here then do not appear those massive cellular growths which are found on the Athyria, but in time one bulbil gets the predominance and a little plant of several small fronds is developed. Unfortunately, neither my leisure nor my training permit me to investigate properly the transitional stages which must exist in cases like these, but I should be happy to provide material to any one who desires to follow up this line of research.—CHARLES T. DRUERY, 11 Shaa-road, Acton, London, W.

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[5] Jour. Linn. Soc. **21**: 254. 1884.

NOTES OF TRAVEL. IV.

COFFEE GROWING IN BRAZIL AND THE GIANT JEQUITIBÁ TREES.

It was the writer's pleasure to accompany Colonel Charles Page Bryan, American minister to Brazil, on a visit to São Paulo and one of its large coffee estates. Santos, the port of São Paulo, and therefore the greatest coffee port of the world, is connected by an excellent line of railway with the latter. São Paulo is a rapidly growing town of some 65,000 inhabitants and is surrounded by many square miles of plantations of Arabian coffee.

The geological and geographical commission of the state of São Paulo is situated here at the capitol, and Dr. Orville Derby, a graduate of Cornell, is its originator and present chief. Under Dr. Derby's direction a botanical department has been established and an economic botanic garden started. with Mr. Alberto Löfgren at its head, a competent and thoroughly enthusiastic Swedish botanist. Mr. Löfgren is assisted by a systematist, Mr. Gustavo Edwall, who has charge of the rapidly increasing herbarium, and also by a young Belgian gardener.

At Tremembé, an hour's ride by steam train from the city, is the young botanic garden, now with about four acres in cultivation and many more available, a small laboratory, cold frames, and a convenient house for orchids and other shade loving plants. In this garden Mr. Löfgren is planting native forage plants, fruit trees, and ornamentals, with the view of introducing them into Brazilian culture. As in all new countries, the field here for such work is quite open, and this garden, if properly supported, will be of great importance to the country.

The best varieties of East Indian mangoes, the southern varieties of alfalfa, and the best sorts of oranges are all quite unknown in this immense region that is so admirably suited to their cultivation, and to that of many other economic plants. The pioneer work of plant introduction has scarcely been begun in São Paulo, and will not make much progress until coffee ceases to be what wheat is in our prairie states, the one lucrative crop.

At the invitation of Dr. Eduardo Prado. owner of one of the largest coffee estates, as well as owner and editor of one of the prominent newspapers in Brazil, Minister Bryan and his party spent a day on the Bergõn coffee estate, some eight hours' ride by train from São

Paulo. To any one who has seen Ceylonese, Javanese, or even Hawaiian coffee plantations, the Brazilian method of culture will be in striking contrast, as no shade trees are employed. The sight of thousands of acres of any perennial plant is impressive, but a plantation of 770,000 trees of coffee, loaded with dark red berries, is really beautiful as well as impressive.

The Brazilian coffee soil is more like New Jersey red clay than any other American soils I know, but it breaks up into an impalpable powder and rises in brick-red clouds about the horses and wagons driving through the plantation, and stains every thing a bright red that is very difficult to remove. To a man of fastidious tastes this choking, sticky dust would be a decided drawback to life on a Brazilian coffee estate.

From the railway station, the party were driven several miles through a broad stretch of coffee trees, and in the very heart of the plantation found a bit of virgin forest several acres in extent, that had been spared the axe, to show how nature clothed that fair land in the days when coffee had no market value. Under the monster trees we passed, marveling at their size and beauty, until without a word of warning we found ourselves in the presence of two giant trees towering above the lesser giants as those would tower above our grandest elms and oaks. It has never been my fortune to stand beneath such majestic forms of plant life as these Jequitibá trees of the Brazilian jungle. The largest specimen measured nearly sixty-two feet in circumference six feet above the ground, or over twenty feet in diameter. Its height was unknown, but certainly exceeded two hundred and fifty feet. The trunk was covered with a regular clear gray bark, and was as columnar as if taken from a Grecian temple, tapering very gradually to the immense crown of spreading branches. Nothing could have given a better idea of the magnitude of this crown than one of the fallen branches which lay like a large tree trunk on the ground, measuring at least four feet in diameter and fifty feet in length. From beneath, we could see that in this tree top a veritable forest of epiphytes and parasites was growing, which added very much to its graceful outlines.

These Jequitibá trees, I believe, challenge the world for majesty of size and form. They are certainly more beautiful than the slender, spire-like Eucalyptus of Gypsland, Victoria; their crowns are far more picturesque than those of the Kauri gums (Jammary) of New Zealand, although their trunks are similar in shape; and the columnar form of their trunks is more graceful than the rapidly tapering ones of the Sequoia, whose crowns in comparison are as the Norway spruce to the cedar of Lebanon in picturesqueness. On the following day a second visit to this wonderful grove confirmed both Mr. Lathrop and me in the opinion that there are nowhere in the world more beautiful trees than these specimens of *Couratari legalis* (Myrtaceae). I believe there are very few such giants in São Paulo, and any botanist traveling in this state would be repaid by a visit to these trees, which have only been easily accessible to visitors for two years past.

The coffee estate of Dr. Prado is equipped with modern machinery; and many signs of ingenuity in the arrangement of the drying floors, pulping machines, and utilization of dried parchment for fuel, indicate decided progress since the days when the whole berry was dried and the seed removed by a species of husker.

No seed selection is practiced in the planting of the trees, and as yet all these coffee estates, like those of the East Indies, are composed of unselected seedlings, although it is an admitted fact that there is a great variation in the productive powers and other advantageous qualities of the different individuals. As yet no fertilizer save the refuse pulp is applied to the soil, although the latter is gradually becoming exhausted.

With Brazilian coffee at the price it now holds in the New York market there is little money in coffee raising, and the time is near when more labor-saving machinery and improved economical methods of culture will necessarily be employed in order to make the business pay.—DAVID G. FAIRCHILD, *Agricultural Explorer of the U. S. Department of Agriculture.*

CURRENT LITERATURE.

BOOK REVIEWS.

The morphology of spermatophytes.[1]

THIS volume forms the first part of a treatise on seed plants. The reputation of the senior author as a lucid and interesting writer is well borne out in the present instance. The illustrations, which in many cases are obviously due to the junior author, are admirably executed when original, and well chosen where they are drawn from earlier publications. The typography and general make-up of the book are creditable.

As is stated in the preface, the present volume grew out of a course of lectures, accompanied by laboratory work, and it shows throughout a command of the most recent literature and a knowledge at first hand of all the morphological facts which may be investigated in a well equipped laboratory in the temperate region of the United States. It presents original views in regard to morphological terminology and phylogeny, while concerning Ginkgo and the Coniferales a considerable amount of original information is supplied.

The extant Gymnosperms are divided in accordance with the results of recent investigations into four classes, the Cycadales, Ginkgoales, Coniferales, and Gnetales. The information supplied concerning the first class incorporates the important recent works of Ikeno, Webber, and Lang on the gametophyte. The interesting genus Ginkgo is elevated on the basis of the researches of Hirasé, Webber, and Seward into the representative of a group (Ginkgoales) distinct from the Coniferales. We find here a considerable amount of original information concerning the earlier and later stages of the seed, including several good figures and photomicrographs. More space is naturally given to the Coniferales than to any other class of Gymnosperms, since they are the representative group of the present day. In this connection we find an excellent photograph illustrating the heteromorphy of certain coniferous seedlings. The account of the reproductive organs is mainly based on the original examination of *Pinus Laricio.* The photomicrographs and figures in this section are particularly fortunate, especially those figures illustrating the development of pollen and of the embryo. The authors express the opinion that the genus Pinus is perhaps the most specialized representative of the group. Towards the much disputed question of the

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[1] COULTER, JOHN M., and CHAMBERLAIN, CHARLES J.: Morphology of Spermatophytes. Part I. Gymnosperms. 8vo. pp. x + 188. *figs. 106.* New York: D. Appleton & Co., 1900. $1.75.

morphology of the ovuliferous scale of the Coniferales they occupy a judicial attitude, although obviously inclining to the view that in the Pinaceae at any rate it is to be regarded as a modified shoot in the axil of the sterile bract. Concerning the treatment of the Gnetales little need be said. Although of necessity presenting no original features it summarizes the most recent literature.

In its treatment of the fossil Gymosperms the present work is far beyond any previous American botanical work. The Cordaitales receive a sufficient consideration, illustrated chiefly by Renault's well-known figures. The extinct cycadoid group, the Bennettitales, is fully discussed from the standpoint of the existing literature, and an interesting account, in part original, is given of the recently discovered microsporophylls of the group, which as yet have been found in a state of suitable preservation only in the United States. The microsporangia occur in synangial sori on the abaxial surfaces of the sporophylls, thus resembling at once Cycas and the marattiaceous ferns. A further interesting feature is that the strobili in this group were not unfrequently bisporangiate, bearing both megasporophylls and microsporophylls.

The work closes with chapters on the comparative morphology, phylogeny, and geographical distribution of the Gymnosperms. As regards comparative morphology the authors have almost entirely excluded vegetative anatomy from their work, and among so many admirable illustrations of the external features and reproductive organs of living and fossil Gymnosperms there are few or none representing anatomical structures of the vegetative organs. The present volume is destined to have such an important influence on the study of Gymnosperms on our continent, that it is impossible not to regret that its authors have not done something to direct the attention of American botanists to the importance of anatomical studies, so much neglected as yet in North America. The work of European palaeobotanists has apparently finally set at rest the claim that the reproductive organs of the higher plants are the only trustworthy guide in matters of morphology and phylogeny. It appears to be established as a result of the work of the late Professor Williamson and his followers that the fibrovascular skeleton of plants is quite as important phylogenetically as the osseous skeleton has proved to be in the case of animals. The Calamities and Sigillariae, for example, were put by Williamson, on account of the constant and characteristic features of structure of their vegetative organs, with the Equisetales and Lycopodiales respectively, in opposition to Brongniart who placed them among the Gymnosperms. The subsequent discovery of their reproductive organs by Williamson and Zeiller only confirmed Williamson's predictions. At the present time the Cycadofilices, a group on anatomical grounds alone considered transitional between the Filicales and Gymnosperms, are in the same position as that formerly occupied by the Calamites and Sigillariae.

The actual condition of our anatomical knowledge seems to justify the general statement that the skeletal features of plants are even more conservative than their reproductive organs, and of quite as great importance in establishing the phylogenetic grouping of the Vasculares.

Turning to phylogenetic matters, the authors consider with Potonié and Scott that the Cycadofilices form the connecting link between Ferns and Gymnosperms. This group they believe to have given rise in all probability to two series, the Bennettitales and the Cordaitales. From the former the Cycadales were derived at a later date, while from the latter stock branched off subsequently the Ginkgoales and Coniferales. The significance of this phylogenetic tree would be more apparent had the earlier part of the book given a better illustrated account of the Cycadofilices and the Cycadofilicinean features of the living and extinct Gymnosperms.

The present admirable volume is indispensable to every botanist, and the reviewer may perhaps express the hope that in the second edition, which will doubtless soon be called for, the authors will add to its usefulness by a well illustrated summary of the relevant points of vegetative anatomy.—E. C. JEFFREY, *Toronto*.

Bergen's botany.

WHEN there began a revulsion against the teaching of botany from the floral standpoint, Bergen's *Elements of Botany* was one of the most helpful text books, because it looked toward the introduction of the student to the more vital phases of botany. The book met instant and increasing success, because it was just different enough from the former texts to attract the teacher who felt the need of a change, and not so different as to repel the teacher who was willing but not anxious to find a new guide.

The *Foundations of Botany* recently issued[2] is in some sense a revision of the older book. It is said to be written upon the same lines, but it differs from the *Elements* in the extension of the portion treating of cryptogams, and in the introduction of a section on ecology. The adoption of these features, which characterize several of the more recent texts, is an acknowledgment that the lines on which they proceed are approved by teachers, and evidence that the publishers desire to meet this demand. The *Flora*, which in the earlier book was wholly inadequate, has been increased fivefold, and, judging from the title-page, is issued in editions adapted to various sections of the country.

The illustrations are all new and almost without exception admirably selected and well made. Many improvements in the text are also evident, and the book is probably as accurate as any text-book now on the market.

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[2] BERGEN, JOSEPH Y.: Foundations of botany. 12mo. pp. xii+412. *figs. 276.* With which is combined: Bergen's botany, key and flora; northern and central states edition. pp. 257. *figs. 25.* Boston: Ginn & Co. 1901.

We regret that the author did not use the metric system; his objection that it is not familiar outside of chemical and physical laboratories is really an indictment of botanical laboratories.

But the book still lacks the treatment of cryptogams which alone can make them worth study. The studies of "types of cryptogams," which section is credited to Mr. A. B. Seymour, have no obvious connection with those of seed plants, and the unfortunate name "spore plants" serves to set the two sharply apart. The chapters on thallophytes, bryophytes, and pteridophytes contain directions for enough laboratory work for a year, but they are not well organized pedagogically, nor in such fashion as to indicate the more important parts. A single chapter on the evolutionary history of plants attempts to furnish a thread of philosophy which has been wanting earlier, but the student is left almost unaided to string his pearls of fact, great and small, into a shapely whole. The great pregnant ideas of alternation of generations, heterospory, and the seed habit lose all their significance unless they are presented in connection with the facts they coordinate.

One naturally expects the *Foundations of Botany* to exemplify, as most books do, the subjects and mode of presentation which the author thinks best for the schools. But we find it difficult to interpret Mr. Bergen. One looks for the present book to show advance along the lines which characterized the *Elements*. On the contrary it seems to encourage the teacher of "analysis" by bringing to his hand a better flora; it meets the demand for ecology by organizing a section on this subject; it gives the histological teacher ample scope for the use of microscope and reagents; it does not develop further the physiological features. What is the teacher to do? Is the book a guide to wise botanical instruction or simply a book catering to all tastes? This uncertain pedagogical sound seems to us to make it doubtful whether *Foundations* will prove as satisfactory as *Elements*, which had in its time a mission that it excellently fulfilled.— C. R. B.

Two books on mushrooms.

POPULAR books on mushrooms multiply. The latest two issue from New York. There are many good things to be said for Miss Marshall's account[3] of the more conspicuous Ascomycetes and Basidiomycetes. In the first place, the figures and diagrams are excellent and so numerous that eighty-three of the hundred and more species described are well illustrated. A number of the half-tone plates are printed in colors and the remainder in black and white. The descriptions are simple and clear, and there is also much interesting information appended concerning habits and the edible and poisonous properties

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[3] MARSHALL, NINA L.: The mushroom book. A popular guide to the identification and study of our commoner fungi, with special emphasis on the edible varieties. Imp. 8vo. pp. xxvi + 167. With many illustrations in color and black and white. Doubleday, Page & Co. New York, 1901. $3.00.

of the important species. Miss Marshall has introduced an elaborate key at the beginning of the book, designed to lead the reader directly to the genus. This naturally presents the complexities inherent in a subject of such acknowledged difficulty. One notes some inconsistencies. "For convenience," Craterellus is described among the "fungi with gills," but even then the writer failed to find its place in the key. Such looseness reacts in the end on the general worth of the book. Then it seems a pity that Miss Marshall should attempt to describe in general language, and sometimes even figuratively, structural characters and physiological activities that are fundamental to all careful observations of fungi. Such expressions have a pseudo-simplicity, which deceives and misleads instead of enlightening the novice.

The second work is issued as a *Memoir* of the New York State Museum, by the botanist, Mr. Charles H. Peck. The forty-eighth report for 1894, containing quarto colored plates and descriptions of edible fungi, was in great demand, so that several editions were exhausted almost as soon as issued. The forty-ninth, fifty-first, and fifty-second reports, contained illustrations and descriptions of thirty-three species. The work of the past year adds fourteen species to the list. On account of the great demand for these reports by mycologists and mycophagists, the parts on edible fungi are brought together to form the present memoir, illustrations and text having been revised when necessary.[4] Thus the forty-eighth report with sixty-nine species and the present memoir with forty-eight species illustrate to date the edible and poisonous fungi of the state. The character of descriptions and plates is like that of former reports. The figures are stiff and mechanical in drawing and rather crude in coloring. A comparison of the two books in this respect shows the great superiority of photographs and half tones over anything but the most expert and artistic drawing, and the most expensive reproduction.—B. M. DAVIS.

MINOR NOTICES.

THE REPORT of the state botanist of New York for 1899 has just appeared in its usual dilatory fashion. It contains descriptions of numerous new fleshy fungi, and three colored plates.—J. M. C.

THE THIRD FASCICLE of Schumann's *Blühende Kakteen* (Iconographia Cactacearum) has appeared, containing beautiful illustrations of *Echinocactus longihamatus* Gal., *E. Monvillei* Lem., *E. Fordii* Orcutt, and *E. Knippelianus* Liebn.—J. M. C.

THE SEVENTH FASCICLE of the first volume of "Illustrations de la Flore du Congo," by Wildeman and Durand, has just appeared, containing *plates*

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[4] PECK, CHARLES H.: Report of the State Botanist on Edible Fungi of New York, 1895–1899. 4to. pp. 133–234. *pls. 44–68.* Albany: University of the State of New York. 1900.

73-84. The publication continues its high character, and the plates represent the best of the lithographer's art.—J. M. C.

ONE of the most recent additions to the local floras of Britain is the *Flora of Cheshire,*[5] prepared from the manuscripts of the late Lord de Tabley. It gives in great fullness an account of the floral districts, the ecological conditions, and a list or species accompanied by a detailed account of stations.—J. M. C.

THE FIRST FASCICLE of the third volume of Pittier's *Flora of Costa Rica*[6] has appeared. It contains the "Filices, Equisetaceae, Lycopodiaceae, Selaginellaceae, and Rhizocarpaceae," by H. Christ. Seventeen new species and ten new varieties of ferns are described, besides one new species and two new varieties of Lycopodium.—J. M. C.

BILTMORE BOTANICAL STUDIES is the title of a new botanical journal, to be "issued at irregular intervals," and to include papers by the director of the Biltmore Herbarium and his associates. The first number was issued April 8, 1891, and includes the following papers: C. D. BEADLE and F. E. BOYNTON, Revision of the species of Marshallia (7 species, 3 of them new); C. L. BOYNTON and C. D. BEADLE, Notes on certain coneflowers (including 5 new species of Rudbeckia); T. G. HARBISON, New or little known species of Trillium (3 new species); C. D. BEADLE, New species of thorns from the southeastern states (21 new species of Crataegus); C. D. BEADLE, a shrubby oak of the southern Alleghanies (*Q. Boyntoni*). The journal is very handsomely printed and illustrated.— J. M. C.

PROFESSOR E. L. GREENE has begun the publication of a series of papers bearing the title *Plantae Bakerianae.*[7] It is to contain lists of plants collected by Mr. Carl F. Baker and his colleagues and distributed to various herbaria on both sides of the Atlantic. The first volume is to include the collections of 1898 by Messrs. Baker, Earle, and Tracy in southern Colorado, and the fascicle now at hand extends from Fungi to Iridaceae. A prefatory narrative by Mr. Earle describes clearly the region traversed, and gives an adequate background for the list of plants which follows. The fungi are by Messrs. Earle and Tracy, and the list includes descriptions of thirty-one new species. The Polyporaceae have been determined by Professor Underwood, the lichens by Professor Fink, and the grasses by Professor Tracy; otherwise the determinations are by Professor Greene, who includes descriptions of new species of Zygadenus and Allium.—J. M. C.

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[5] TABLEY, LORD DE: The flora of Cheshire. Edited by Spencer Moore, and with a biographical notice of the author by Sir Mountstuart Grant Duff. 8vo. pp. cxiv + 399. London: Longmans, Green, & Co. 1899. $3.50.

[6] PITTIER, H.—Primitiae Florae Costaricensis. Vol. III. pp. 1–69. San José de Costa Rica. 1901. 75 cents.

[7] Plantae Bakerianae 1: 1–52. 23Ja1901. Fungi to Iridaceae. Catholic University of America, Washington, D. C. Price 40 cents.

NOTES FOR STUDENTS.

W. A. WHEELER[8] has published an ecological account of the vegetation of southeastern Minnesota in connection with a list of the species collected there. The paper is accompanied by several excellent heliotypes.—H. C. COWLES.

E. M. WILCOX has investigated[9] a rhizomorphic root-rot of fruit trees that is doing great damage to the peach, apple, and cherry trees of the southwest. The fungus concerned is described as a new species, *Clitocybe parasitica*, and is also found infesting oak trees. A very extensive bibliography and several plates accompany the report.—H. C. COWLES.

CORRENS has shown experimentally[10] that in *Mirabilis Jalapa* only one pollen grain out of five, and two ovules out of three, are fit, while in *Mirabilis longiflora* one pollen grain out of four, and one ovule out of two are fit. Therefore the chances of fertilization increase with the number of pollen grains used in pollination, and the progeny are stronger.—C. R. B.

IN A RECENT number of Engler's yearbook[11] there is an account of the recent attempts to secure a uniform nomenclature in plant geography. Warburg's address before the Berlin geographical congress in September 1899 is given, as is also the resolution passed by the Paris botanical congress in 1900. Engler makes an appeal for contributions that will tend to clarify the various questions, offering to publish them in the yearbook. Particularly with reference to the use of the word "formation" is there need of a general understanding.—H. C. COWLES.

VON SCHRENK has published a preliminary report on diseases of New England conifers[12] which contains a good deal of interesting material. General remarks are made on the conditions in the New England forests, and on the relation of fungi to forest problems. Several fungi, mainly Polypori, are described with especial reference to the mode of occurrence and the effect on the tree. A number of excellent plates accompany the report. Dr. von Schrenk's work has often been noticed in this journal, and must be highly commended both for its botanical importance and its practical aspect.—H. C. COWLES.

IN A SHORT paper entitled "A contribution to the natural history of marl, C. A. Davis[13] shows conclusively that water plants, especially Chara

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[8] Minn. Bot. Studies, ser. 2, pt. 4. 1900.

[9] Bull. 49, Oklahoma Agric. Ex. Sta. 1901.

[10] Berichte d. deutsch. bot. Gesells. **18**: 422–435. 1900.

[11] Eng. Bot. Jahrb. **29**: Beiblatt 66, 23–30. 1900.

[12] Bull. 25, U. S. Dept. of Agric. Div. of Veg. Phys. and Path. 1900.

[13] Jour. Geol. **8**: 485–497. 1900.

and blue-green algae, are of great importance in marl formation. The calcareous incrustations, which give rise to marl upon the decay of the plants, are formed by the deposition of $CaCO_3$ when the CO_2, which caused it to remain in solution, is used in photosynthesis. The oxygen set free in photosynthesis also causes the precipitation of $CaCO_3$. One interesting fact brought out by the study is that plants vary widely in respect to the incrustations, indicating selective processes not yet understood.—H. C. COWLES.

MISS ELIZABETH DALE, in a communication to the Royal Society, London, through Professor H. Marshall Ward, shows that the abnormal outgrowths, or intumescences, in *Hibiscus vitifolius* Linn. are due to pathological conditions, being formed in a moist atmosphere, provided there is also adequate light and heat. The immediate effect of the damp atmosphere is to check transpiration. This, in its turn, by blocking the tissues with water, disturbs the normal course of metabolism, and so leads (when the light and heat are sufficient) to abnormal development of certain regions. The formation of these outgrowths is accompanied by the production of oil, which is not found in normal leaves. Its presence suggests that events similar to those occurring in succulent plants are taking place, viz., reduced respiration and the development of osmotically active substances in excess. It is therefore probable that the intumescences are due to the local accumulation of osmotically active substances, produced under the abnormal conditions.—H. M. WARD.

THE LITERATURE of the first mitosis of the spore mother cell of Lilium shows a wide divergence of opinion in regard to the phenomena involved, but there are certain stages which have been constantly observed. How these stages are derived from one another is the most debated question. In a recent paper Professor Dixon[14] figures and describes six well ascertained stages, and then proceeds into the debated territory. Nearly all observers describe a longitudinal splitting of the entire thread just before the segmentation into chromosomes, but Professor Dixon believes that the stage so constantly observed arises from the looping on each other and approximations of two portions of the thread. Several very suggestive objections are urged against the commonly accepted interpretation. Although believing that each of the two twisted portions undergoes a longitudinal splitting while still in the spirem stage or immediately after differentiation into chromosomes, regarded as a second longitudinal splitting by Guignard and others, the author believes that this is the first and only longitudinal splitting. A series of very clear diagrams illustrates the author's interpretation of the composition of the chromosomes and their behavior during the later phases

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[14] On the first mitosis of the spore mother cells of Lilium. Notes from the Botanical School of Trinity College Dublin 4:129–139. *pls. 7–8.* 1901.

of mitosis. According to this interpretation there is no qualitative reduction during the first division of the spore mother cell.—CHARLES J. CHAMBERLAIN.

THE LIFE HISTORY of *Schizaea pusilla* has been investigated recently, and the results form the first fairly complete account of this interesting fern.[15] The material was collected at Forked river, New Jersey, in July 1900. Sections do not seem to have been made except in the study of the root, stem, and leaf. While the peculiar gametophyte and the general aspect of the young sporophyte are shown more clearly without sections, one cannot help feeling that the account of the development of the antheridia and archegonia, and also of the very young sporophyte, would have been more satisfactory if the study had been made from microtome sections. The gametophyte is composed of numerous erect branching filaments which have a somewhat uniform diameter and bear a striking resemblance to the protonema of a moss. The filaments persist until the young sporophyte has attained considerable size. The archegonia are not imbedded, but are entirely free, in general appearance suggesting the archegonia of certain liverworts. The archegonium originates as a single superficial cell which gives rise to a row of three cells. From the outermost of these is formed a neck consisting of four tiers of cells with four cells in each tier. From the middle cell comes the central cell which gives rise to the neck canal cell, the ventral canal cell, and the egg. The basal cell forms the venter. One figure illustrating the development of the antheridium shows a row of three cells. The outermost cell "becomes large and globular and cuts off a cap cell at the summit, with the wall oblique. The large cell divides up into the mother cells of the antherozoids and one ring cell." The anatomy of the root, stem, and leaf is described in detail.—CHARLES J. CHAMBERLAIN.

DR. A. KLETT[16] has recently studied anthrax to ascertain if it is possible to produce the spores in a culture of the bacillus grown under artificial anaerobic conditions, and to observe the effect of nitrogen and hydrogen upon the growth of the colonies. For the nitrogen experiments Buchner's tubes containing pyrogallic acid and caustic potash were used. By this means the oxygen and carbon dioxid of the atmosphere in the sealed tubes were absorbed, leaving nothing but nitrogen. For the hydrogen experiments he employed Kipp's apparatus for generating the hydrogen, and Botkin's apparatus for growing the cultures in plates and in liquid media. Although every precaution was taken against the possibility of error, Klett shows by careful experimentation that spore formation in anthrax is independent of the presence of oxygen. He was enabled to obtain a rich growth of the bacillus with

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[15] BRITTON, ELIZABETH G. and TAYLOR, ALEXANDRIA: The life history of *Schizaea pusilla*. Bull. Torr. Bot. Club **28** : 1–19. *pls. 1–6.* 1901.

[16] Die Sporenbildungen des Miltzbrandes bei Anaërobiose. Zeit. f. Hyg. u. Infectionskrank. **35** : 420. 1900.

abundant spores in an atmosphere of nitrogen. In the hydrogen atmosphere, on the other hand, there appeared only a very meager growth of the colonies, without a trace of spores. From these observations Klett opposes the more commonly accepted view that the presence of free oxygen is a necessary condition for the formation of spores in the anthrax bacillus, and holds that spores cannot be formed in an atmosphere of hydrogen owing to the retarding effect of this gas upon the growth of the colonies. He further concludes that it is not the presence or absence of oxygen that determines the growth and the development of spores in the bacillus, but that every gas has its specific influence in this respect. The paper is a most interesting and valuable contribution to the controversy of spore formation in anthrax, and it also has an important bearing on many experiments where hydrogen, considered as an inert gas, has been employed to bring about an anaerobic condition.—A. A. LAWSON.

ITEMS OF TAXONOMIC INTEREST are as follows: L. DIELS (Engler's Bot. Jahrb. **29**:577–659. 1901) has completed his account of the flora of central China, the closing part extending from Bignoniaceae to Compositae. Besides numerous new species, *Kolkwitzia* (Caprifoliaceae) and *Hoeckia* (Valerianaceae) are described by Graebner as new genera.—O. E. SCHULZ (*idem* 660–735. *pls. 6–8*) has published a monograph of *Melilotus*. A discussion of the history, morphology, teratology, biology, and geographical distribution of the genus is followed by a detailed presentation of the twenty-two recognized species, three of which are new.—S. SOMMIER and E. LEVIER (Acta Horti Petropolitani **16**:1–586. *pls. 1–49.* 1900) have published an elaborate account of the plants collected in the Caucasus in 1890, illustrated by forty-nine fine lithographic plates. The list includes cryptogams as well as seed plants. More than a hundred new species are described, and still more numerous new varieties.—W. LIPSKY (*idem* **18**:1–146. 1900), in a contribution to the flora of middle Asia, has described numerous new species, and with them two new genera of Umbelliferae, *Korshinskia* and *Galagania*.—N. L. BRITTON (Torreya **1**:21. 1901) has described a new Senecio (*S. Crawfordii*) from Pennsylvania.—M. L. FERNALD (Rhodora **3**:43–56. 1901) has published a synopsis of the northeastern species of Carex of the subsection Vesicariae, recognizing eleven somewhat polymorphic species and describing seven new varieties.—F. LAMSON-SCRIBNER (Div. Agrost. Circ. 30. 8 Mr 1901) has described new species of Ichnanthus, Agrostis, Bouteloua (2), and Danthonia, besides numerous new varieties and combinations.—E. L. MORRIS (Bull. Torr. Bot. Club **28**:112–122. *pl. 12.* 1901), in his second paper on N. Am. Plantaginaceae, has described six new species of Plantago.—G. N. BEST (*idem* 123–131. *pls. 13–14*), in a revision of the N. Am. Species of Heterocladium, recognizes six species and varieties, three of which are described as new.—J. M. C.

OPEN LETTERS.

THE NAMES OF OUR FERNS.

THE deadly parallel has always been a striking method of impressing a point. When its bald statements are unqualified it seems to mean more than the facts will warrant, and it is expected to kill at long range. In a recent issue of the BOTANICAL GAZETTE, Mr. Fernald has made use of it to show the supposed instability of the "reform movement," but does not note the fact that ten of the fifteen changes of which he accuses me were made in accordance with changed conceptions regarding the limitations of genera, and consequently have no bearing whatever on the point he is attempting to illustrate. His illustration in other respects is very happily chosen, and its full import will become apparent when we add the part he forgot to use. For the benefit of the younger generation of botanists who, like Mr. Fernald, might be misled to suppose that all the changes of plant names have been proposed by the "reform movement," I will add from the same group the changes of trans-Carline origin that have been made in the past generation as follows:

FERN NAMES USED IN GRAY'S MANUAL, FIRST EDITION.	FERN NAMES USED IN GRAY'S MANUAL, SIXTH EDITION.
Polypodium Phegopteris L. (2, 3, 4).[*]	Phegopteris polypodioides Fee.
Polypodium hexagonopterum Michx. (2, 3, 4).	Phegopteris hexagonoptera Fee.
Polypodium Dryopteris L. (2, 3, 4).	Phegopteris Dryopteris Fee.
Struthiopteris Germanica Willd. (2, 3, 4, 5).	Onoclea Struthiopteris Hoffm.
Allosorus gracilis Presl. (2, 3, 4).	Pellaea gracilis Hook.
Pteris atropurpurea L.[†]	Pellaea atropurpurea Link.
Scolopendrium officinarum Smith (2, 3, 4).	Scolopendrium vulgare Smith.
Dicksonia punctilobula Hook. (2, 3, 4, 5).	Dicksonia pilosiuscula Willd.
Dryopteris Thelypteris [A. Gray].	Aspidium Thelypteris Swartz.
Dryopteris Noveboracensis [A. Gray].	Aspidium Noveboracense Swartz.
Dryopteris intermedia [A. Gray].	Aspidium spinulosum intermedium D. C. Eaton.
Dryopteris dilatata [A. Gray].	Aspidium spinulosum dilatatum D. C. Eaton.
Dryopteris rigida [A. Gray].	Aspidium Boottii Tuckerm.
Dryopteris cristata [A. Gray].	Aspidium cristatum Swartz.
Dryopteris Goldiana [A. Gray].	Aspidium Goldianum Hook.
Polystichum aculeatum Roth.	Aspidium aculeatum Braunii Koch.
Polystichum acrostichoides Schott.	Aspidium acrostichoides Swartz.
Polystichum Lonchitis Roth.	Aspidium Lonchitis Swartz.
Osmunda spectabilis Willd. (2, 3, 4).	Osmunda regalis L.
Botrychium lunarioides Swartz (2, 3, 4, 5).	Botrychium ternatum Swartz.
Botrychium Virginicum Swartz (2, 3, 4, 5).	Botrychium Virginianum Swartz.

---

[*] These numbers indicate the successive editions in which this same form appeared.

[†] This passed through the intermediate stage of Allosorus atropurpureus [A. Gray] before reaching its final form.

Or in other words, out of the fifty species of ferns from the northeastern states described in the first edition of Gray's *Manual*, 21, or 42 per cent., bore different names in the last issue of the same work, and more than that, eight of these suffered a change in the specific name also, not including those whose relative rank was changed from variety to species or *vice versa*. Surely the trans-Carlines will have to admit that this exceeds the 25 per cent. which Mr. Fernald cites as such a horrible example. But after all, what matters it if 99 per cent. are changed so long as the change is an evolution towards a more stable system based on principles less unseaworthy than the personal preference hit-or-miss system of Kew and Berlin?

LUCIEN M. UNDERWOOD.

NEWS.

MR. B. E. FERNOW, Director of the New York State School of Forestry, Cornell University, will give a course of lectures on forestry at The University of Chicago during the summer quarter.

DR. ROSCOE POUND, whose studies on the phytogeography of Nebraska have made him well known as a botanist, has been appointed a member of the new Supreme Court Commission, which is to assist the Supreme Court of Nebraska to clear up its docket. The work of the court is far in arrears, and the commissioners are *de facto* justices. Dr. Pound is winning laurels in his vocation as well as in his avocation.

MR. EDWARD F. BIGELOW, the editor of the Nature and Science department of *St. Nicholas*, has had prepared compressed tablets after Sachs' formula for making nutrient solution. Two of the tablets make a pint of the solution of usual strength. Two forms are made, those with and without ferric chlorid. The tablets are exceedingly convenient. Doubtless they can be purchased through Mr. Bigelow.

THE DEATH of J. G. Agardh on January 17, in his 88th year, removed a notable student of marine algae. His first paper on marine algae was published in 1836, and his last paper has just come to the writer's desk, not all the proof of which did the author live to read. His greatest work is the *Species Genera et Ordines Algarum*, and to this his last paper was a supplement. A brief résumé of his work appears in the *Journal of Botany* for April. His great collection, full of types, passes under the immediate control of the University of Lund.

THE following circular letter has been sent to many botanists in this country. As the committee find it difficult to ascertain the addresses of American botanists they desire that all botanists who may see this notice send their application for membership in the proposed association to DR. J. P. LOTSY, *Wageningen, Holland*, by postal card, even though they may not receive a copy of the circular:

> The undersigned, convinced that a better organization of the botanists of the different countries would contribute in a most desirable manner to our mutual aim, viz., the progress of botany, have the honor to invite you to become a member of a new society to be called the *International Botanical Association.*
>
> A general meeting will take place at Geneva, Switzerland, on the 7th of August next in the botanical laboratory of the university at 10 A. M.

During this meeting several questions will be submitted to the judgment of its members, and you are invited to propose orally or in writing such measures as you think it desirable that the new society should adopt.

The chief object of the association will be the establishment of a bibliographic periodical abstracting in a perfectly impartial manner all botanical publications in such a way that the important will be separated from the less so.

It will not — as some periodicals do — devote page after page to publications of questionable value, while most important works are put off with two or three lines or even not mentioned at all.

The abstracts will — at the desire of the contributors — be published in English, French, or German. All will be submitted to the judgment of an editor nominated by the association and responsible to it.

It is most desirable that the membership be as wide as possible, since this is the only way of making membership inexpensive. Under no circumstances will the membership cost more than $6, including the free delivery of the periodical.

We wish to call your attention to another great advantage of the new society; by its means members who live in different parts of the globe will be brought into more intimate contact one with another and this will greatly facilitate the procuring of material for investigation and demonstration.

Under certain conditions to be discussed, accepted, or rejected at the general meeting in Geneva, Switzerland, the proprietors of the *Botanisches Centralblatt* have consented that their journal become the property of the association.

The call is signed by Bornet, Borzi, Bower, Celakovsky, Chodat, Fairchild, Farlow, Goebel, Lotsy, Nawaschin, Raciborski, Rauwenhoff, Schimper, Stahl, Warming, and v. Wettstein.


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Surgeon-in-Chief, Battle Creek Sanitarium.

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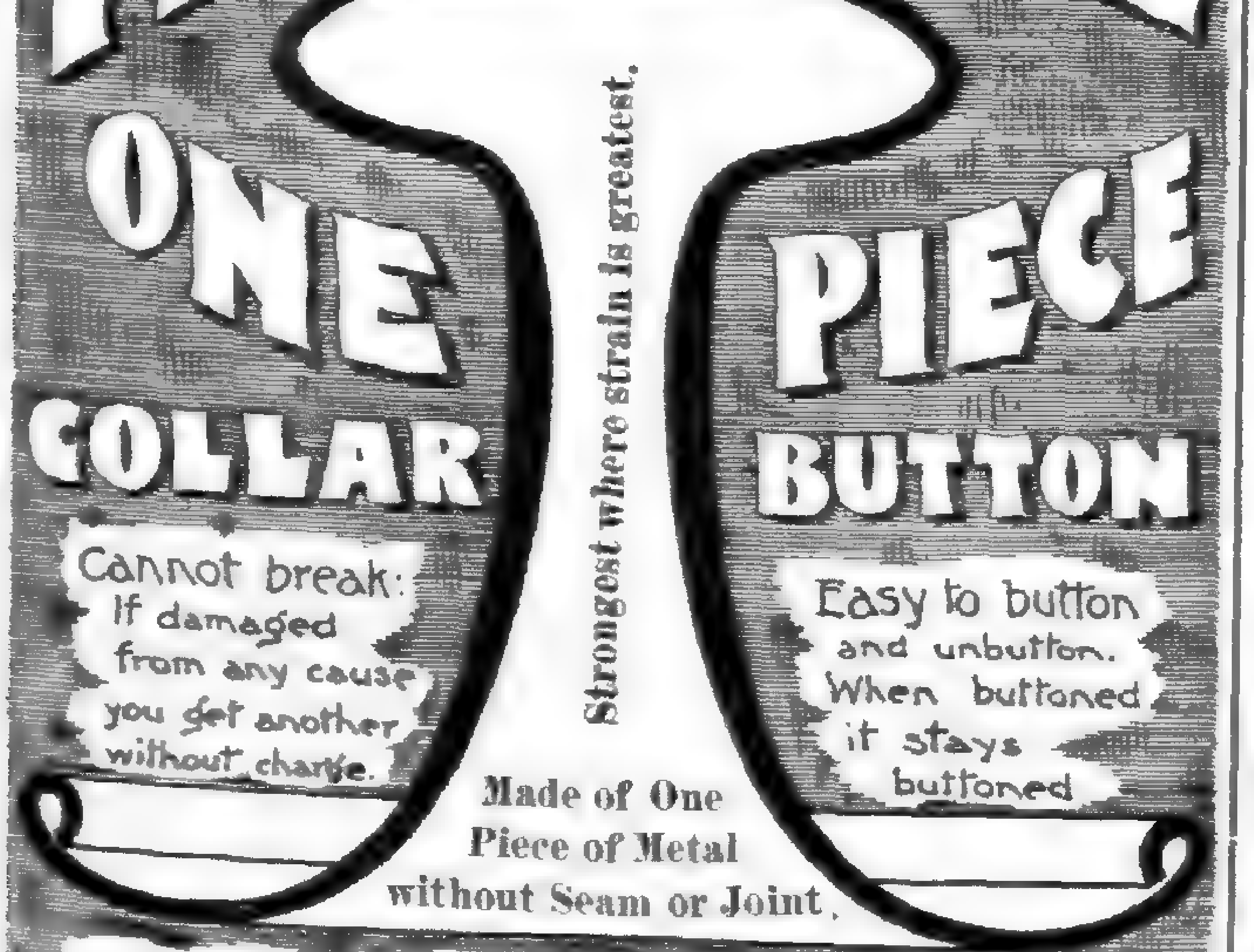

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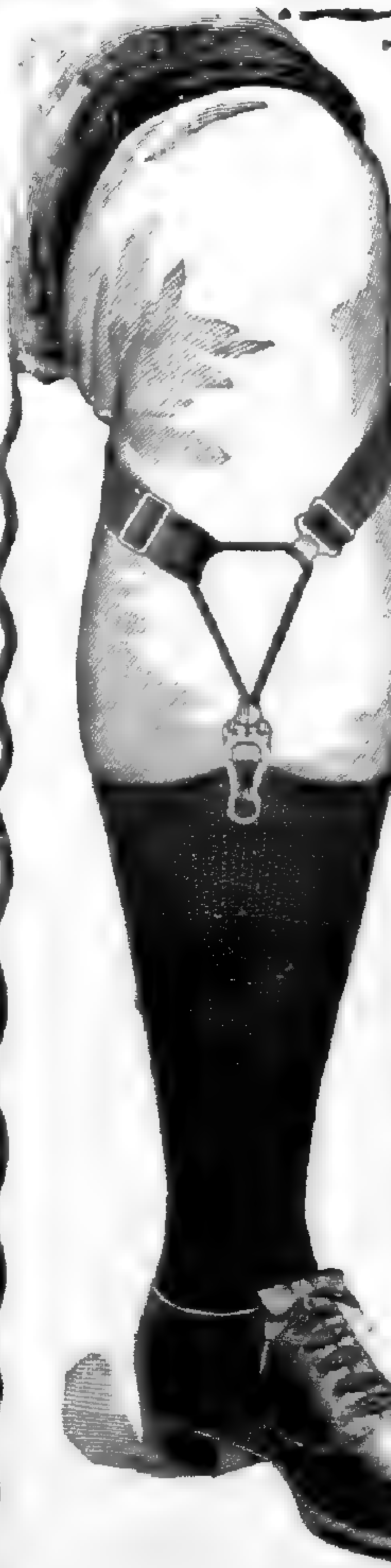

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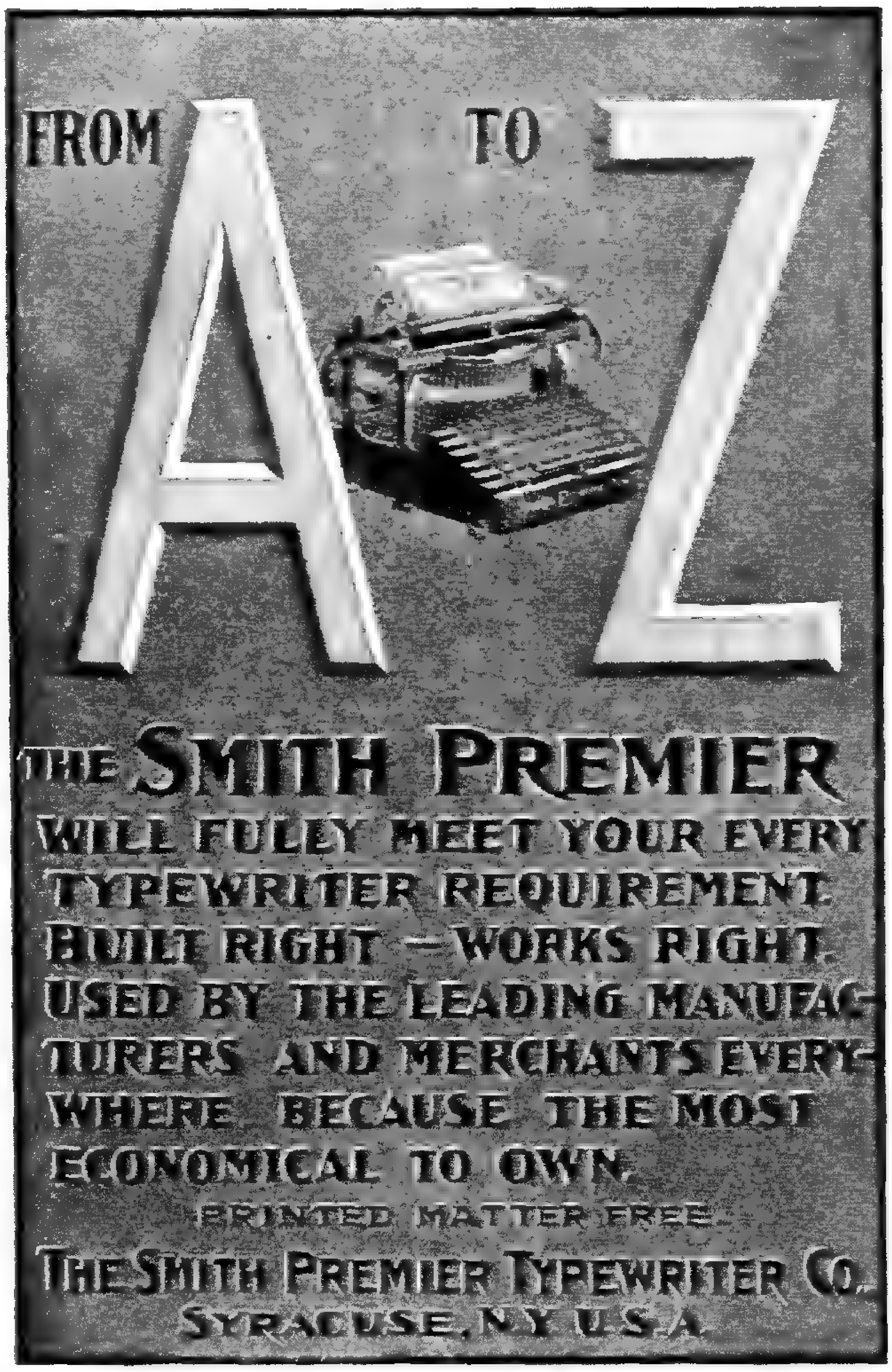

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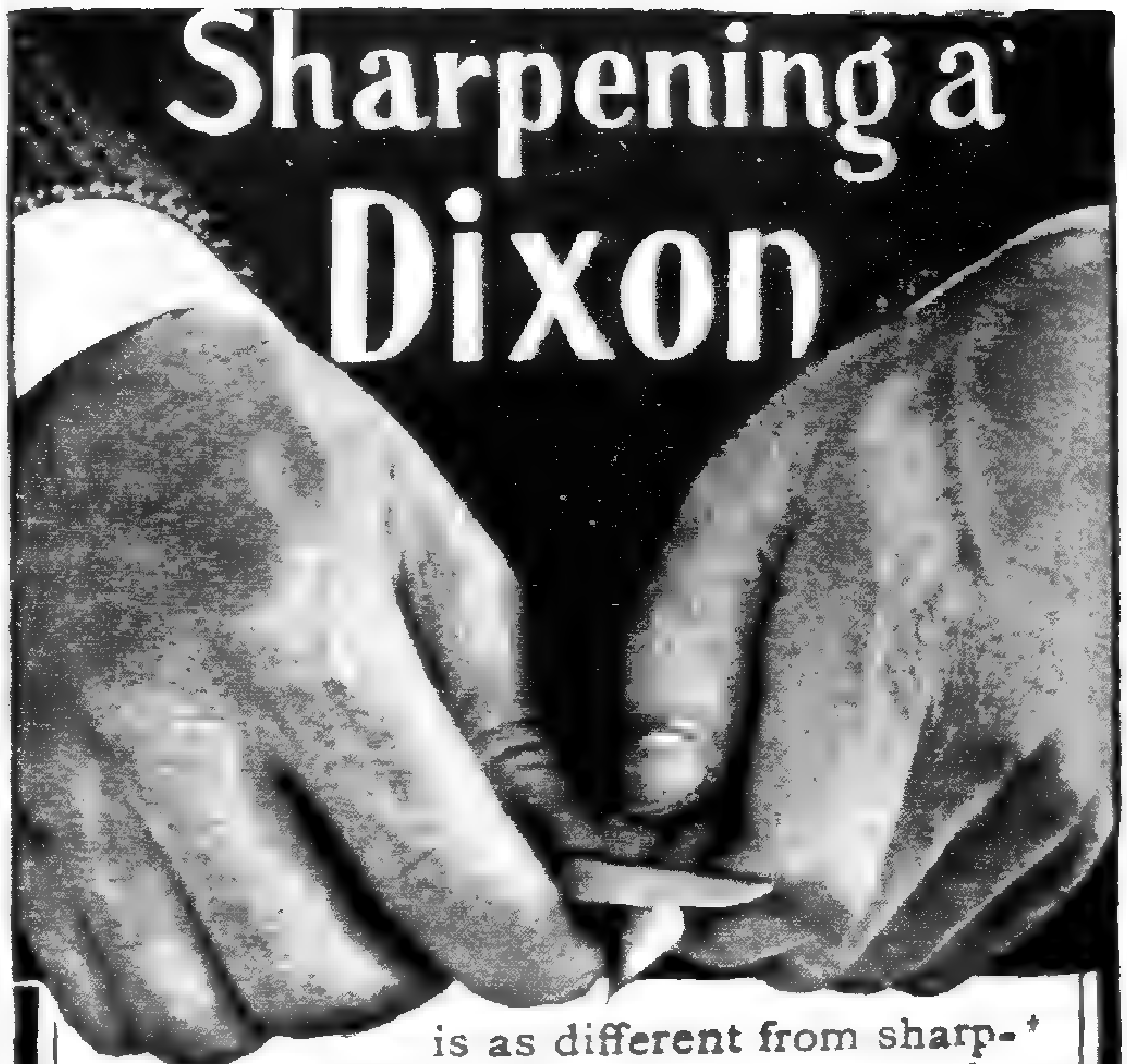

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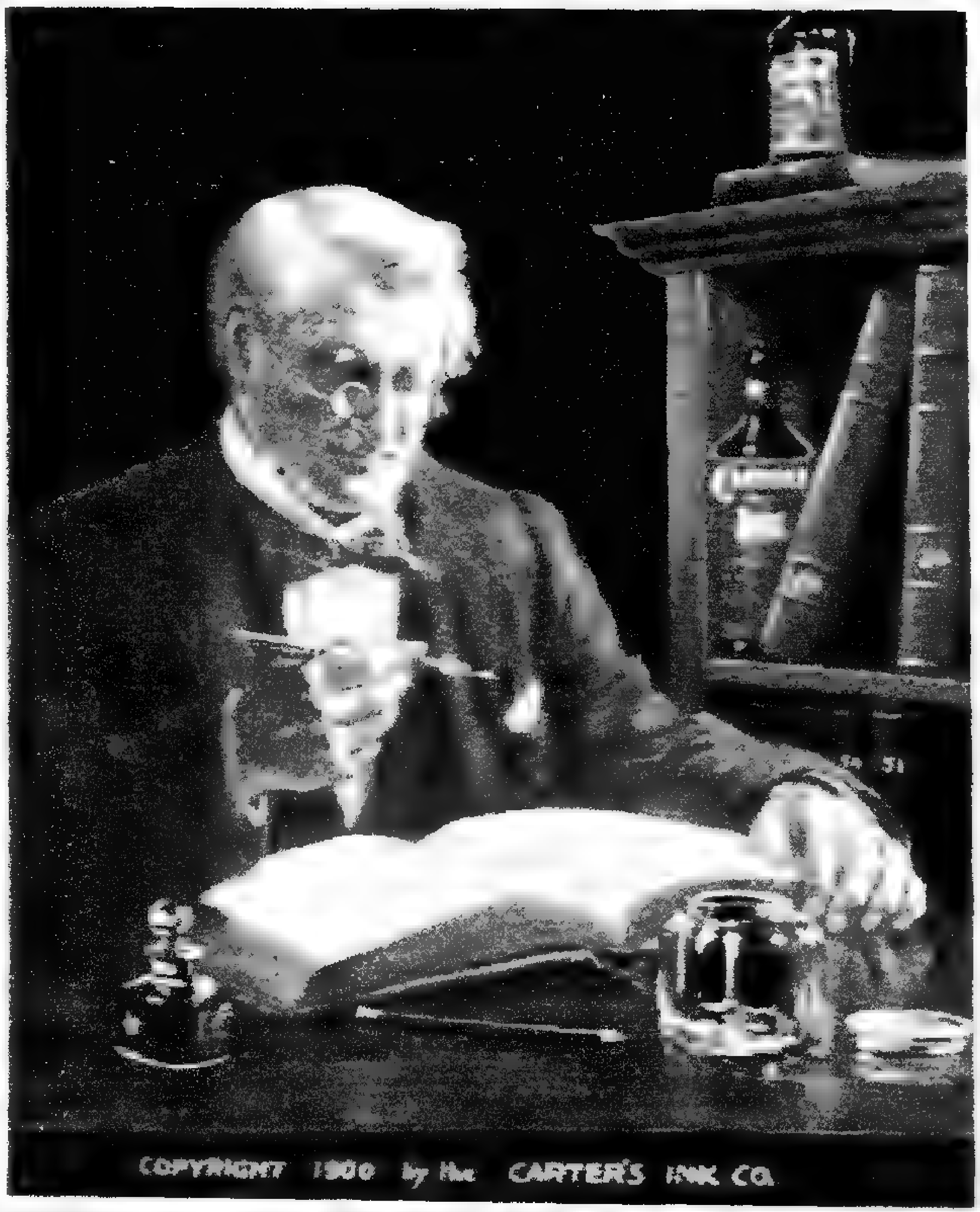

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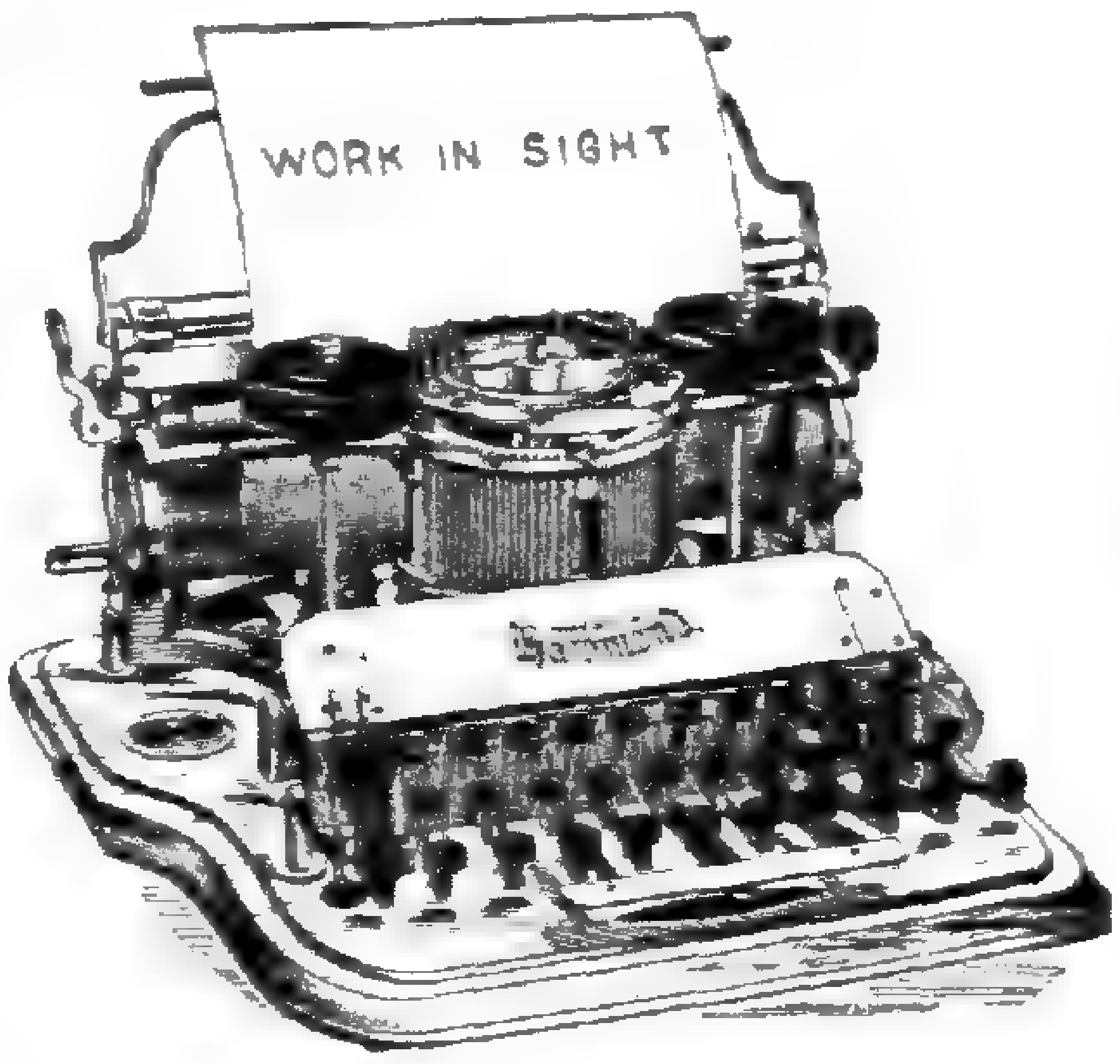

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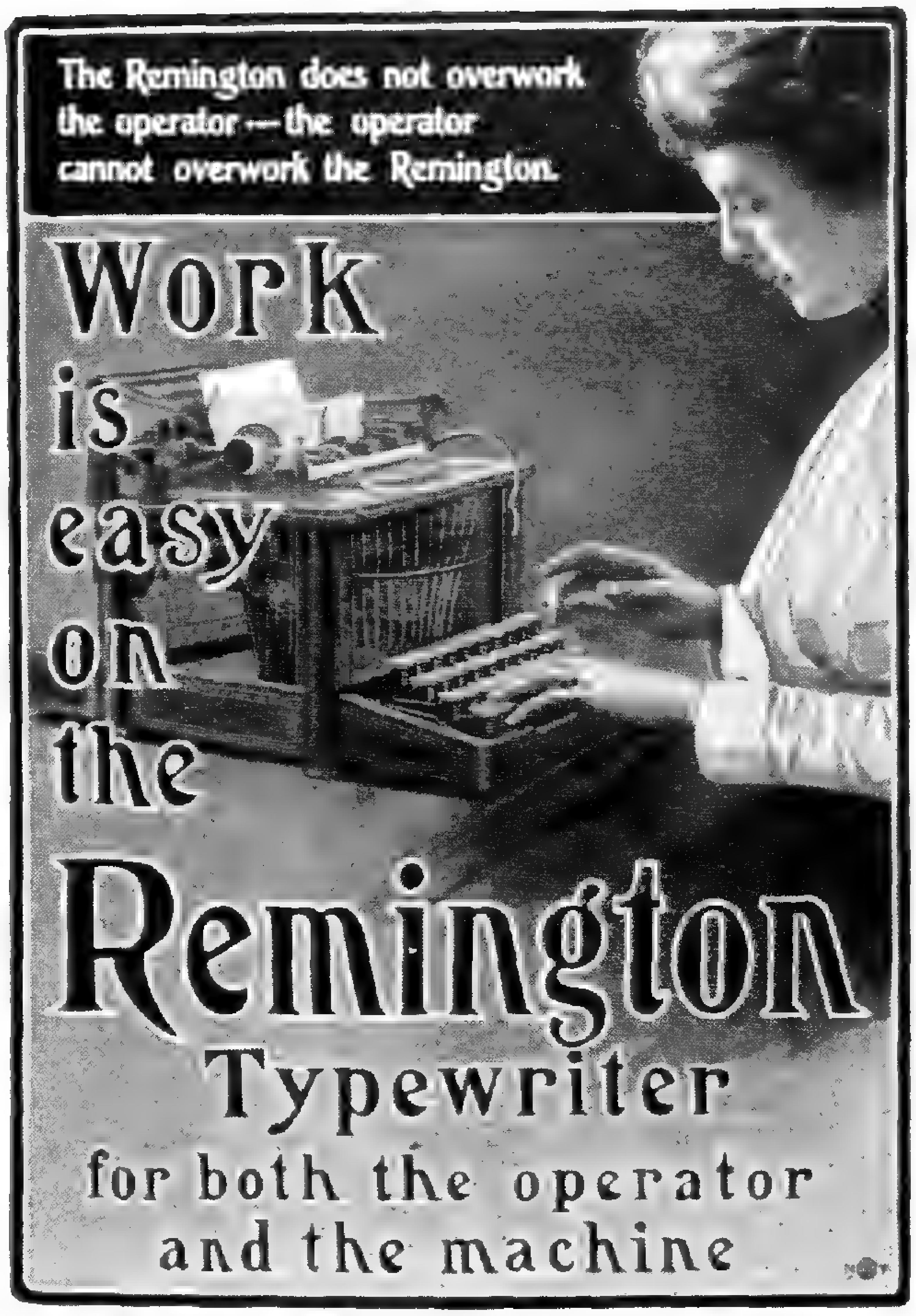

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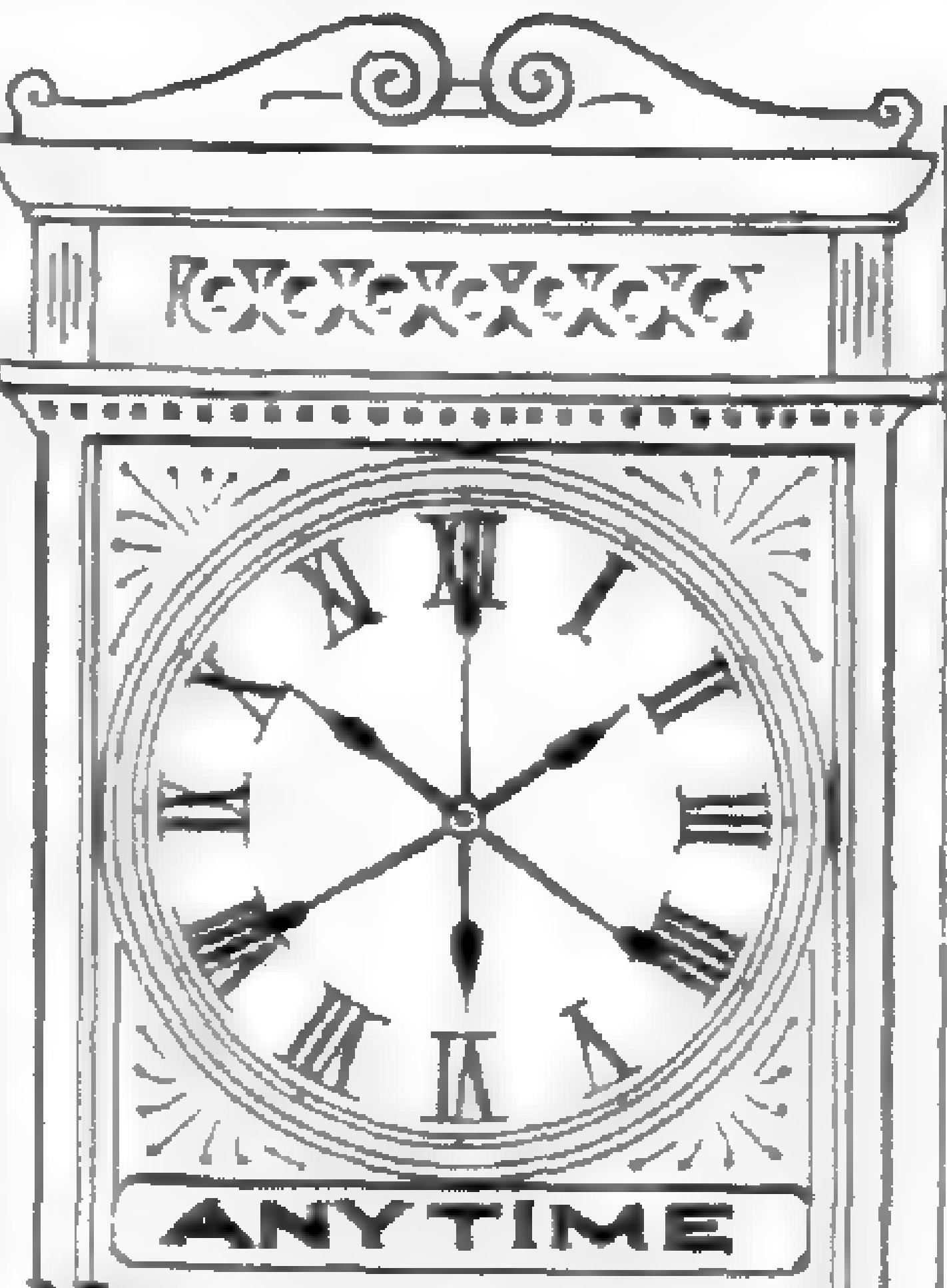

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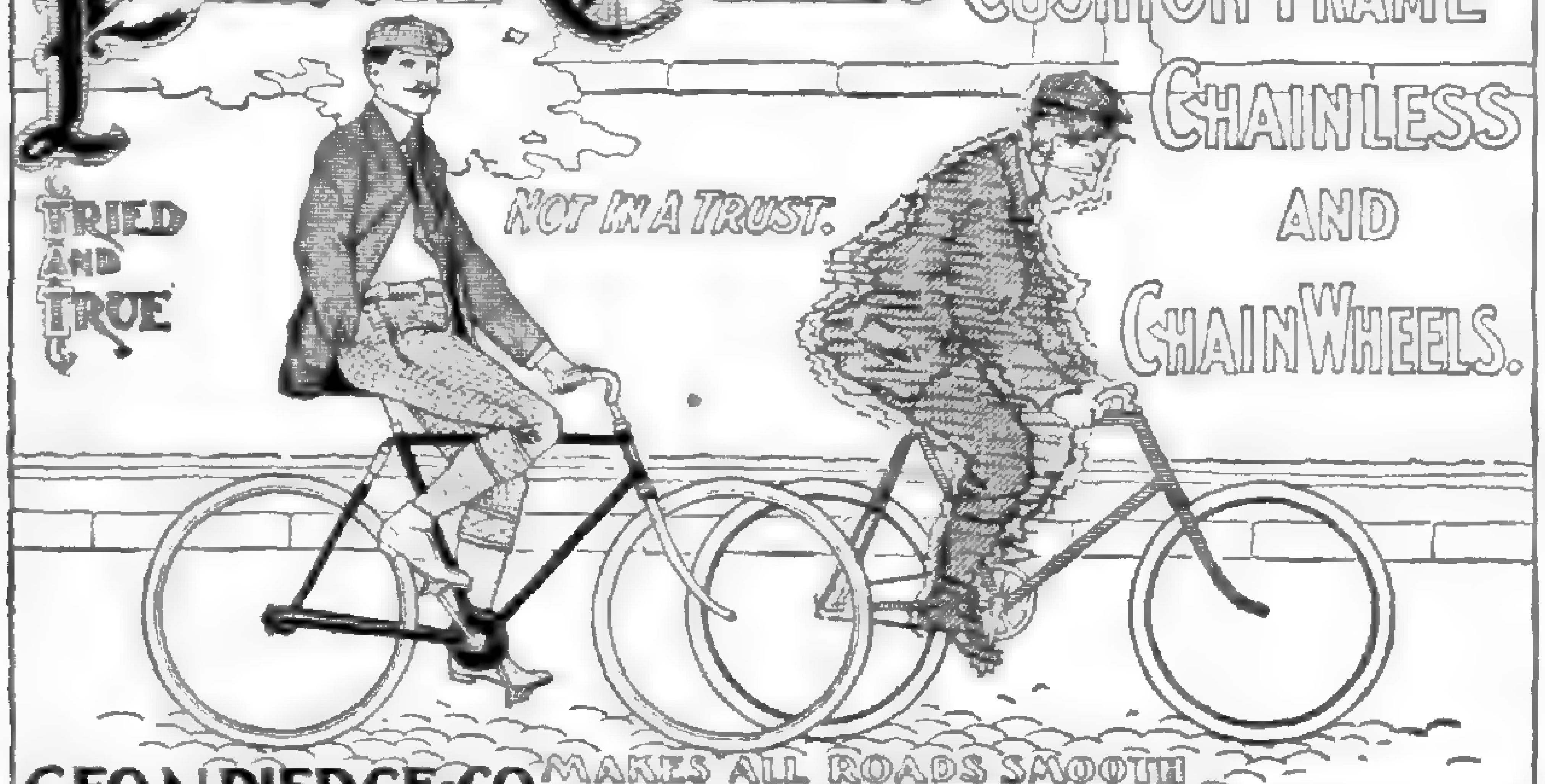
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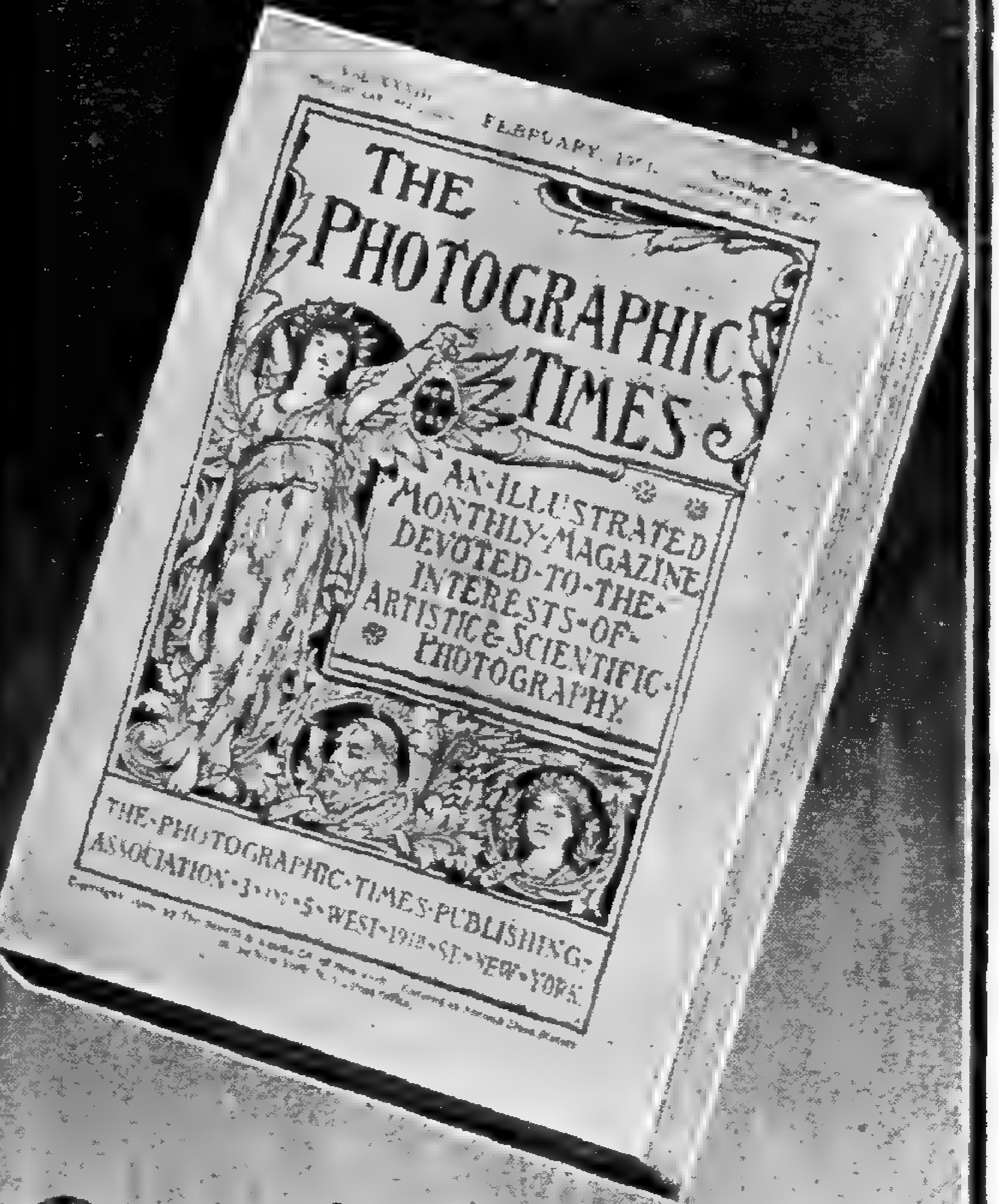

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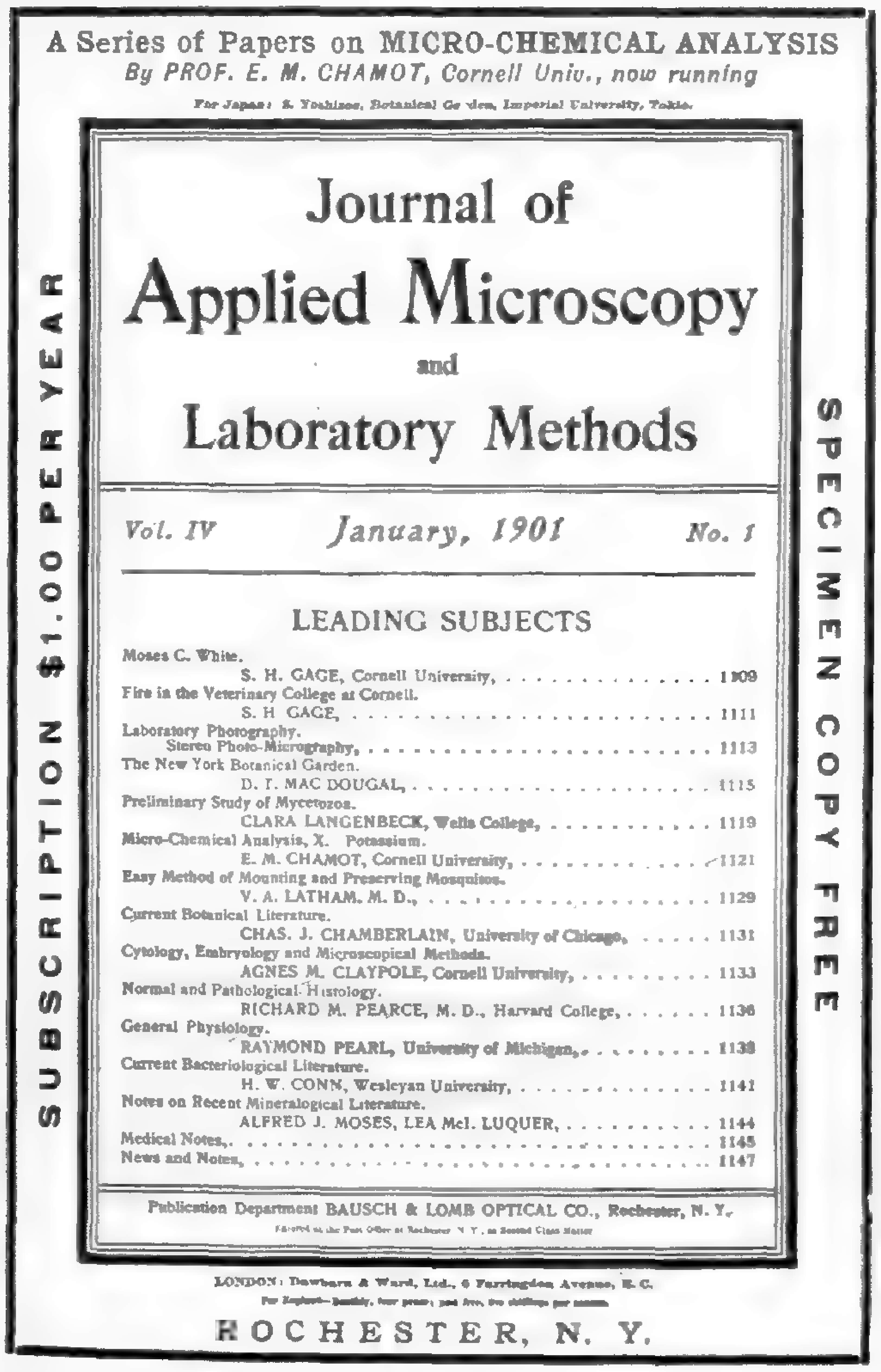

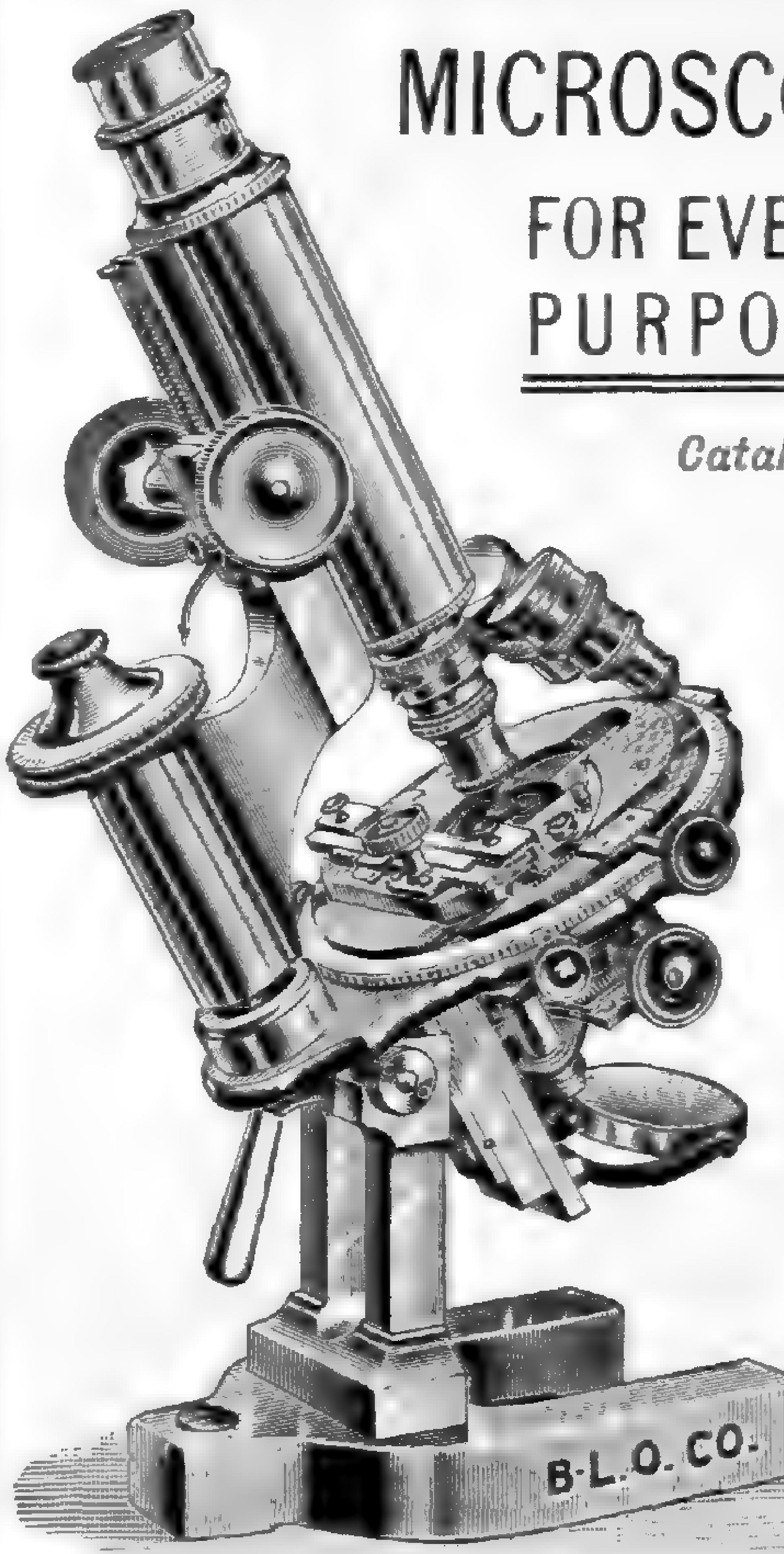

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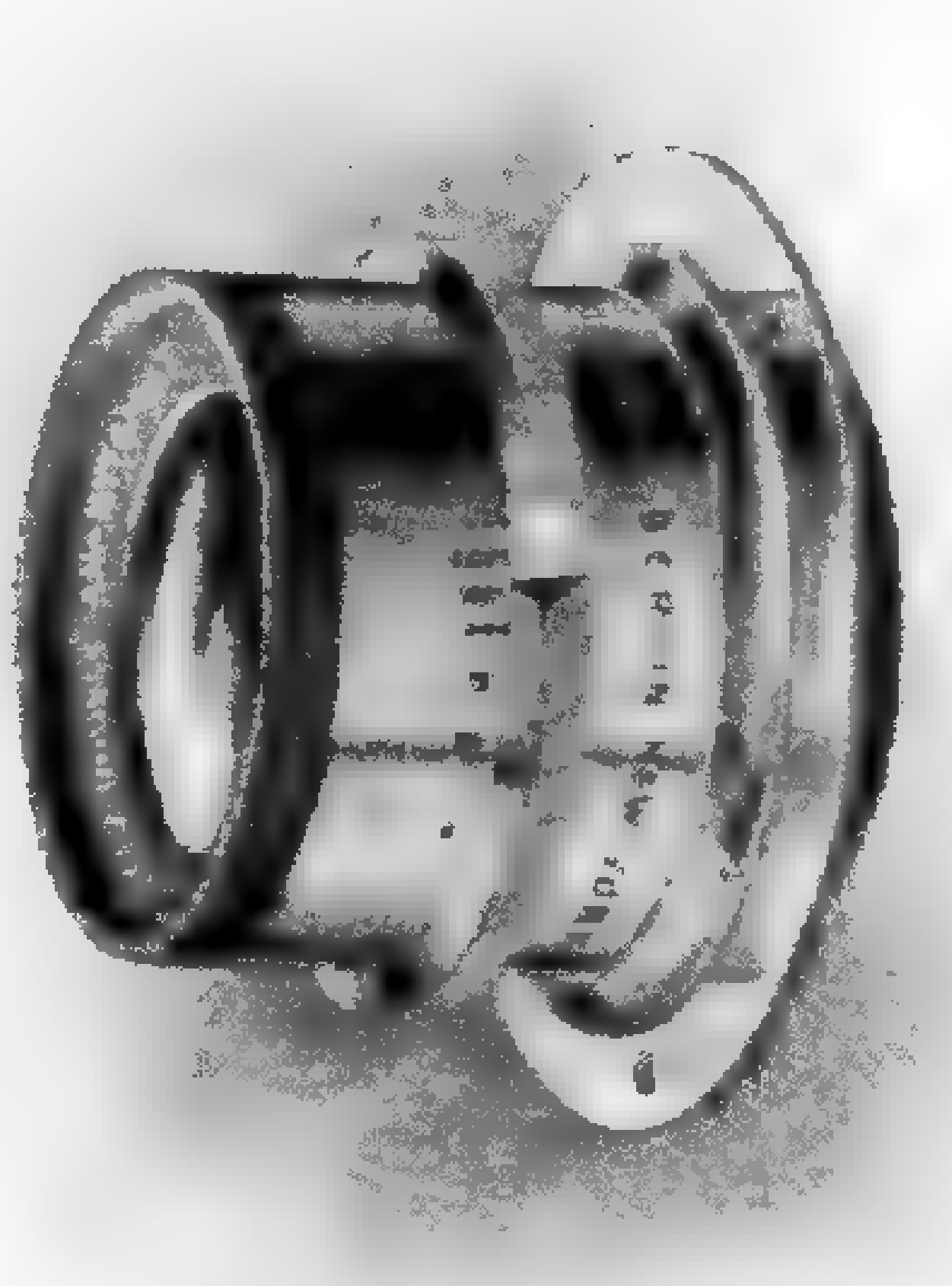

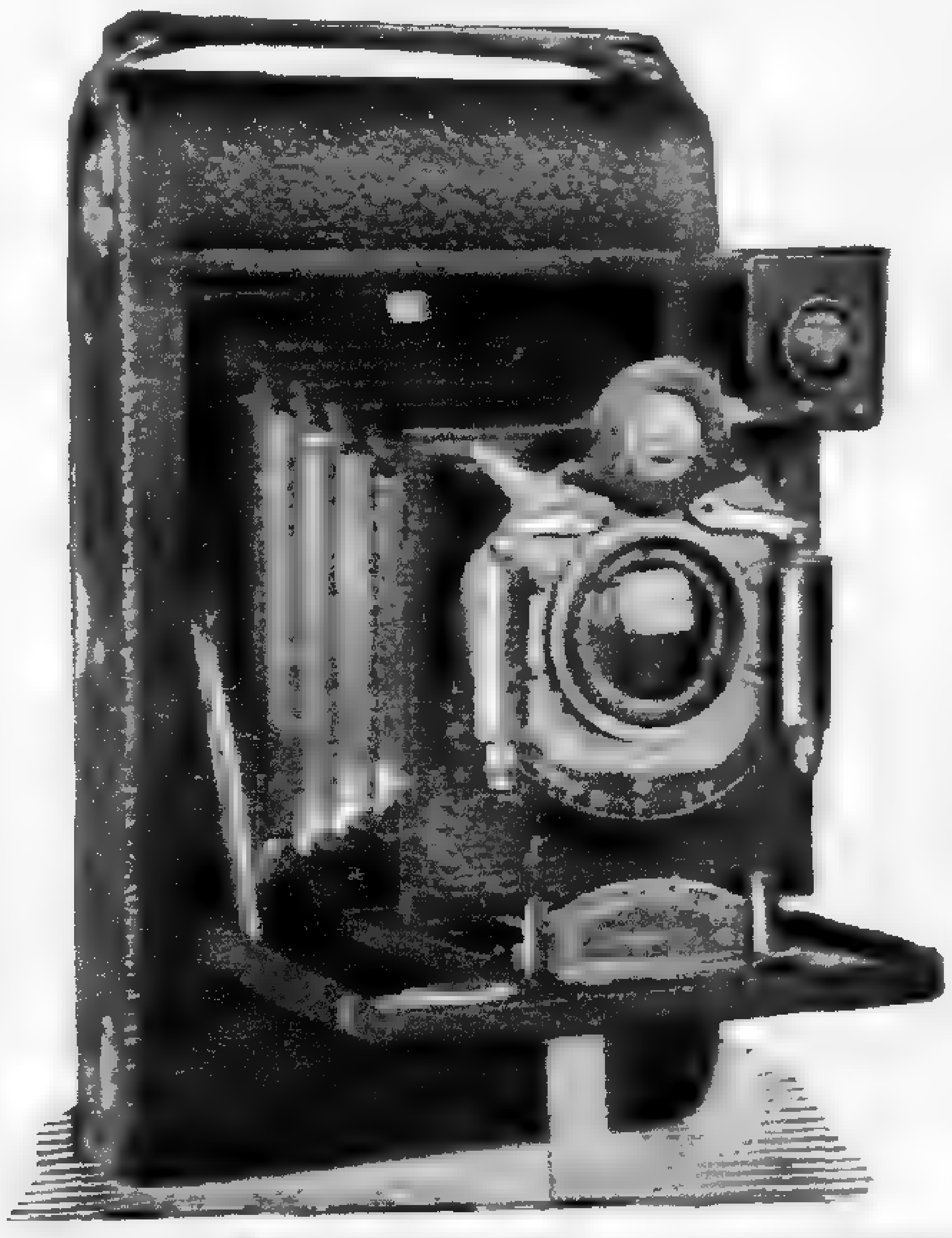


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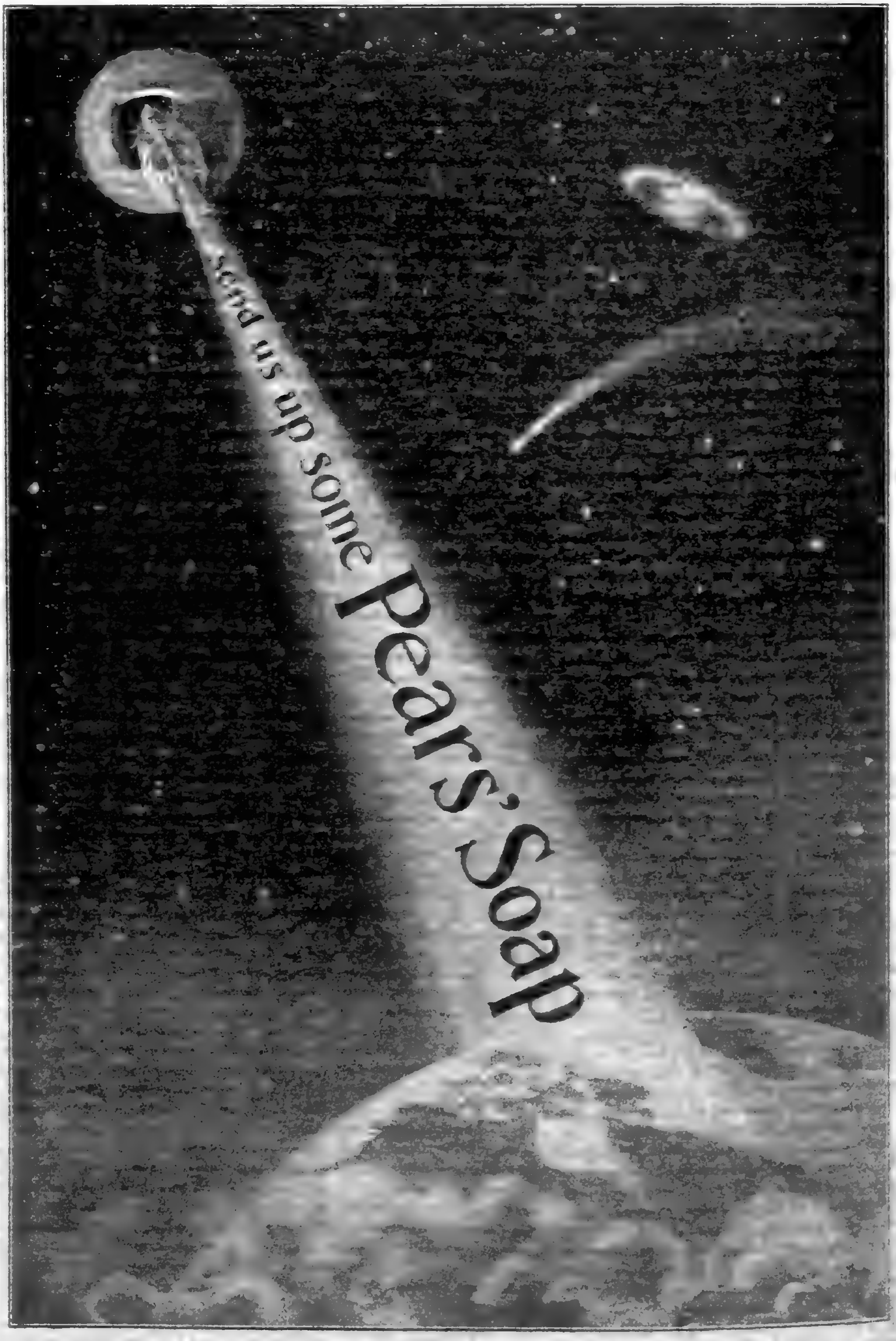

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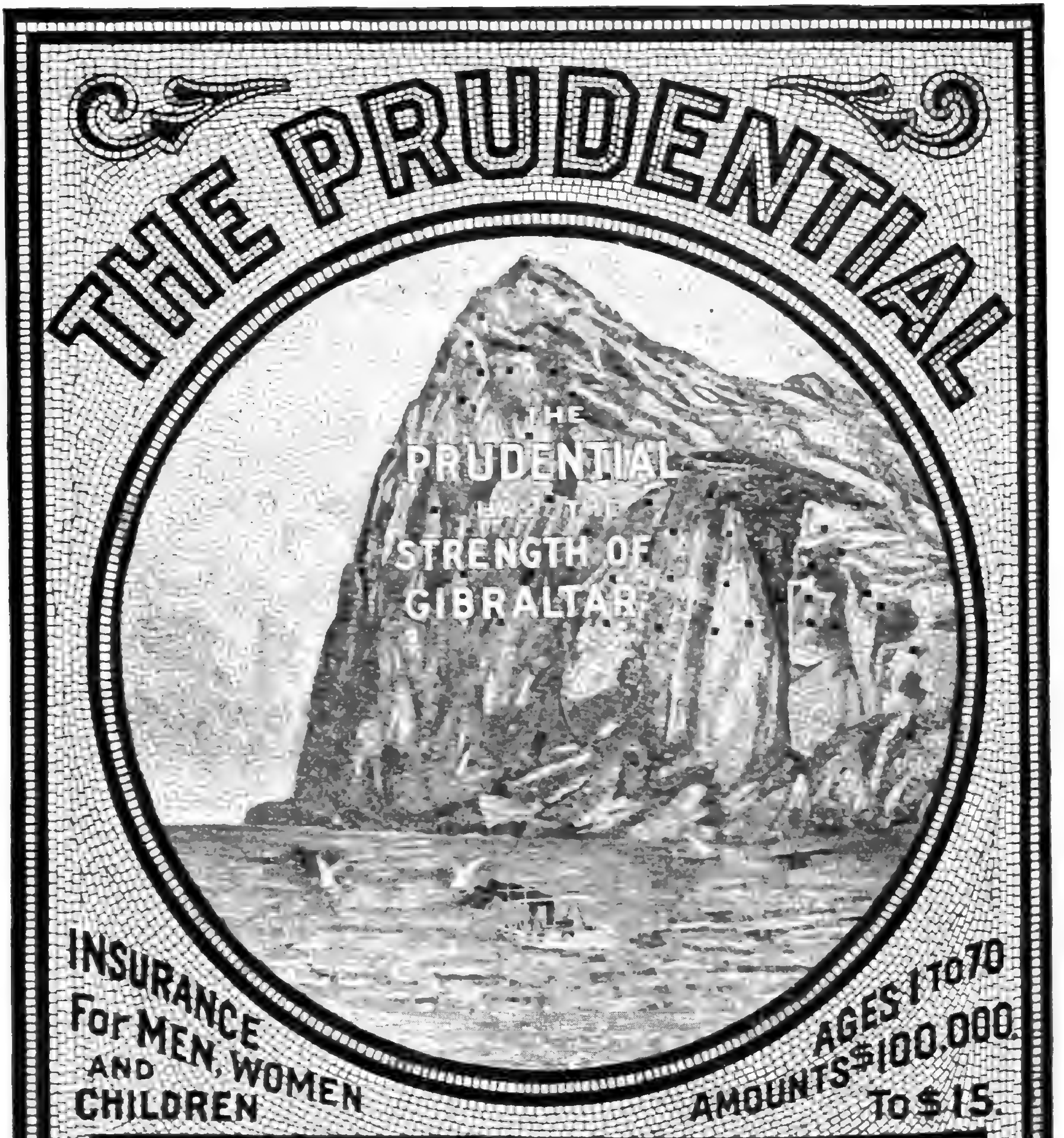
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BOTANICAL GAZETTE

JUNE, 1901

A CONTRIBUTION TO THE LIFE HISTORY AND CYTOLOGY OF ERYTHRONIUM.

CONTRIBUTIONS FROM THE BOTANICAL LABORATORY, OHIO STATE UNIVERSITY. VIII.

JOHN H. SCHAFFNER.

(WITH PLATES IV–IX)

SEVERAL years ago, while studying at the University of Chicago, the writer made a special investigation of the reduction nucleus in the ovule of *Lilium Philadelphicum*, maintaining that a true reducing division occurs in this plant (**29**). Immediately after the completion of the investigation, search was made for another plant in which to continue the study of reduction, together with other points of interest in the life history. The type finally selected was Erythronium, and both *E. albidum* and *E. Americanum* have been studied. The work was carried on for some time at the University of Chicago, and has been continued for the past three years at the Ohio State University. The material was collected mainly near Chicago and in the vicinity of Columbus, but some was also obtained from Kansas. It is exceedingly difficult to procure the earlier stages of the flower, since bulbs with flower buds are very rare when compared with the numerous younger sterile ones.

The usual methods of killing and staining were used; the killing fluids being chrom-acetic acid and Flemming's weaker fluid; and the stains anilin-safranin and gentian-violet, Heidenhain's iron-alum-hæmatoxylin, Delafield's hæmatoxylin, and anilin-safranin and picro-nigrosin. The sections were mostly cut 10, 12, and 18μ, and stained on the slide.

GENERAL CHARACTERS.

The deeply buried bulbs begin to develop the incept of the flower early in the summer. By the first of September the incipient flower bud is considerably advanced, and the carpels are developing the ovules. Usually before the first of October the single hypodermal archesporial cell can be distinguished, and the integuments are just beginning to make their appearance. The anther wall shows five layers and the pollen mother cells are enlarging. By December first the tetrads are formed, but separation of the four microspores may be delayed for some time later in certain flowers. The cells of the anther are filled with starch grains and the tapetum is still active, some of its nuclei being in stages of direct division. At this time there is no sign of the division of the nucleus of the microspore, but the exine of the wall is developing. The nucleus divides some time between December 1 and April 1, but the time was not ascertained. In the meantime, the archesporial cell in the ovule has been increasing in size and activity, and has formed the continuous spirem from the chromatin network. In this condition it passes the winter. The cell in which the reduction takes place, therefore, has a period of development extending over six months. In some years it cannot be much less than eight months. It will also be observed that while the reduction division in the anther takes place in the fall, in the ovule it is delayed until early spring.

The flowers are growing rapidly long before the frost is entirely out of the ground, and during this time the divisions in the embryo sac occur, so that when the flowers come out of the ground the divisions are usually completed.

Very few flowers appear to develop ovules of any size, and ripe seed is very scarce. In fact I have seen very little during the past three years. Propagation is effected largely by means of the multiplication of the bulbs. About the first of June, at

Columbus, most of the leaves have wilted away. The plant, therefore, is rarely much more than two months above ground.

Erythronium is an ideal example of the retreating bulb. The retreating stems are axillary buds which are carried downward by growth and division of the cells above and beside the apex of the bud. *Fig. 1* is a section of such a young bulb, and the dotted region shows where active cell division is going on. The development of these offsets has been described several times recently, so that it is unnecessary to refer to the subject further.

The deep burrowing is probably not only to place the plant in deep soil, but also to keep the flower protected in the warm earth during winter. The advantage of retreat for nine or ten months underground must be decided, and the causes for the habit complex. The leaves come out before there is any danger of shading from other plants, and before the leaves of the higher stratum of trees shut out the light. The plant is thus well adapted to forest conditions.

KARYOKINESIS IN THE BULB.

The division stages in the bulb were studied in order to trace out the development of the spindle. The resting nuclei usually have a rather dense chromatin network with numerous nucleoli imbedded in cavities (*fig. 2*). Often the nucleoli take on fantastic shapes, probably due to budding and division. Some of these are shown in *fig. 3, a, b, c*, etc. Farther up, beyond the division region, the nuclei elongate in the cells of the developing vascular bundles. After the continuous spirem begins to form, two caps of fibers appear on opposite sides of the nucleus, which are the incepts of the future spindle. These are dome-shaped or cone-shaped in appearance, and often end in definite granules around which there is sometimes a system of radiations (*fig. 5*). Similar incipient spindles, but farther advanced, are shown in *figs. 6, 7*, and *8*. In *fig. 7* the chromatin granules are plainly visible in the spirem, forming a single chain. *Fig. 9* represents a loose mother skein some time before the formation of the mother star. The spindle at this stage is sharply pointed and ends in small centrosomes. After the daughter star stage there are sometimes two bodies at each pole, which may represent divided centrosomes (*fig. 10*). The cells of the bulb are often packed with starch. In some cases the starch is so abundant that the spindles are very much crowded by it (*figs. 11, 12*). It will be seen from an examination of the figures that the development of the spindle proceeds as in the roots of Allium (**30**) and Pinus (**12**). It is never multipolar. This seems to be the normal course of division in vegetative cells, and represents the way in which the spindle is developed during the normal quantitative karyokinesis in the higher plants.

Some time after the appearance of the *Cytologische Studien*, Němec, studying in the Bonn laboratory, announced that in vegetative cells the spindle is bipolar from the beginning. It is doubtful, however, whether the classification he made of bipolar and polycentric spindles will be found to hold good in general.

THE MALE GAMETOPHYTE.

The nucleus of the microspore probably divides early in the spring, for the pollen grain is well developed before the frost has left the ground. The tube nucleus takes a very light stain and is comparatively small, while the generative nucleus is large and is surrounded by dense-staining cytoplasm which is organized into a cell amoeboid in form (*figs. 16–18*). These generative cells are very striking in appearance. They can hardly have a cellulose wall because of the peculiar shapes they assume. The dense coat of cytoplasm is very different from that of Sagittaria and Alisma, where there is very little cytoplasm, and it is difficult to see anything but the nucleus.

Fig. 19 shows a germinated pollen grain on the stigma. The tube nucleus and generative cell are still side by side in the body of the grain, but are evidently preparing to pass into the tube. In the tip of the tube there is some dark-staining material which becomes very abundant as the tube elongates, forming dark masses or plugs (*fig. 20*). The tips of tubes in very favorable preparations showed no definite nuclei (*fig. 21*). They must be farther up among the masses of dark-staining material and are thus difficult to identify.

In the liliaceous types the division of the generative nucleus takes place in the tube; in many Helobiae and some other monocotyledons, in the grain before it is shed. In Typha the generative nucleus does not divide in the grain, while in Silphium (**22**), one of the highest types, the division is in the grain and the sperm cells are elongated and even coiled like spermatozoids. Such elongated sperm cells are also common in Alisma. It appears, therefore, that progressive reduction of the male gametophyte has not been uniform in the various lines of angiosperms. Search was made for the division of the tube nucleus, as is common in certain species of Lilium (**8**) and Hemerocallis (**13**), but nothing was found. Such a division probably never occurs in Erythronium.

The style has a large continuous canal, from the stigma to the cavities of the ovulary, for the conduction of the pollen tube. This canal is lined by a layer of glandular cells for the nourishment of the tubes (*figs. 13, 14*). The pollen tube does not grow through any tissue until after it passes into the micropyle. It is not difficult to see how such an angiosperm could develop from a gymnospermous condition.

THE DEVELOPMENT OF THE MEGASPORANGIUM AND THE REDUCTION DIVISION.

As stated before, the archesporial cell begins to enlarge about the first of October, and by December first the chromatin network is very distinct and is being transformed into the continuous spirem (*figs. 22–24*). In the following stages the nucleus becomes very large, and the same is true of the chromosomes. This makes Erythronium a favorable subject for the study of these structures. After December the nucleus probably goes into a partial state of rest until early in the spring, at which time development and division continue. During this period it will be convenient to call the cell a megaspore. The spirem is at first very long and slender and the chromatin granules are never so prominent as in *Lilium Philadelphicum* (*figs. 25–25a*). In *L. Philadelphicum* the chromatin granules divide and the chromatin band undergoes longitudinal splitting before much shortening and looping take place, but in Erythronium the division of the granules seems to be somewhat later, and they do not appear double until the band has twisted into the twelve loops (*figs. 26, 27, 28, 37*). The granules are large and more or less irregular in shape. A little later the chromosomes appear homogeneous throughout. This would certainly give support to the belief that the division of the chromatin granules is a mechanical contrivance for bringing about the longitudinal division of the linin band, although this might not at all interfere with their supposed function as bearers of hereditary tendencies.

The breaking apart of the twelve loops to form the twelve individual chromosomes (*fig. 29*) appears to be accomplished by the twisting and contracting movements of the band. The chromosomes are usually of various sizes, some being much larger than others. They often appear as single coiled loops (*figs. 37, 38*), but usually their double nature can be readily observed. The chromatin loops are not so closely coiled as in *Lilium Philadelphicum*, and when they are arranged in the mother star the twisted condition can still be distinguished. The chromosomes appear to be attached to the spindle threads near the two free ends of the loop, the closed end extending outward (see *figs. 39–48*, chromosomes before division, and *figs. 49–57*, chromosomes after division). During metakinesis the loops are uncoiled, and the two free ends are gradually pulled apart until each chromosome breaks in the middle, thus accomplishing a transverse division, one end of the original chromatin loop going to the one pole, and the other to the opposite one. This would be a true reducing division. It is exceedingly difficult to follow out the course of events at this point, and there is always room for doubt as to correct interpretation. There is a possibility that the loops are attached at the closed ends. However, some of the examples are quite convincing, and another than a transverse division seems out of the question (see especially *figs. 46* and *47*, also compare the undivided chromosome, *fig. 44*, with a chromosome in the daughter star, *fig. 57*). There is not a single example which will not agree with the supposition of a transverse division, while many of the figures could not be explained on the supposition of a longitudinal one. And while it may perhaps be granted that a transverse division has not been absolutely established, it may be said that there is much less evidence in favor of a longitudinal one. In the next division the chromosomes are V-shaped and the longitudinal splittings perfectly apparent (*figs. 69, 70*).

Although there is no way known to the writer of tracing the origin of the reduction chromosomes in this nucleus to two previous ones, theoretically one might consider it possible that the reduction chromosome represents two normal chromosomes, and the closed loop the point where the usual transverse break should have taken place. Were this the case, the points of attachment of the spindle fibers at or near the two free ends would represent the heads of the two simple chromosomes, and the break at the head of the loop during metakinesis simply the delayed division bringing about the usual number of pieces. But such a process would necessarily result in a qualitative division.

The process here described is essentially the same as that reported for *Lilium Philadelphicum*, and the interpretation is similar, since it appears to the writer, after a long and careful study of the objects, that no other interpretation seems possible.

On account of the contradictory character of the investigations so far published, it appears that one or the other set of observations has been wrongly interpreted, or else there is more variation in the phenomenon of chromatin reduction than is generally supposed. There may not be so much uniformity in the manner in which reduction is brought about as our present ideas in regard to the nature of chromatin seem to demand; and once the hypothesis is accepted that the chromatin organs are not the only bearers of heredity, there is no reason why a large amount of variation should not be present. There is still room for entirely new hypotheses, and care should be taken lest newer and perhaps better suppositions be rejected by the too common appeal to authority.

Shortly before the publication of my paper on Lilium, but not until the investigation had been completed, articles on the subject of reduction were published by Calkins (**6**), Mottier (**23**), and Strasburger (**34**). Each of these authors presented evidence favorable to the hypothesis that a transverse splitting of the chromosomes occurs during the reducing divisions of the plants studied. Miss Sargant (**27**) had also published a paper somewhat earlier, in which some facts were presented favorable to the supposition of a transverse division. Calkins, however, seems to be the only one of these investigators who has not reversed his published opinion. More recently Belajeff (**2**) has asserted the transverse division, while Stevens (**32**) holds that in the ferns studied by him both divisions which go to form the spore tetrad are longitudinal. Guignard (**14**) has lately also published articles on the subject, maintaining that there is only a longitudinal division. Atkinson (**1**) has published the results of his investigation of sporogenesis in the anthers of *Arisaema triphyllum* and *Trillium grandiflorum*. In the case of Arisaema he states that a qualitative division takes place in the first division, while in Trillium it occurs in the second. Duggar (**11**) also believes that a transverse division occurs in the first division in *Symplocarpus fœtidus*. In studying the development of the microspores of *Convallaria majalis* and *Potomogeton foliosus*, Wiegand (**35**) was unable to determine whether the division was longitudinal or transverse, but he inclines to the belief that it is transverse in the second division. Thus it appears to be very doubtful in which division the reduction normally occurs. Here, as in many other problems of cytology, the personal element is still very large.

The zoologists also report these variations. Paulmier (**25**), in his study of the spermatogenesis of *Anasa tristis*, says that the chromosomes have a twisted appearance, and that the first division is transverse and a true reduction division, while the second is an equation division. Some zoologists have found that in certain animals the second is the reduction division.

Some of the nuclei of Erythronium are of enormous size. Those in the walls of the ovule are usually from 15 to 20 μ in diameter, while the large reduction nucleus often measures from 40 to 50 μ. In many cases, where the sections were cut 18 μ thick, the spindle was distributed through three sections. In such cases the spindle threads not only have their terminals cut but they are often more or less distorted. The same is true of the nuclei before the spindle is formed. If such a large spindle were cut into sections 5 μ thick it would be distributed through nine or ten sections!

In the sliced spindles of Erythronium multipolar figures are very common. Examples are shown in *figs. 31*, *32a*, *33*, *34*, and *35*. In *fig. 31* one pole is intact and ends in a dark body, while the other is cut off. *Fig. 32a* is a multipolar spindle representing a tangential section. The other part of the spidle is little injured and shows well-developed centrosomes at the poles (*fig. 32*). In *fig. 34*, a strand of spindle threads has been displaced, so that it projects beyond the limits of the cytoplasm. In this material no multipolar spindles were found which were not sectioned, and they are therefore not regarded as being the result either of normal or diseased conditions, but simply due to the method of preparation. Indeed, the nuclei and spindles were so large that it was difficult to obtain the chromosomes in their normal positions, as they were frequently displaced by the knife.

Unfortunately, the stages were not at hand for tracing out the origin of the spindle. *Fig. 28* represents the general appearance of a section of the nucleus some time before the final looping takes place. The nucleus usually has an enlarged or expanded appearance, with the spirem lying free in the cavity. *Fig. 27* shows a large number of false poles produced as the result of contraction. In *fig. 26* the spirem has looped up into the twelve loops, but no sign of a spindle appears either on the inside or outside of the nuclear membrane. The loops have not broken apart, but were cut by the knife. It is probable that the spindle begins to form rapidly at about this stage, although it might already have passed its incipient stage and not be detected, if it lies closely applied to the nuclear membrane.

In the study of *Lilium Philadelphicum* the writer was unable to discover the origin of the radiations which appear around the daughter nuclei, but subsequent study of Ranunculus demonstrated conclusively that they originate around the poles. *Fig. 56* in Dr. Coulter's article on Ranunculus (**10**) was furnished by the writer as a good example of this. It is from the endosperm of *R. multifidus*, which is a very favorable object for the study of such radiations. In the root tips of *Allium Cepa* the same origin was traced step by step. A comparison of *figs. 30, 32, 36, 58, 59*, and *60* will show conclusively the origin of the remarkable radiations to be seen in well-prepared material of Erythronium. The radiations have their origin from the poles, and only later do the daughter nuclei push outward and give to the radiations an apparent nuclear origin. The radiations at first appear to be very straight and regular (*fig. 36*), while later they become more or less distorted before they begin to disappear (*fig. 60*). In favorable sections centrosomes are visible, as appear in *figs. 31, 32, 36, 58*, and *59*. In the stage represented in *fig. 36*, the attraction sphere appears to form a rather indefinite area from which the radiations arise. As to whether these bodies are built up temporarily or are permanent, the present study gives no information. In either case it is proper to call them centrospheres. At least they are the centers for the spindle threads and polar radiations.

The fate of the nucleolus was not discovered. It is still present at the time of the looped mother skein (*fig. 26*). In later stages, at the beginning of the daughter skein, spherical bodies were seen in the cytoplasm which may be extruded nucleoli (*fig. 59*). No figures were seen in the entire study which could be interpreted as a synapsis stage. The writer has maintained that what is usually called synapsis is a mere artifact which can be produced at will by using proper reagents. At the beginning of the formation of the spirem, however, the chromatin thread becomes free and continues to orient itself and contract until the looped mother skein is formed. There is a continuous shortening and thickening and often twisting up of the entire spirem, but the contraction is not one-sided, and it does not appear to have any special relation to the nucleolus.

THE SECOND AND SUBSEQUENT DIVISIONS.

The division of the reduction nucleus gives rise to the first two cells of the gametophyte. The daughter nuclei go into a resting stage and form a network from which a new spirem is developed (*figs. 61–63*). The network at first shows granules which are visible in a single chain in the spirem (*fig. 66*), but they are not visible after the mother star is formed (*figs. 68, 69, 70*). The chromosomes are distinctly V- and U-shaped, and the daughter chromosomes are formed in the ordinary way by longitudinal splitting (*figs. 69, 70*). This is a normal quantitative karyokinesis, therefore, which is quite similar to the sporophytic quantitative karyokinesis except that there are only half the number of chromosomes formed by the transverse breaking of the spirem. Several countings indicate about twelve chromosomes in the daughter star. In one case the chromosomes were all distinct and plainly twelve in number.

The spindle in *fig. 68* has been sectioned, and this may account for the lack of poles. The relation of the large vacuoles to the position of the poles of the incipient spindle should also be noted (*figs. 65–67*). There are often remarkable radiations around the mother nucleus. These have nothing to do directly with the formation of the spindle, however, and are the radiations normally present at this stage in both plant and animal karyokinesis. In some cases it appears that they may have their origin at the dome-shaped caps of the spindles (*figs. 63, 64*). There are also numerous strands of the central spindle left between the daughter nuclei of the first division, and it is probable that some of the radiations around the daughter skeins may also be left and be preserved to the beginning of the following division. The third division which gives rise to the eight-celled embryo sac appears to be of the same nature as the second. *Fig. 71* shows the position of these spindles. The uppermost nucleus gives rise to the two synergids, the one below this to the egg and upper polar nucleus. A typical arrangement of these divisions is shown in *fig. 72*. The old spindle has survived in this instance, and has separated into two limbs below. As is usual in many of the Liliaceae, the egg apparatus is not very definitely organized. A nearly mature sac is represented by *fig. 73*. In this case, however, the nuclei are larger than usual.

Some interesting features were observed in the second division. In some cases the cytoplasmic radiations around the nucleus at the beginning of the formation of the spirem did not extend to the incept of the spindle, but ended in a rather dense cytoplasmic zone surrounding this (*fig. 62*). This of course may not be of any special significance, but merely an individual peculiarity. The fate of the central spindle of the first division, however, deserves special mention. This, as stated, persists usually until the following division is well under way. Then it often appears to mass up into two very dense irregular bodies which stain very deeply (*figs. 65, 66, 68*). Whether these masses represent a special substance distinct from the general cytoplasm and that part of the cytoplasm which alone is used in the formation of spindle threads and radiations it would be difficult, of course, to tell at present. There is little question as to the origin of the masses, and if there is a special substance for the formation of spindle threads and radiations, distinct from the cytoplasm proper, these masses must represent such a substance.

THE DEVELOPMENT OF THE EMBRYO.

No stages of fertilization were discovered, nor any in which the polar nuclei were conjugating. When the pollen tube enters the micropyle it increases enormously in size and is exceedingly distinct. It is very different in appearance from the tubes in Alisma and Sagittaria. The definitive nucleus begins to divide about the time of the union of the male and female gametes. *Fig. 74* shows an embryo sac with the three antipodals, the dividing definitive nucleus, the oospore, two synergids, with an extra nucleus which may be a sperm cell, and a nucleus in the pollen tube, probably the tube nucleus. During the first few divisions of the embryo, the formation of the endosperm proceeds very rapidly (*fig. 76*). The oospore divides first by a transverse wall (*figs. 75, 76*), and then each resulting cell divides by a vertical wall, forming a four-celled embryo (*figs. 77, 78*). These divisions are almost simultaneous, although the upper one usually leads. Sometimes, however, the divisions are more irregular (*fig. 81*).

The young embryo lies free in the endosperm some distance from the upper end of the sac, and the synergids disappear very early. After the first few divisions of the embryo the sac enlarges greatly below, while the upper part remains narrow and may even contract (*figs. 76, 77, 79*). *Fig. 79* represents a five-celled embryo, one cell being cut from the upper tier and one from the lower. *Fig. 80* is a six-celled embryo in which the two lower cells have each divided by a transverse wall, while *fig. 81* represents a six-celled embryo with two cells of the lowest tier cut away. *Fig. 82* is a twelve- to fifteen-celled embryo, and *fig. 83* about a twelve-celled one. These examples will show how very irregularly the development proceeds. Up to this time and later there is usually a distinct difference between the cells which came from the upper and lower cells of the first division. This difference is shown not only by a difference in the contents of the cell, but especially by the staining reaction. Thus in *fig. 83* the upper or suspensor cells have a bright yellowish cytoplasm, while the embryo cells are very granular and deep red. This is also present in *Lilium Philadelphicum*, sometimes being very prominent in the older embryos (9). *Figs. 84* and *85* represent later stages of the embryo of *E. albidum.* The suspensor region is rather large and often very irregular in shape and much lobed, but the whole structure gives rise to only a single embryo, as was verified by numerous examples. The embryos were very badly shrunken, however, because imbedded in the horny endosperm which is not easily penetrated by killing fluids. In *E. Americanum*, as shown by Jeffrey, the suspensor is much larger. *Figs. 87* and *88* represent sections of two embryos from this plant. These show well the large umbrella-like suspensor. The lowermost lobe is the one which develops the embryo, but if any of the other lobes of the suspensor should become separated from the main mass it would probably develop an independent embryo. This would be only an accidental case, however, as may frequently happen in any embryonic tissue. This is probably not to be regarded, therefore, as an ordinary case of polyembryony, but the large suspensor is especially developed as an embryonic absorbent organ, as suggested by Coulter (**9**).

COLUMBUS, OHIO.

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EXPLANATION OF PLATES IV–IX.

The figures are reduced to three eighths of their original size. All the figures not especially indicated are from *Erythronium albidum*. The combination of objective and ocular is given for each case, the following being used: Zeiss compensating oculars, 4, 6, 12, 18; Zeiss 8.0$^{\text{mm}}$ apochromatic objective; Leitz $\frac{1}{16}$ oil immersion and 1 objective; Leitz ocular 8; Bausch and Lomb $\frac{1}{12}$ oil immersion and $\frac{2}{3}$ objectives. The drawings were made with the aid of an Abbé camera lucida.

FIG. 1. Section of young bulb showing region of cell division dotted. L. 1 Z. 6.

FIG. 2. Normal resting nucleus in growing tip of bulb. B. & L. $\frac{1}{12}$ Z. 12.

FIG. 3. *a, b, c,* etc. Nucleoli of various shapes from nuclei in growing bulb. B. & L. $\frac{1}{12}$ Z. 12.

FIG. 4. Elongating nucleus in region of developing vascular bundle. B. & L. $\frac{1}{12}$ Z. 12.

FIG. 5. Close mother skein with incipient spindle, from young bulb; fuchsin iodin-green. B. & L. $\frac{1}{12}$ Z. 12.

FIG. 6. Dome-shaped spindle from bulb with granular areas at the tips of the domes; anilin-safranin gentian-violet. B. & L. $\frac{1}{12}$ Z. 4.

FIG. 7. Dome-shaped spindle with centrospheres, from bulb; chromatin granules distinct; early close mother skein; anilin-safranin gentian-violet. B. & L. $\frac{1}{12}$ Z. 12.

FIG. 8. Early close mother skein with dome-shaped spindle, from bulb; anilin-safranin gentian-violet. B. & L. $\frac{1}{12}$ Z. 12.

FIG. 9. Beginning of looped mother skein with bipolar spindle and centrosomes, from bulb; anilin-safranin gentian-violet. B. & L. $\frac{1}{12}$ Z. 4.

FIG. 10. Spindle with centrospheres from nucellus; anilin-safranin gentian-violet. L. $\frac{1}{16}$ Z. 12.

FIG. 11. Cell with starch, from bulb. B. & L. $\frac{1}{12}$ Z. 4.

FIG. 12. Dividing cell, packed with starch, from bulb. B. & L. $\frac{1}{12}$ Z. 12.

FIG. 13. Cross section of style showing glandular cells lining the style canal. B. & L. $\frac{2}{3}$ Z. 4.

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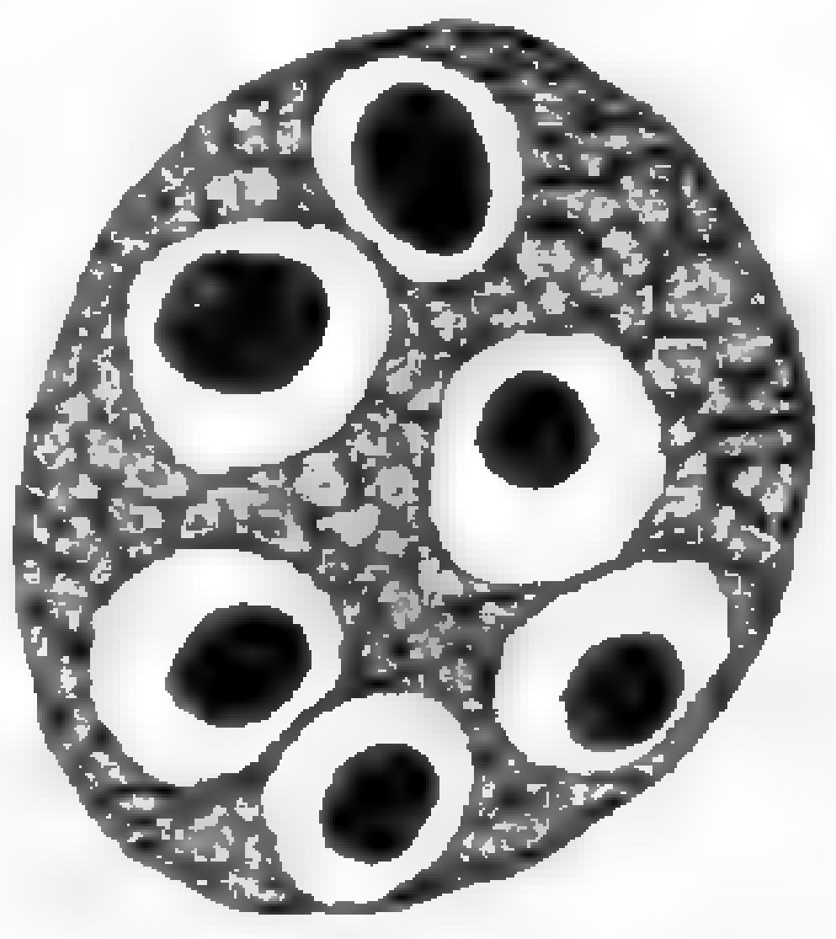

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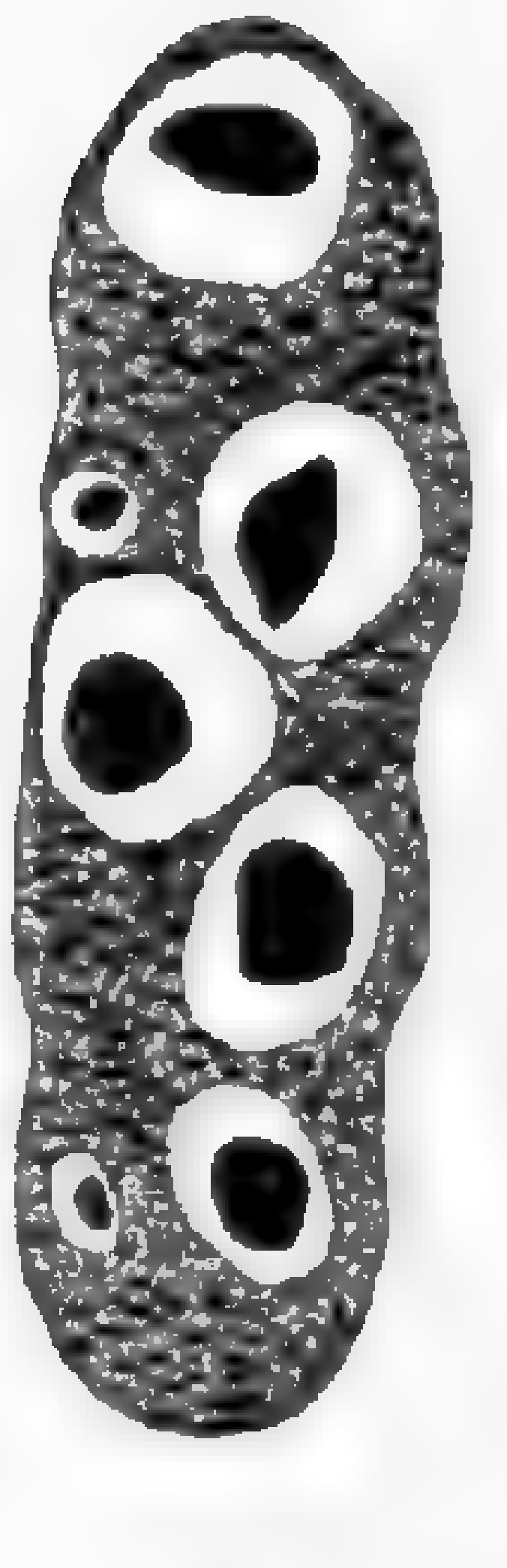

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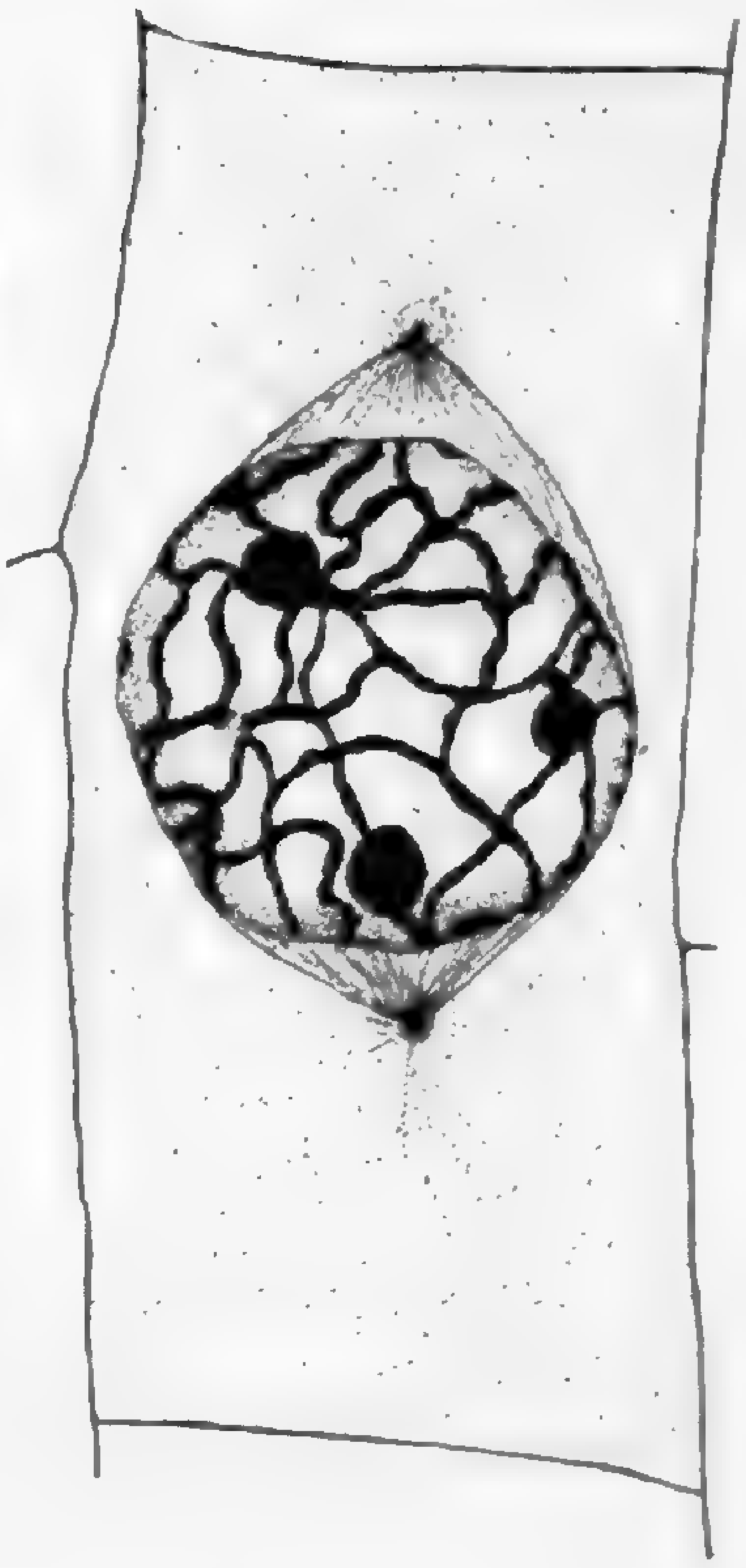

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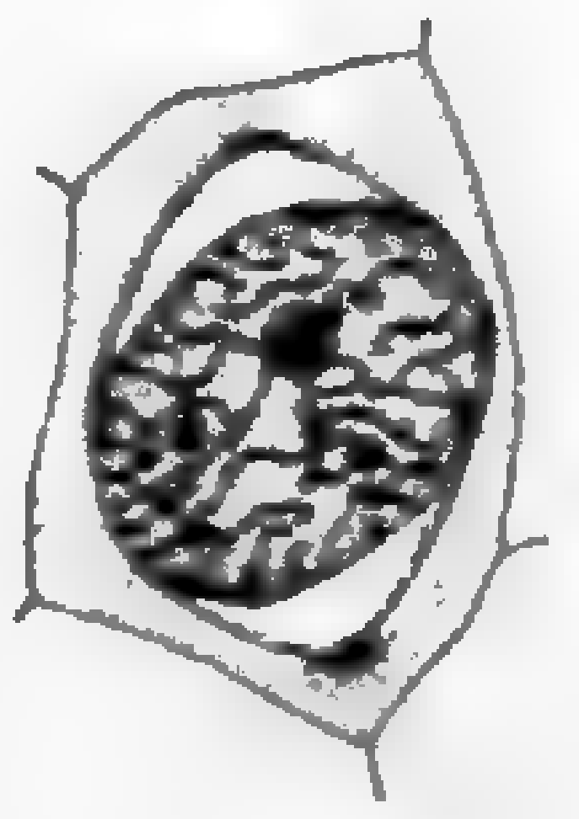

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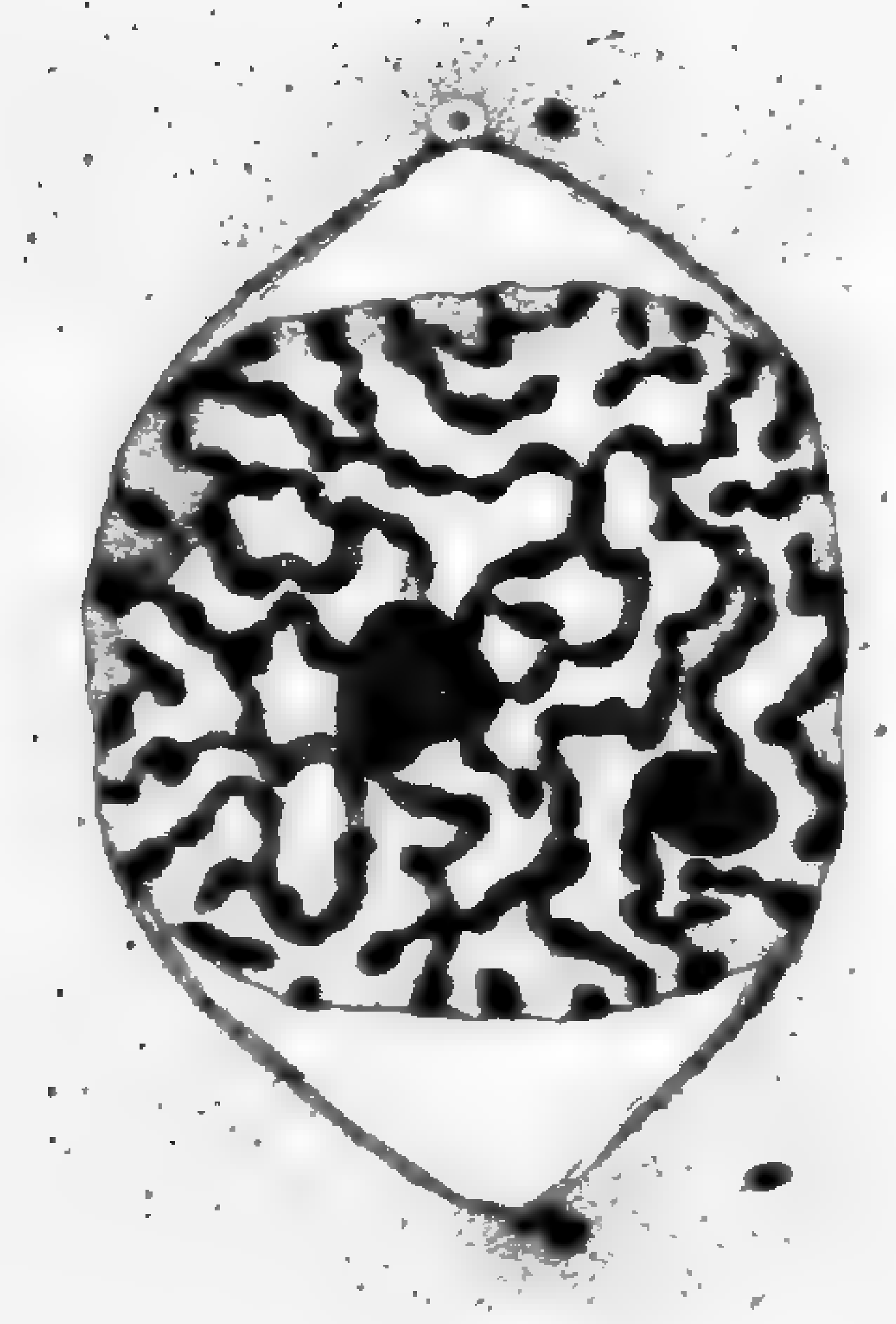

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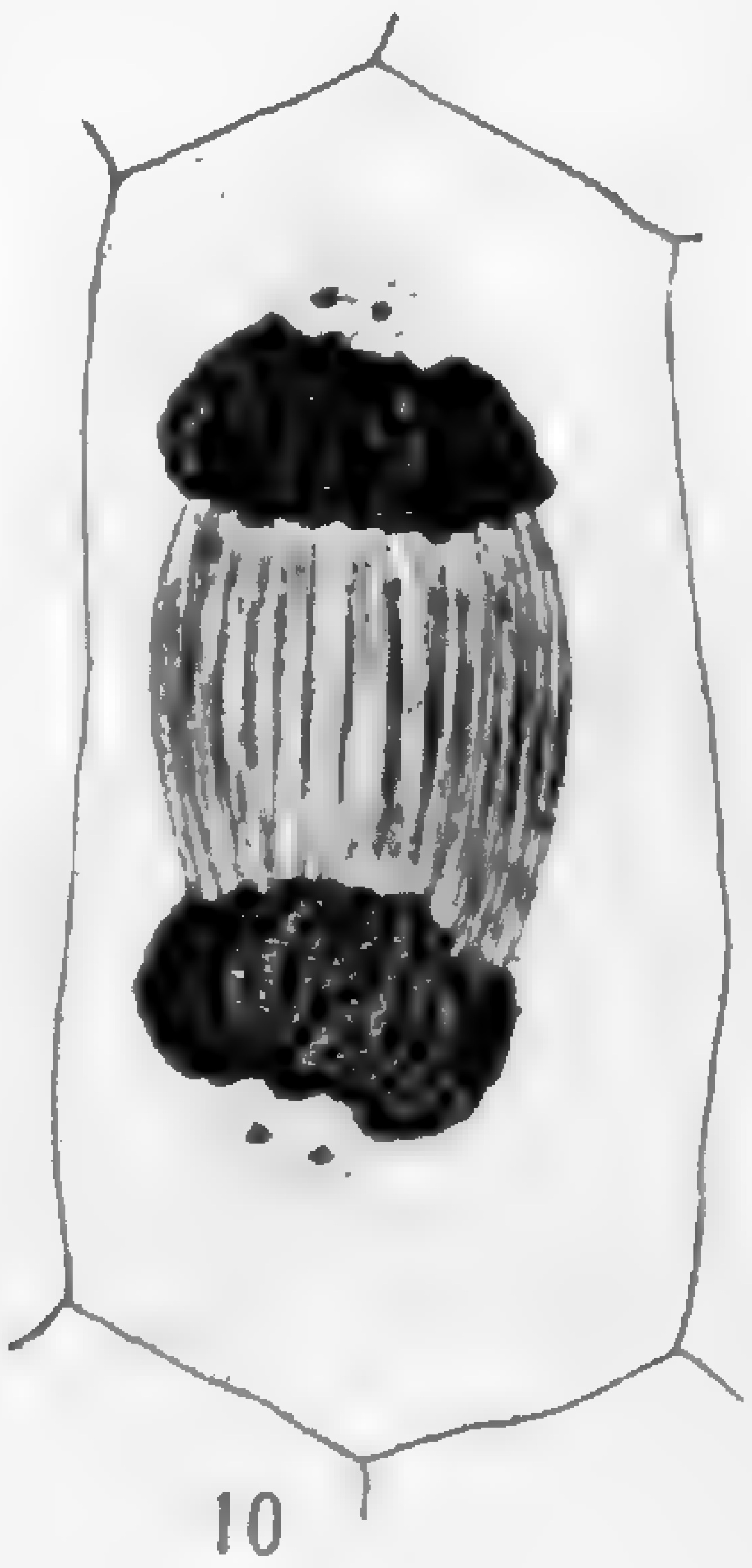

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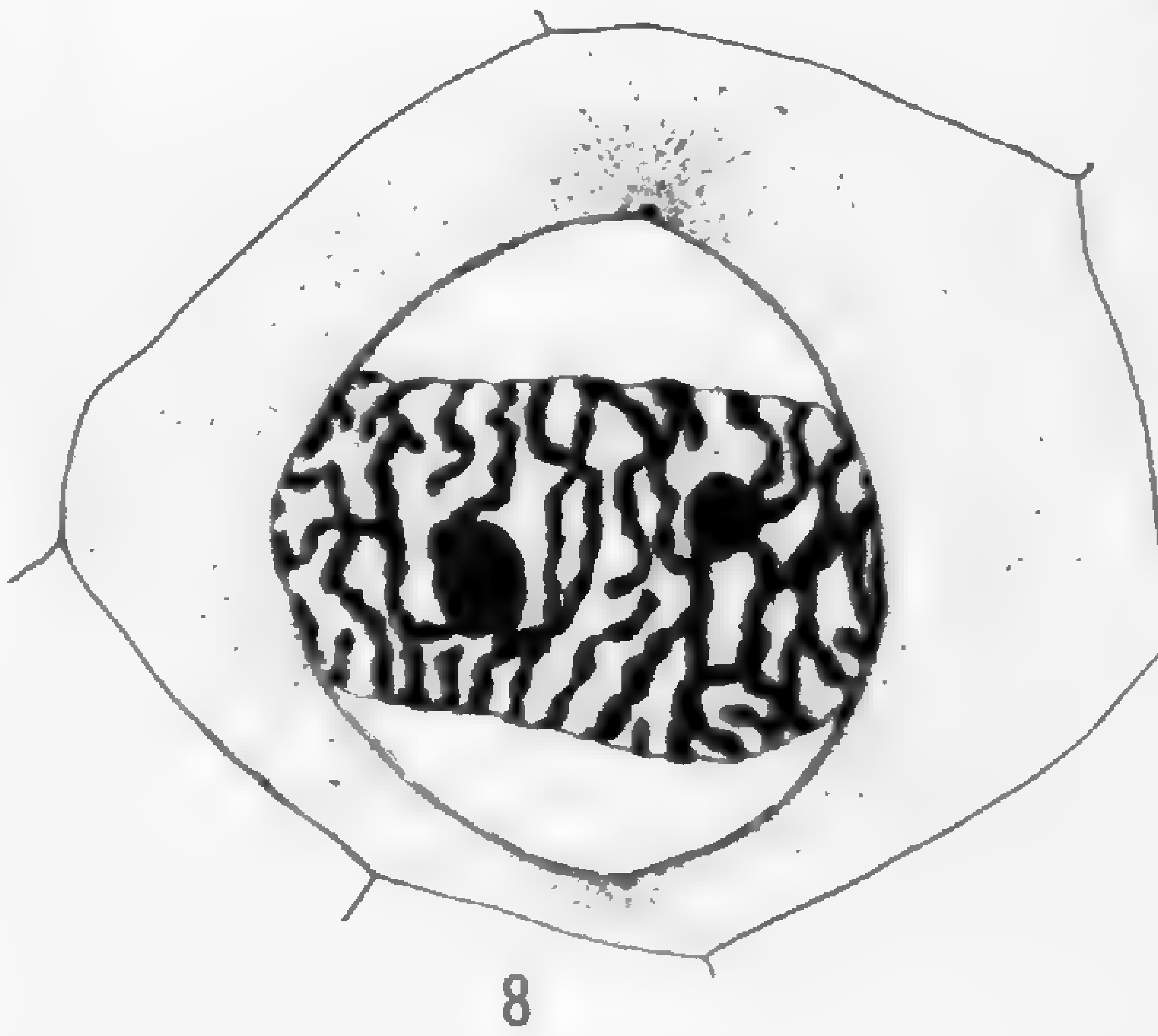

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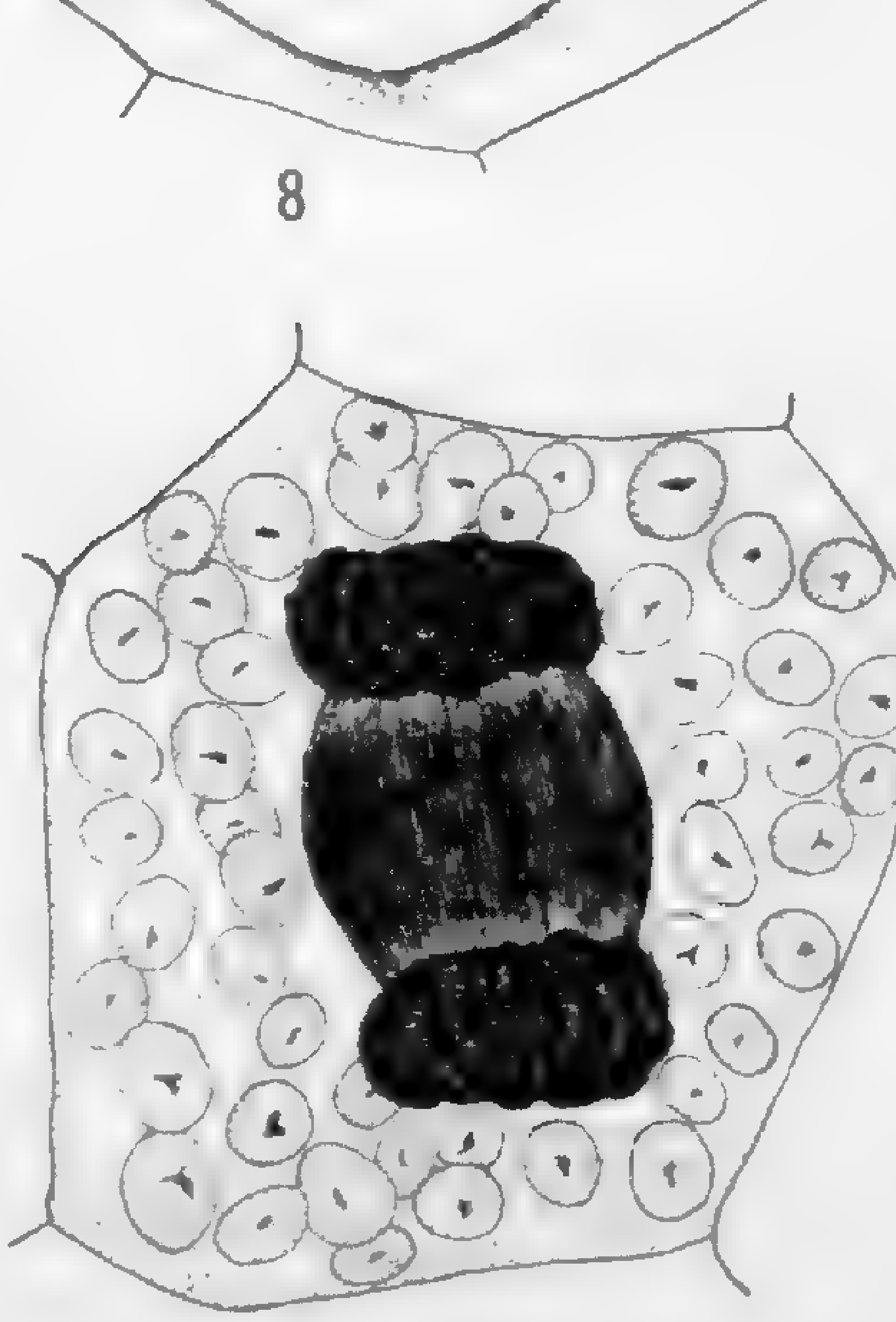

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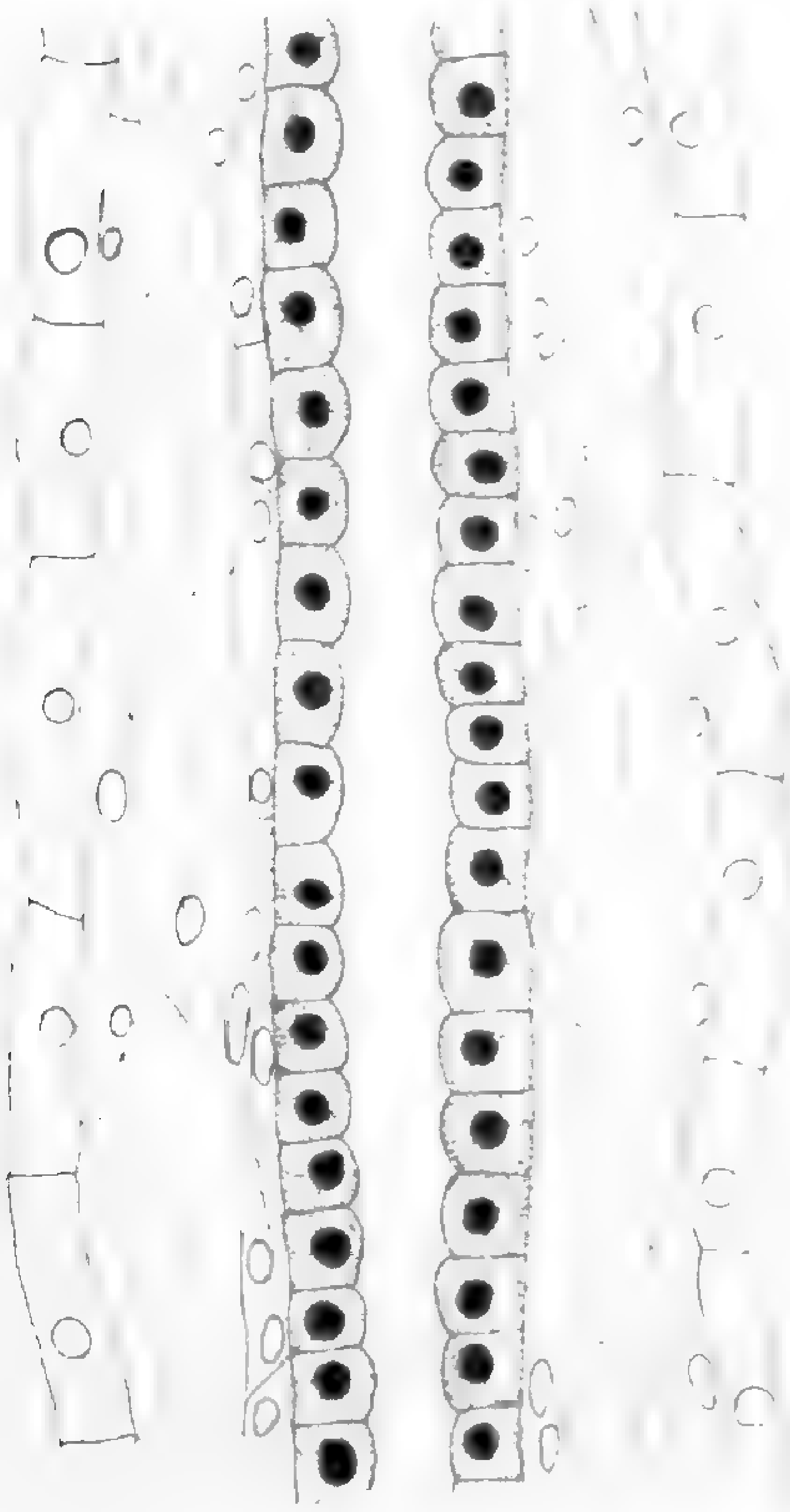

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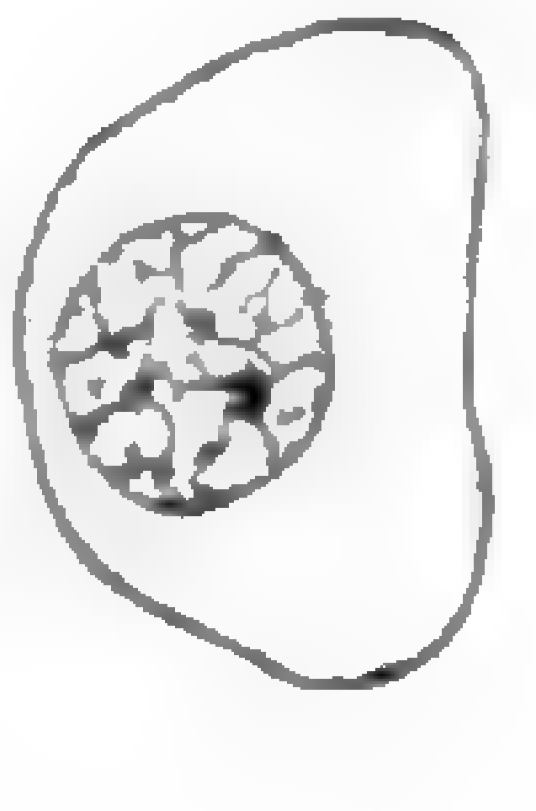

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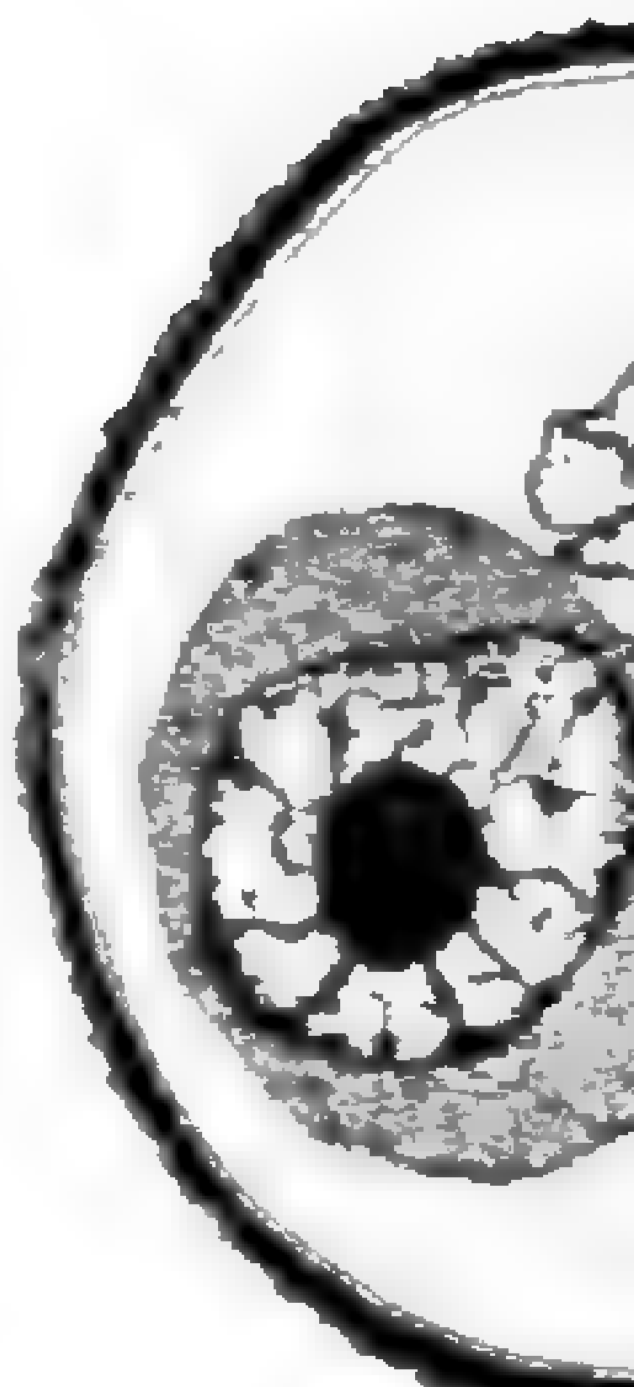

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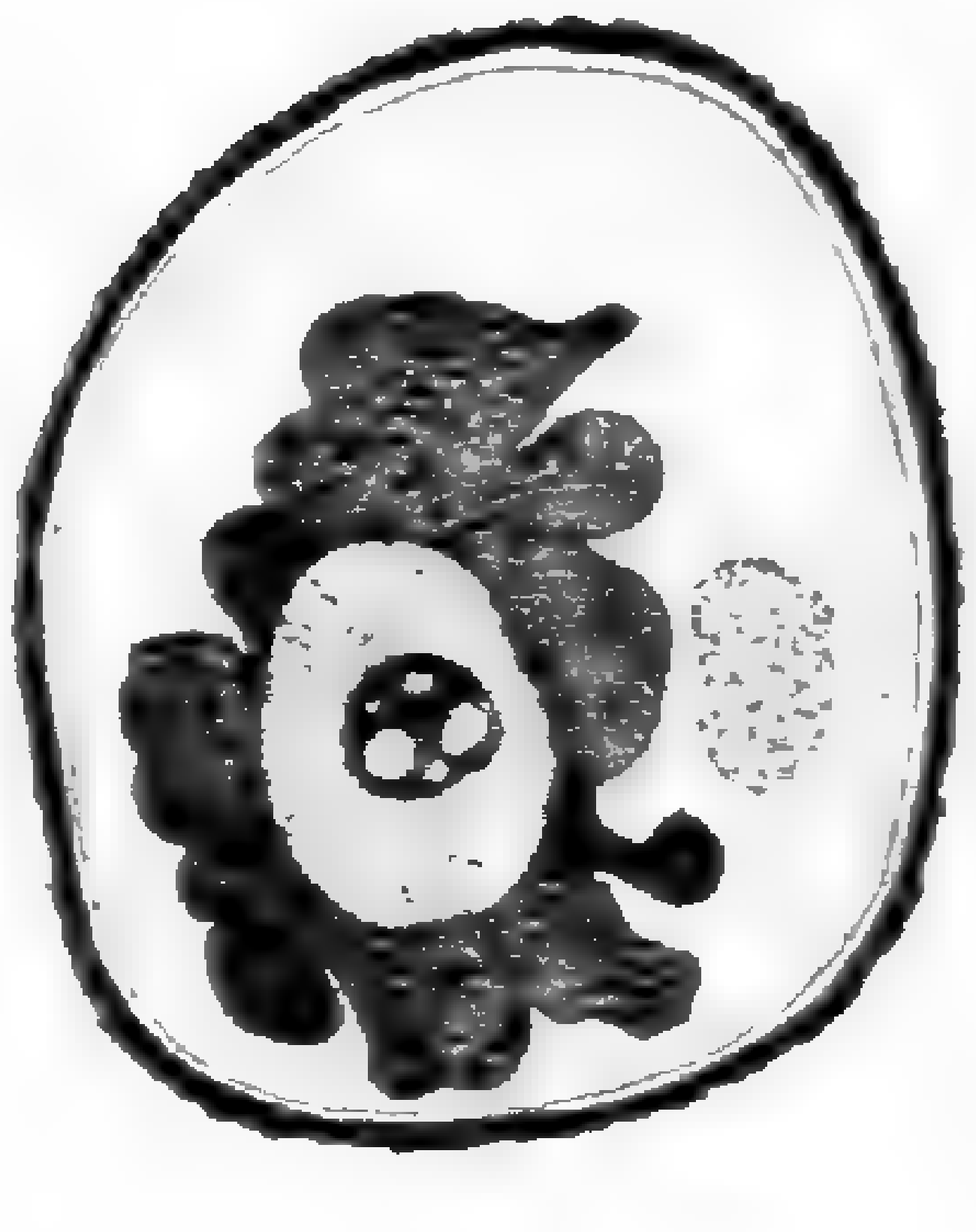

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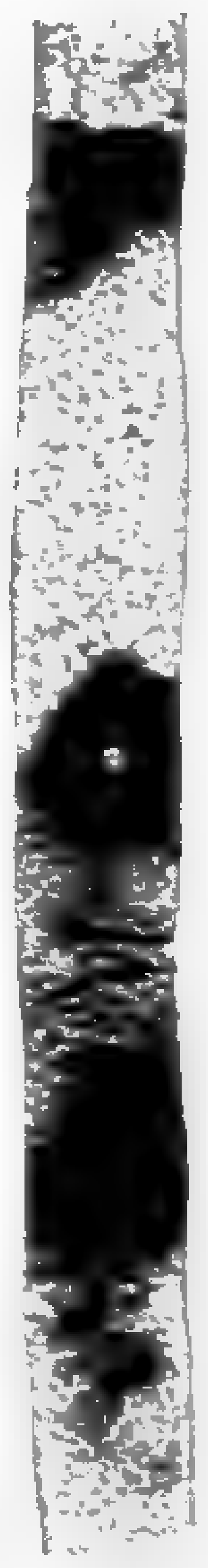

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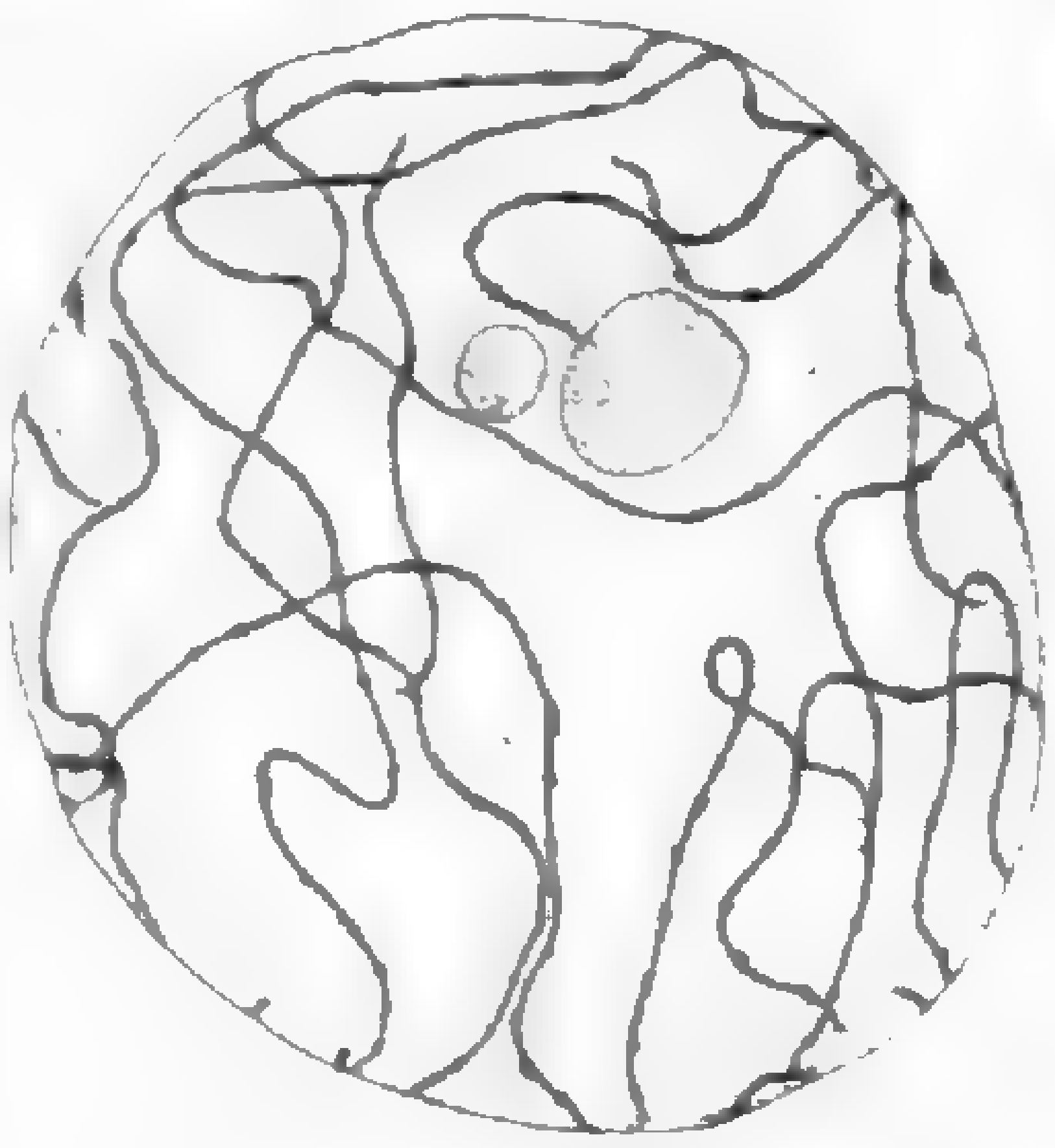

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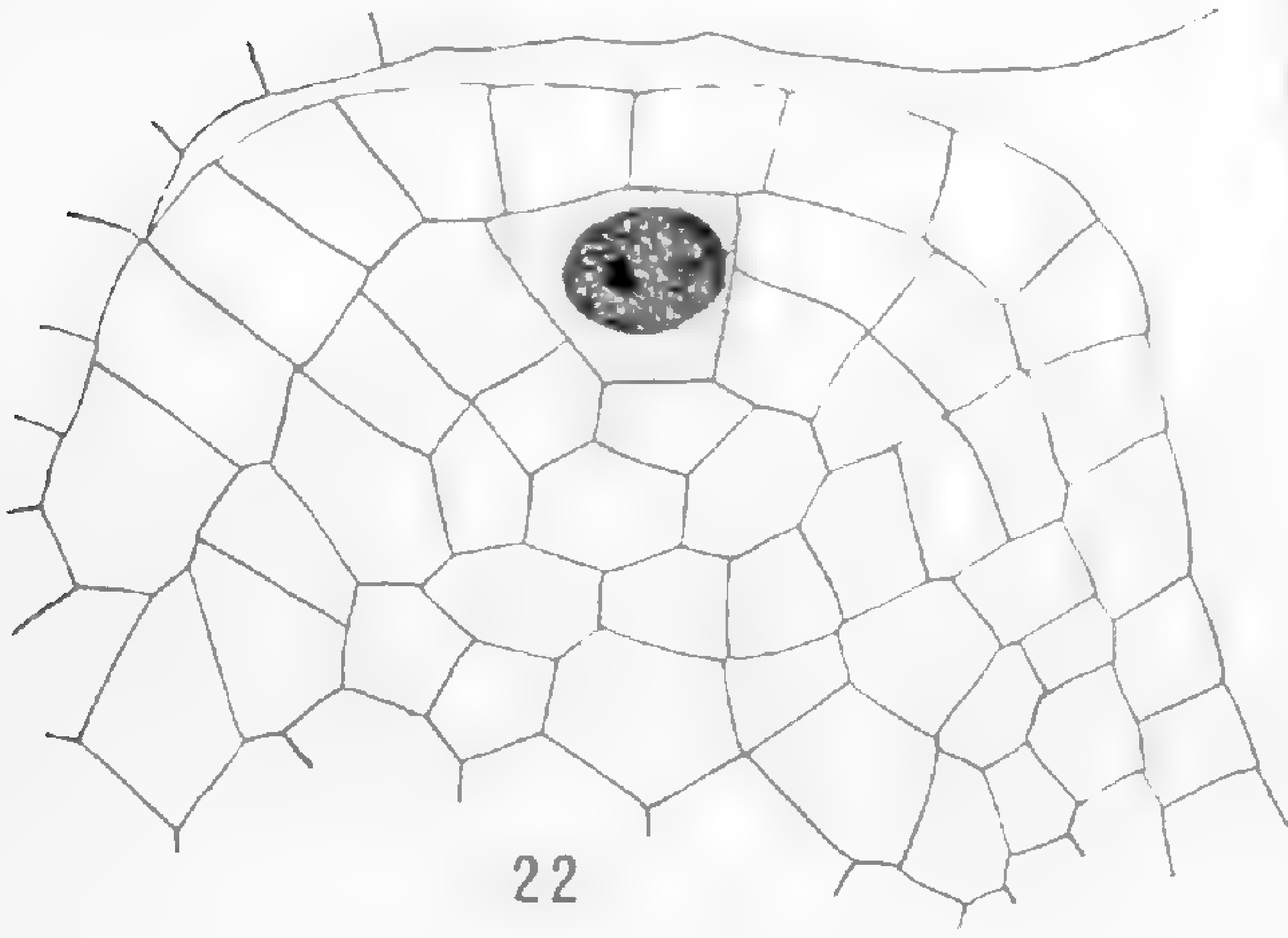

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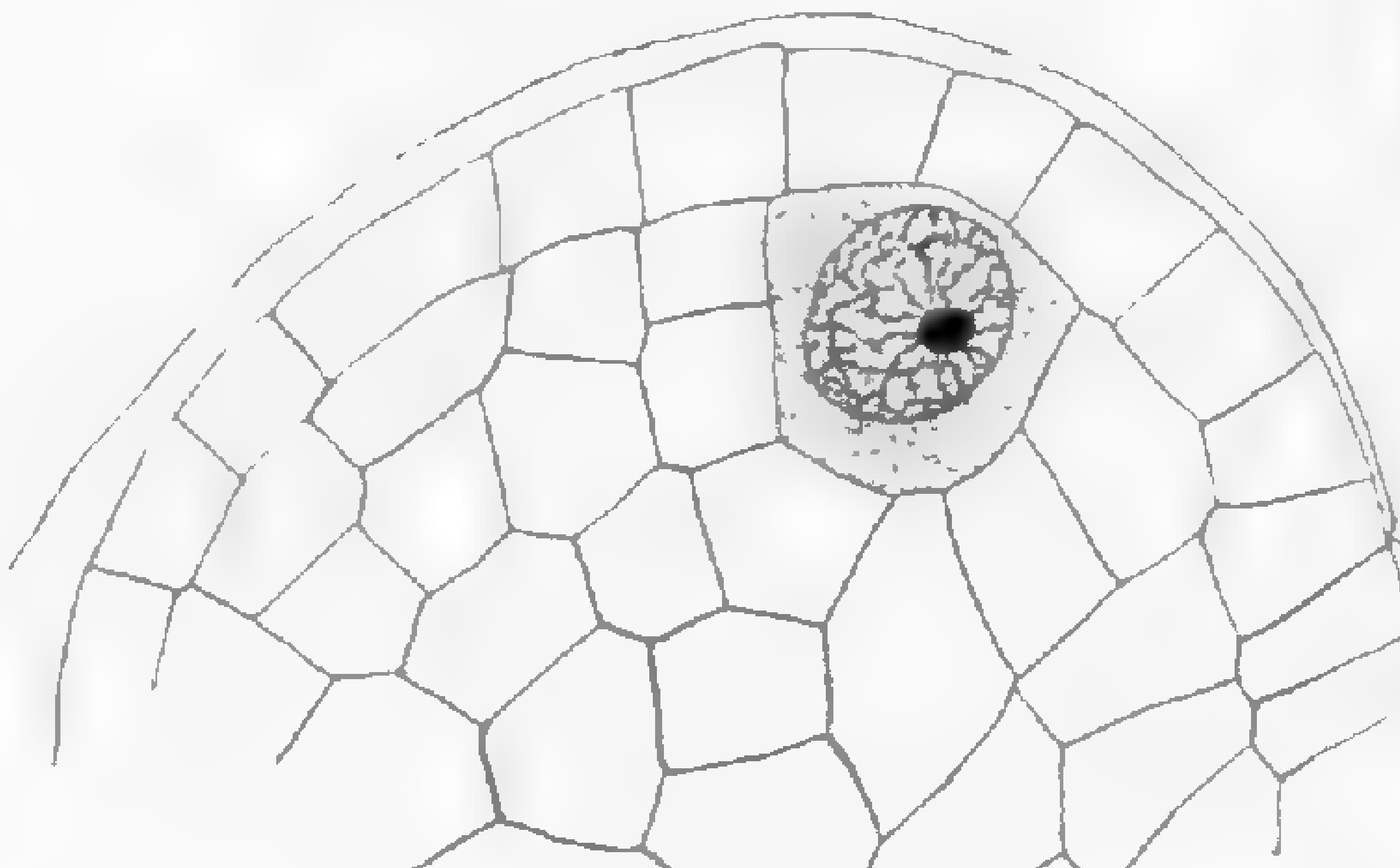

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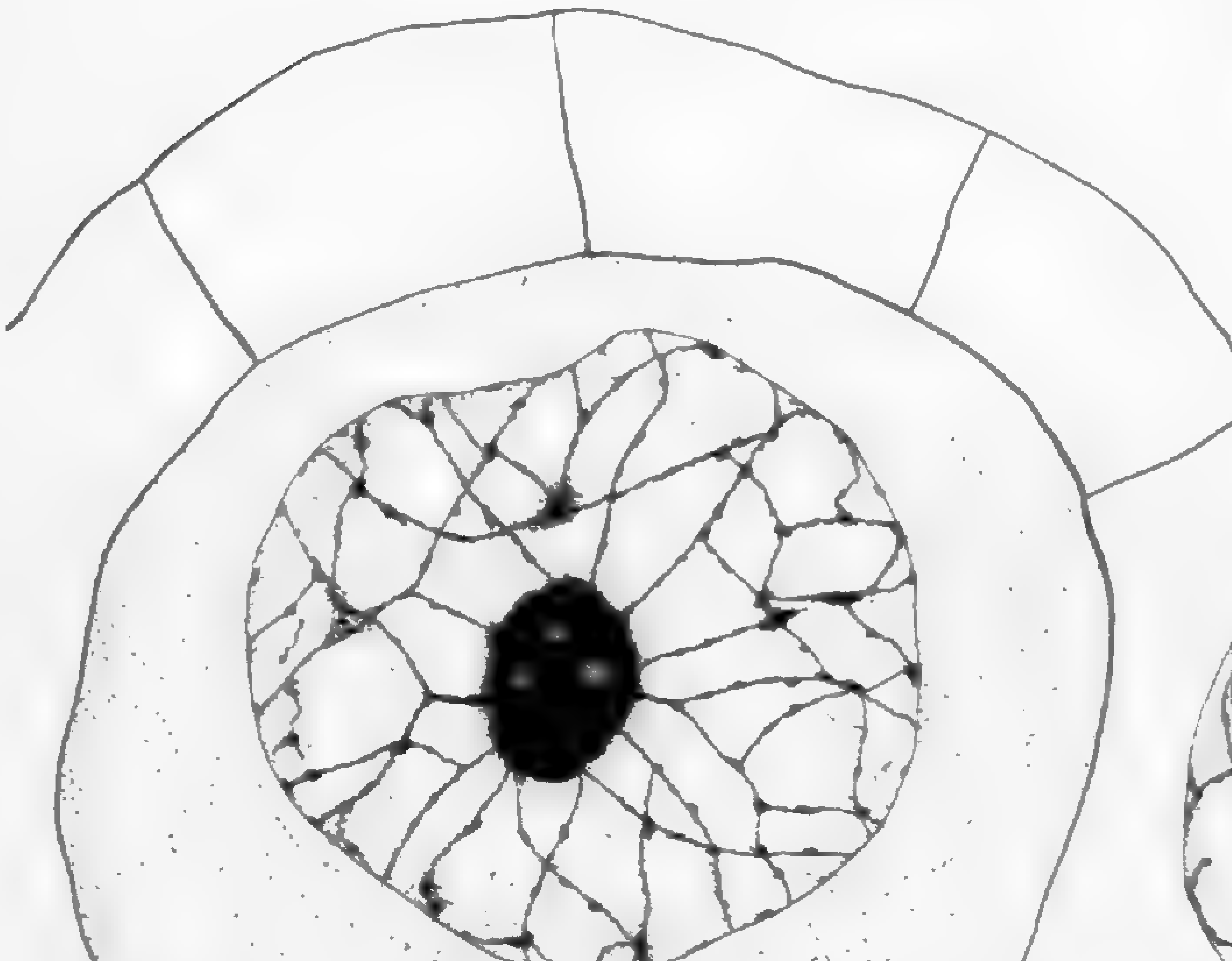

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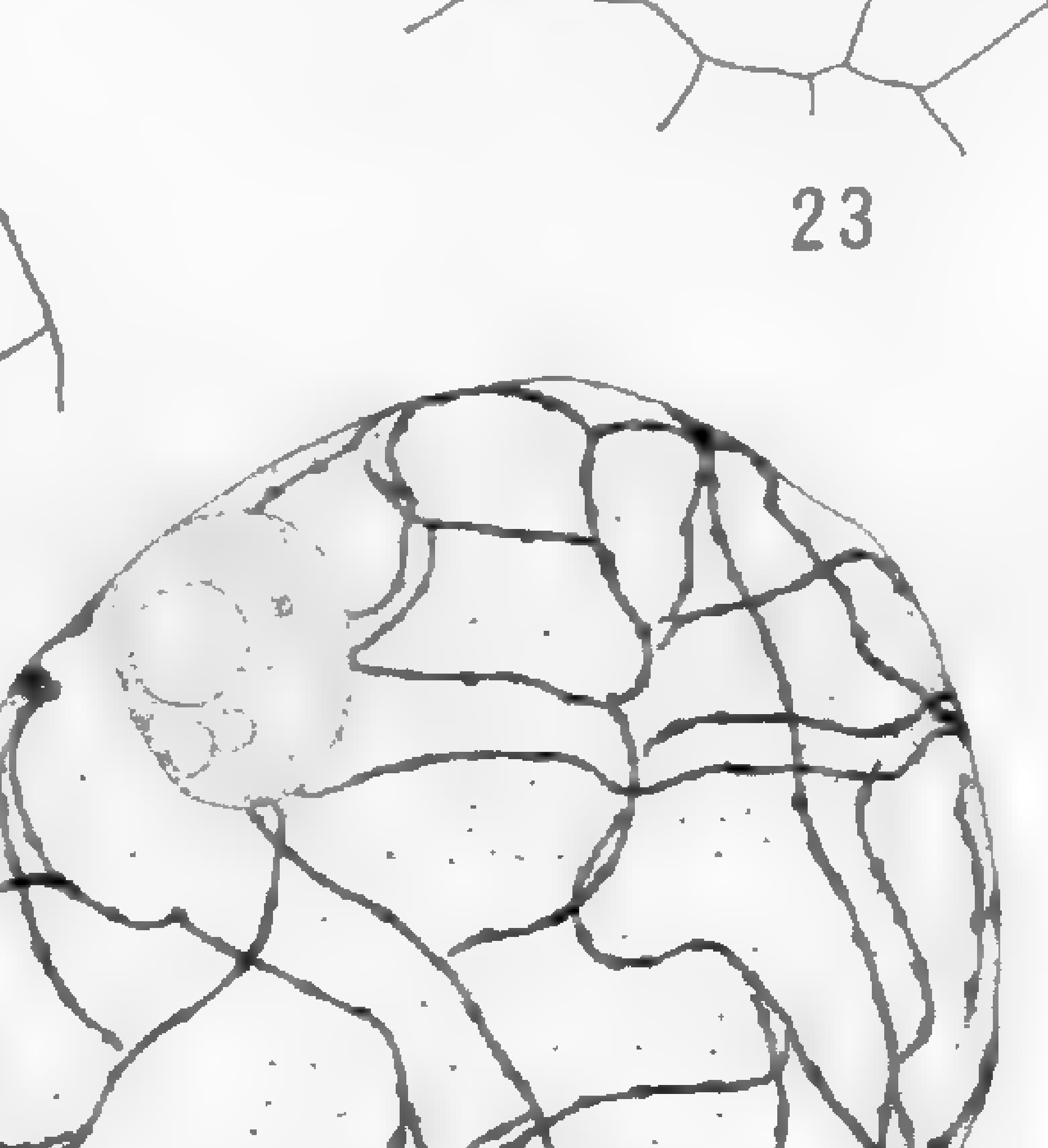

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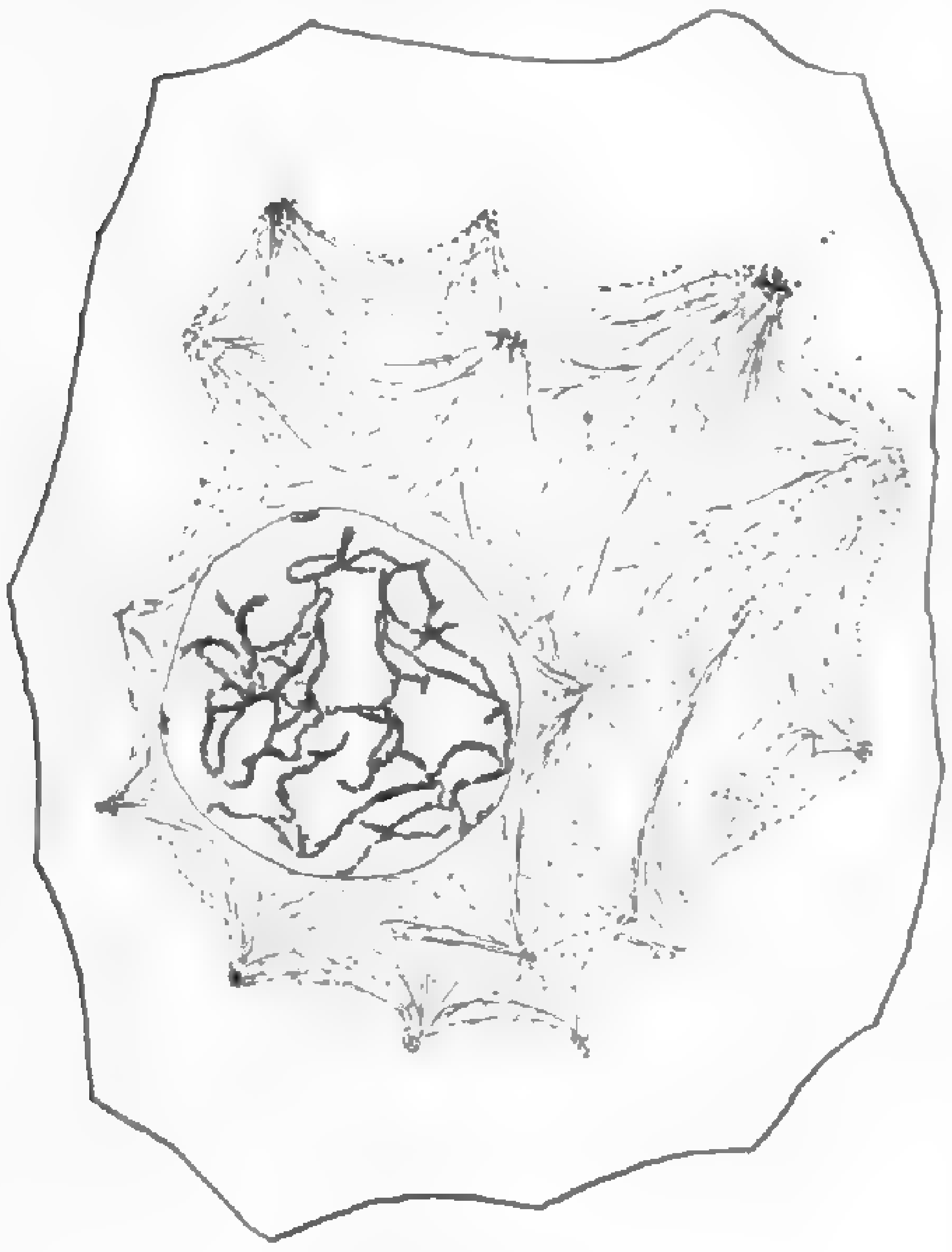

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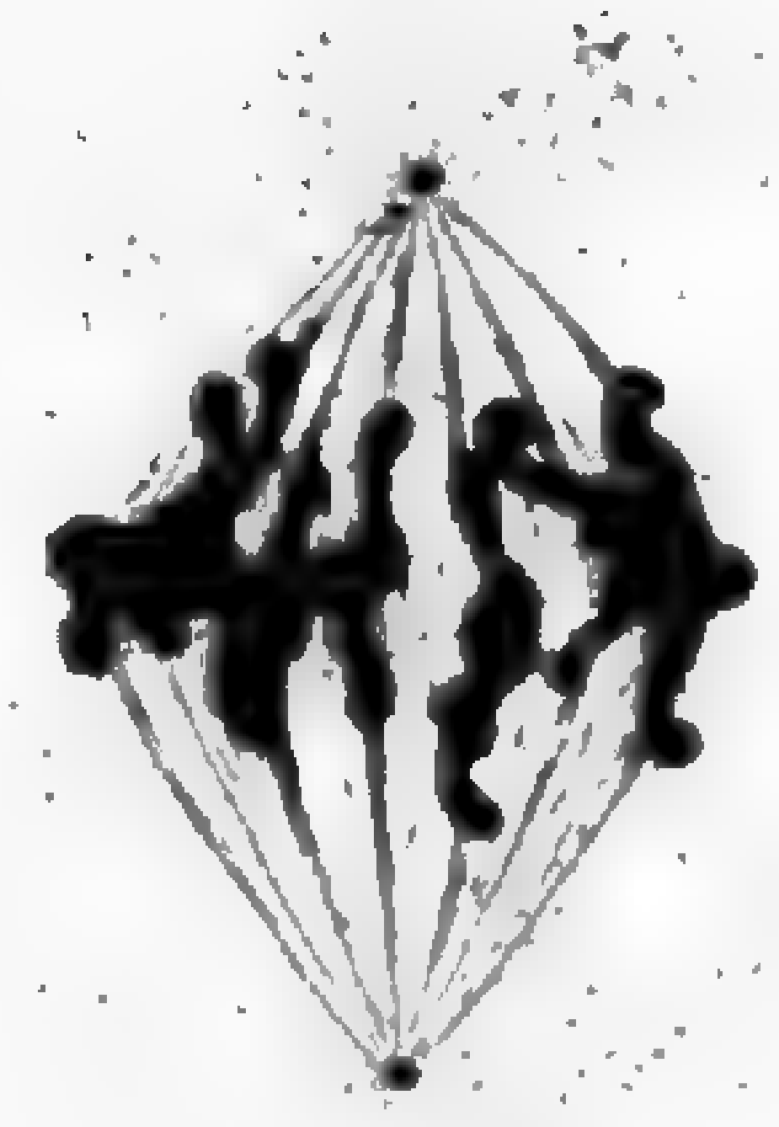

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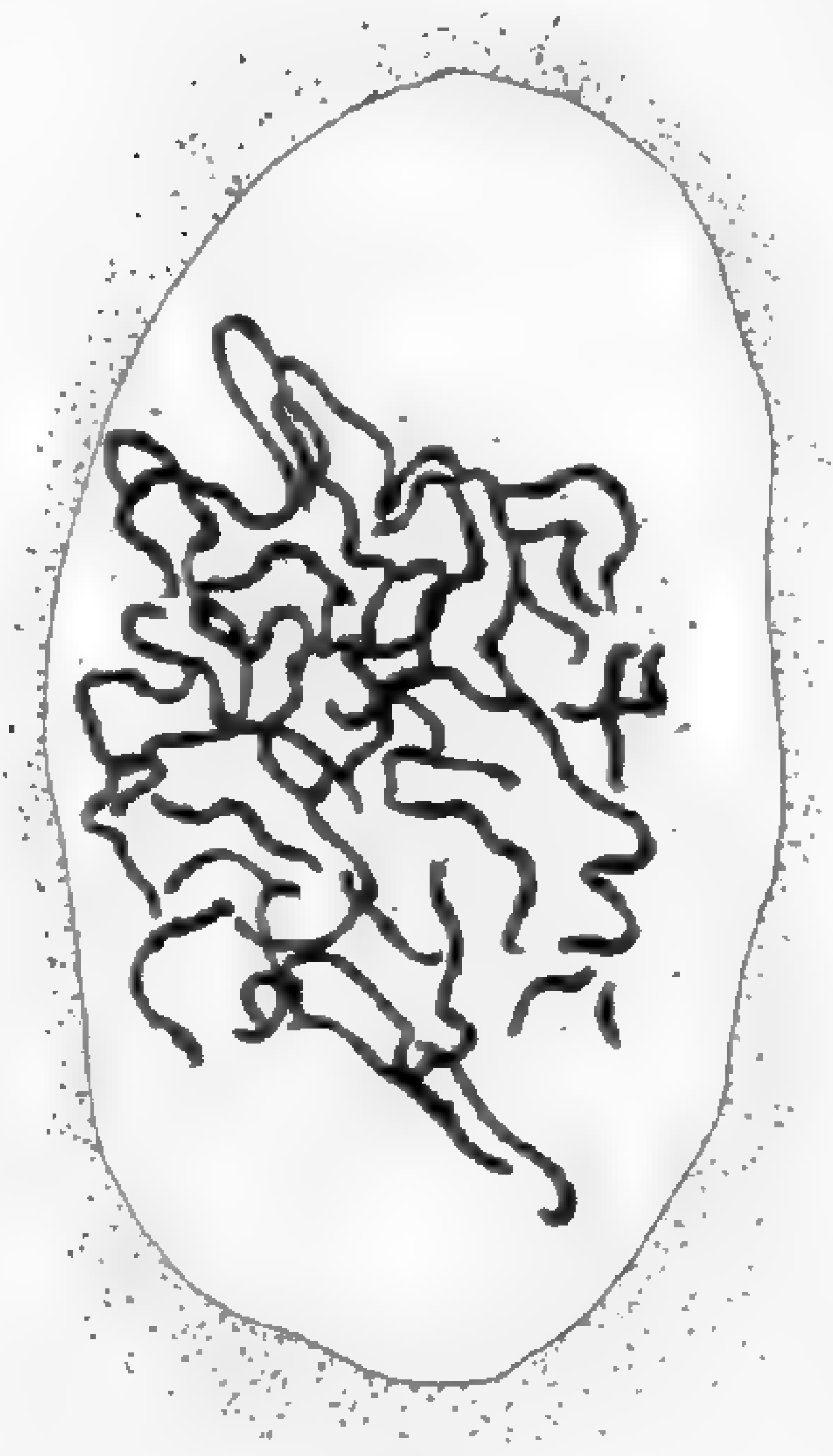

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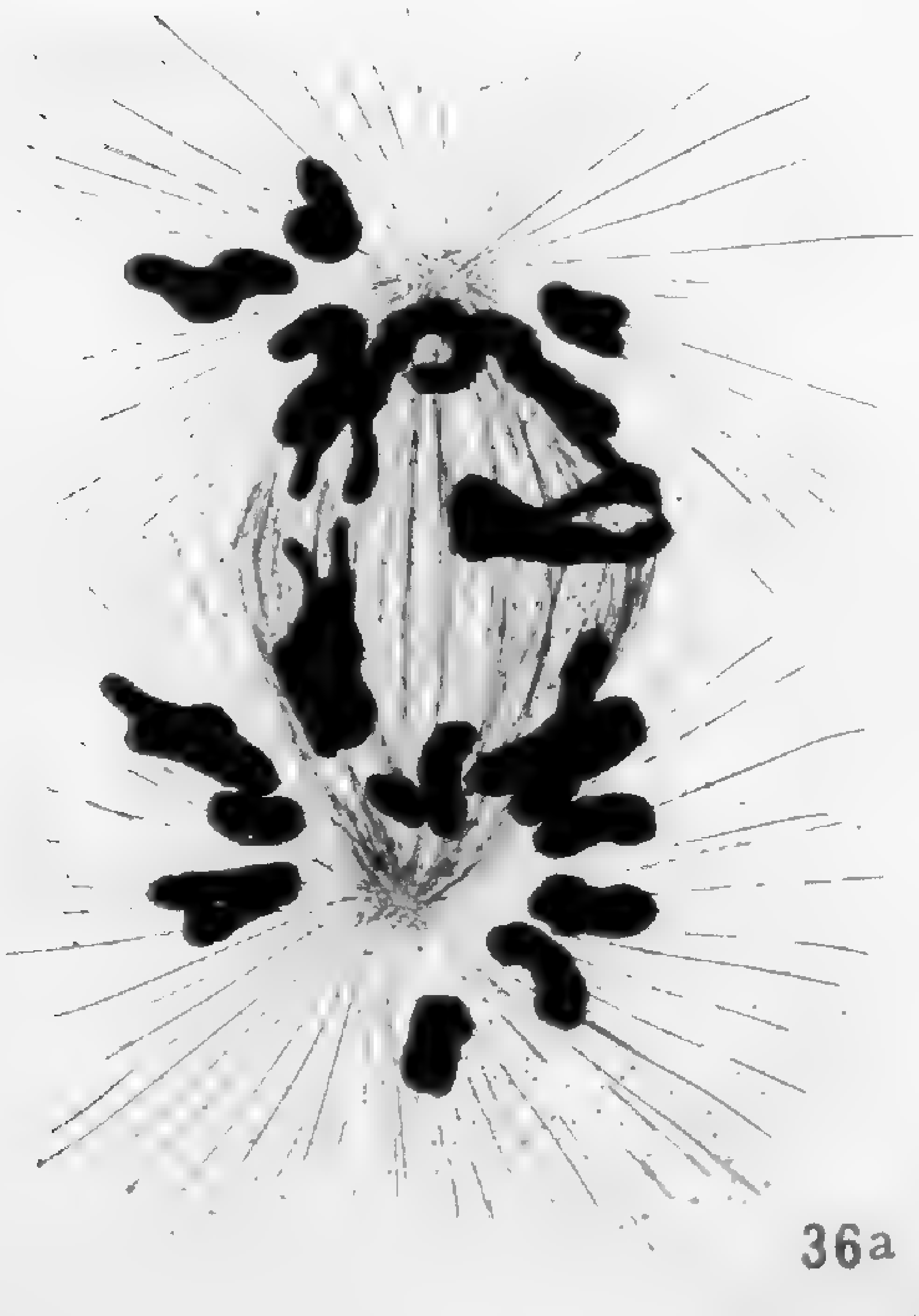

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SCHAFFNER on ERYTHRONIUM


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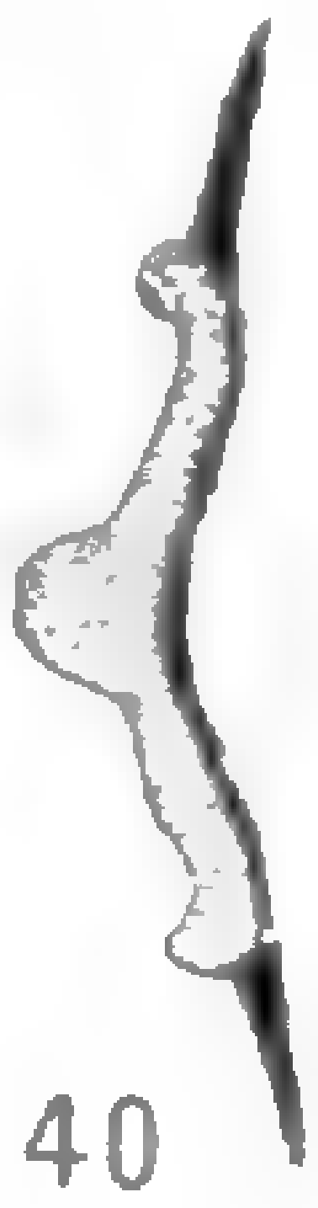
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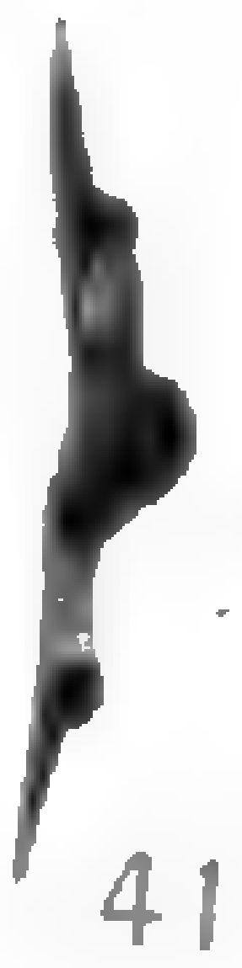
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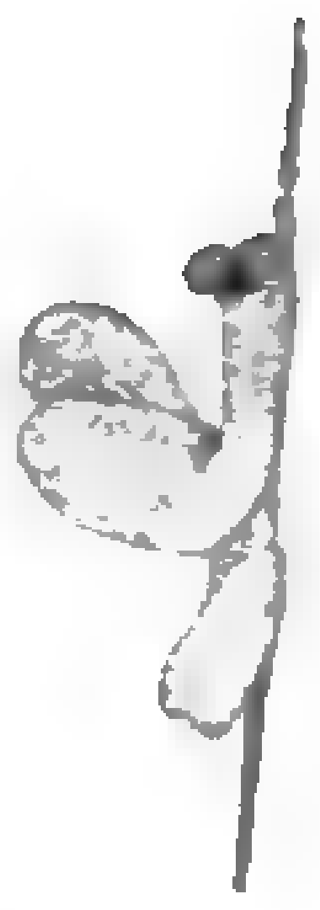
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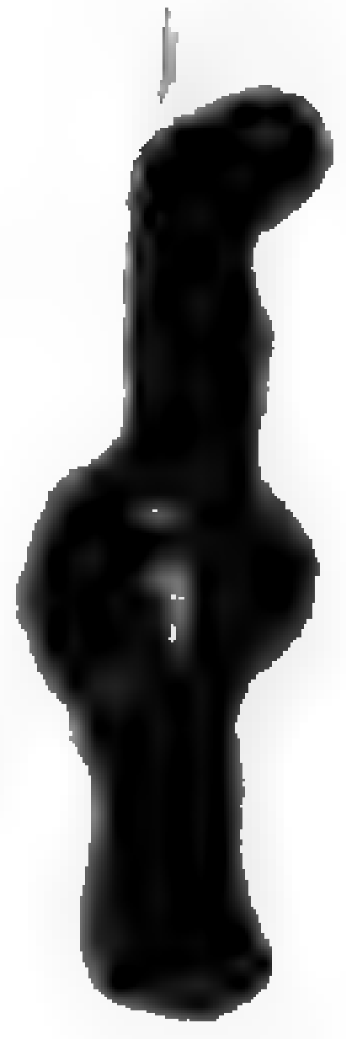
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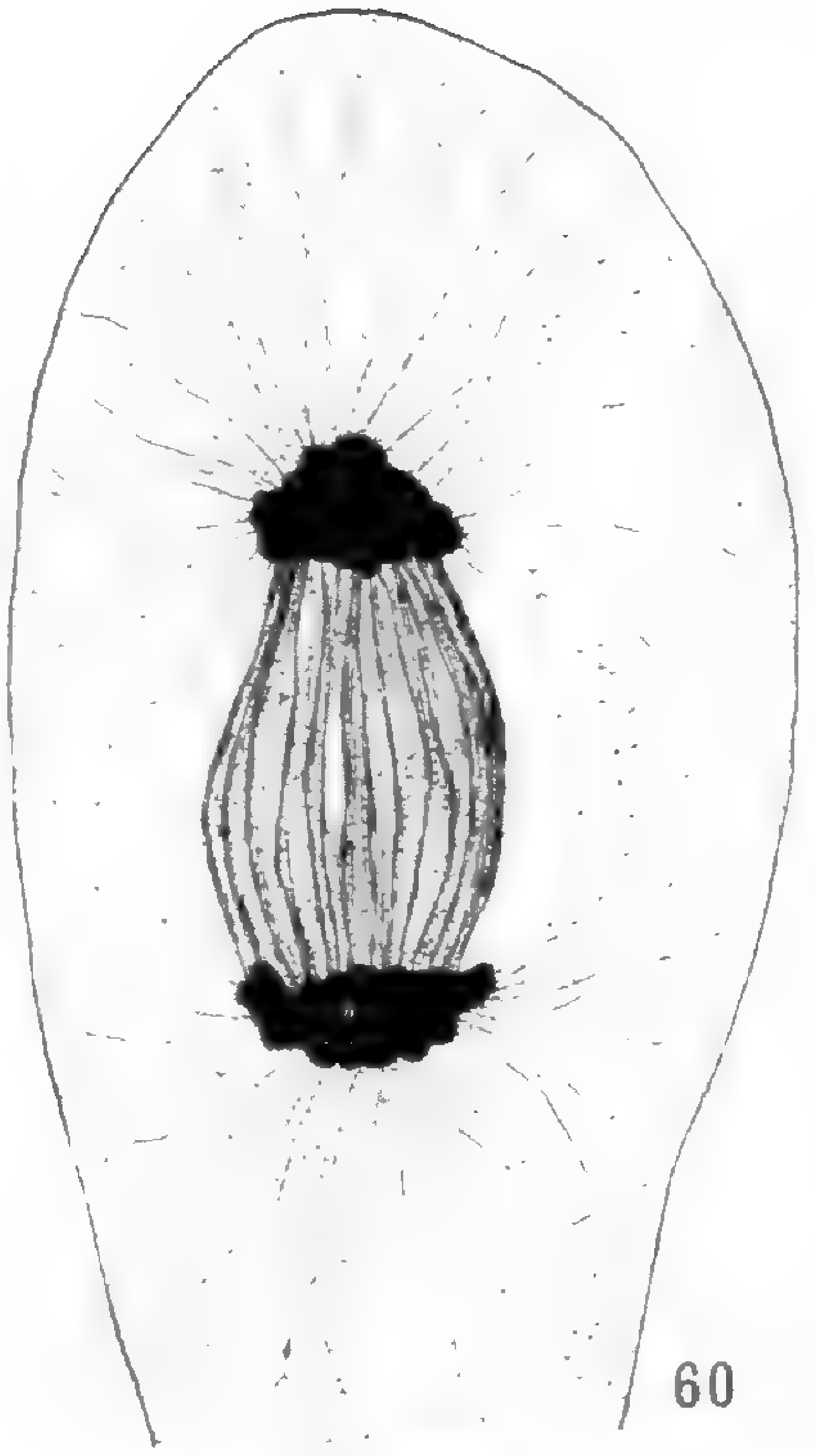
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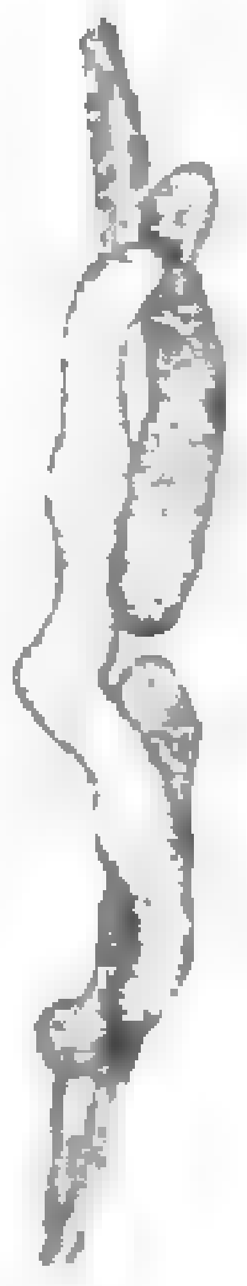
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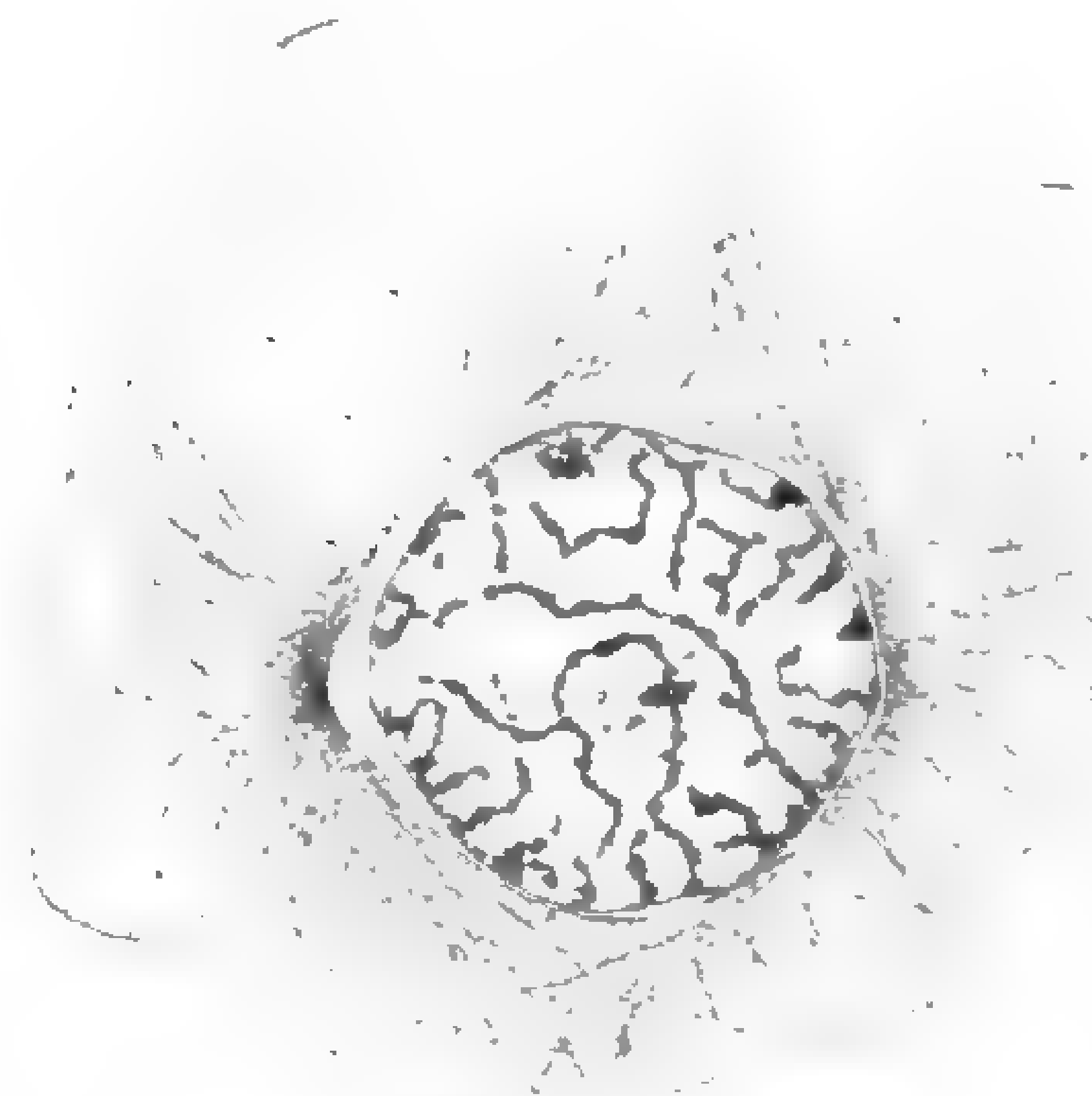
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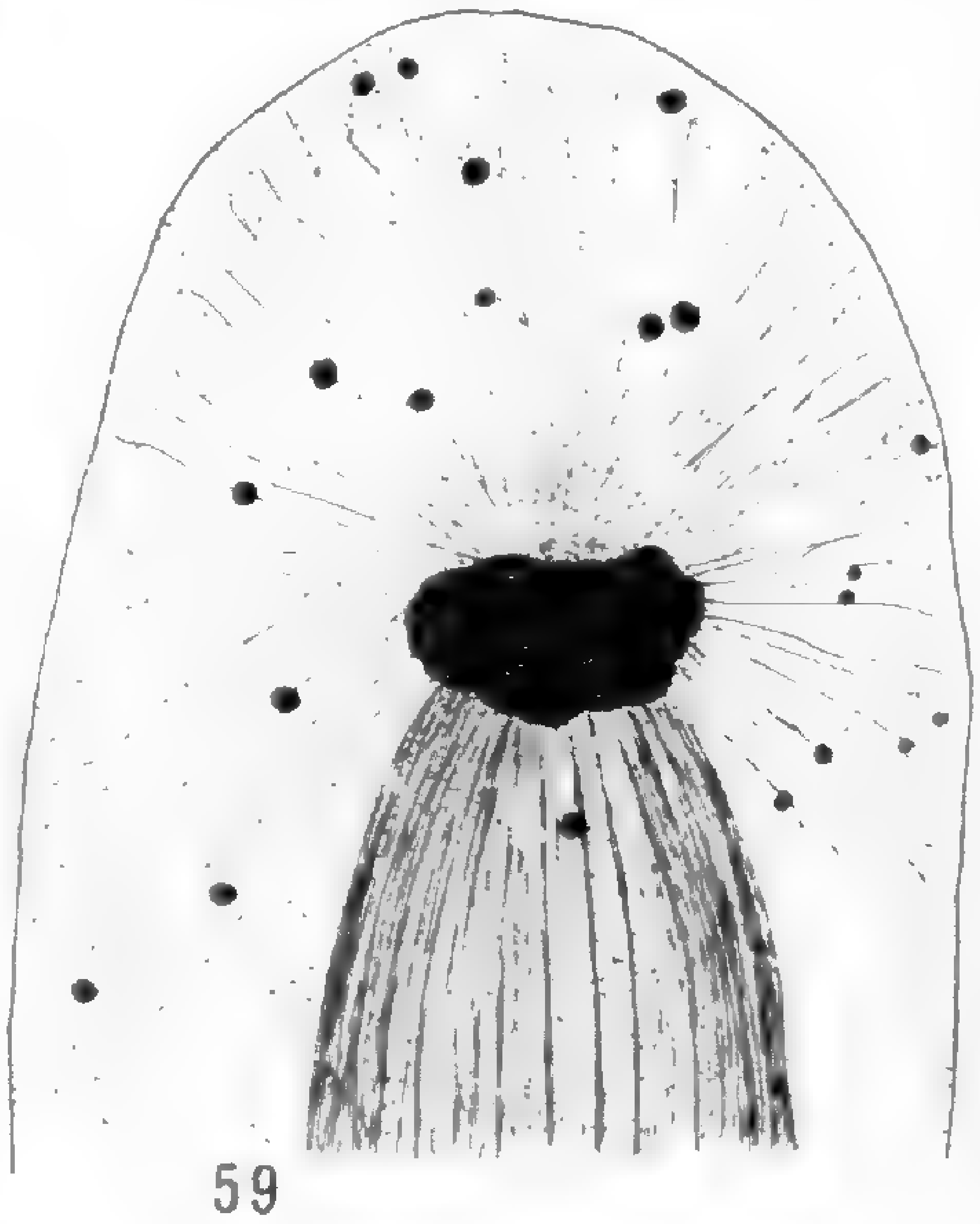
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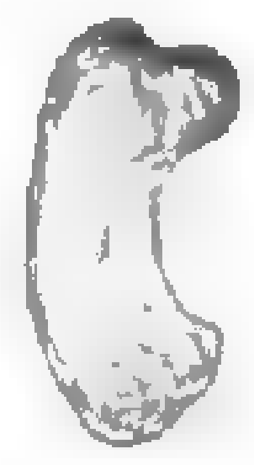
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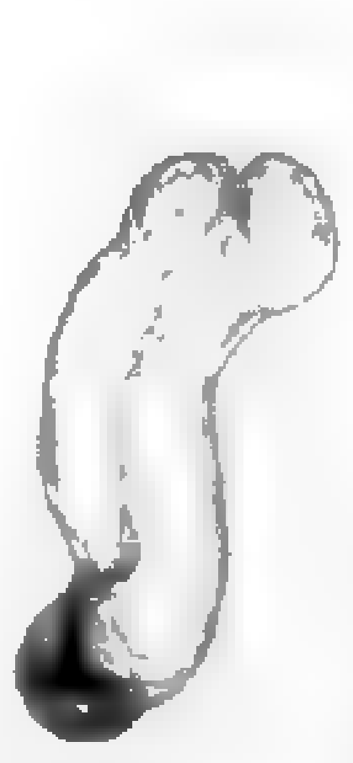
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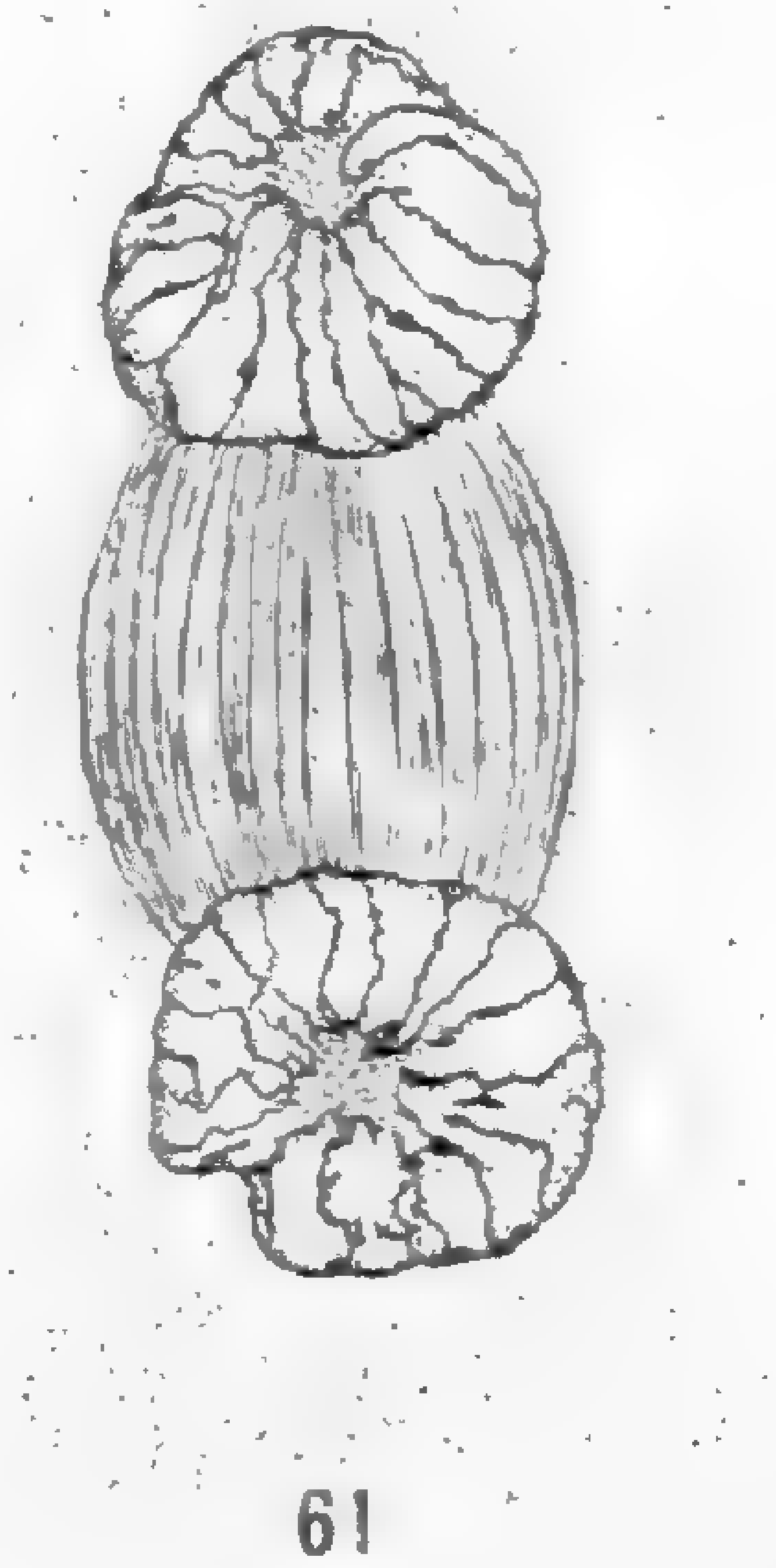
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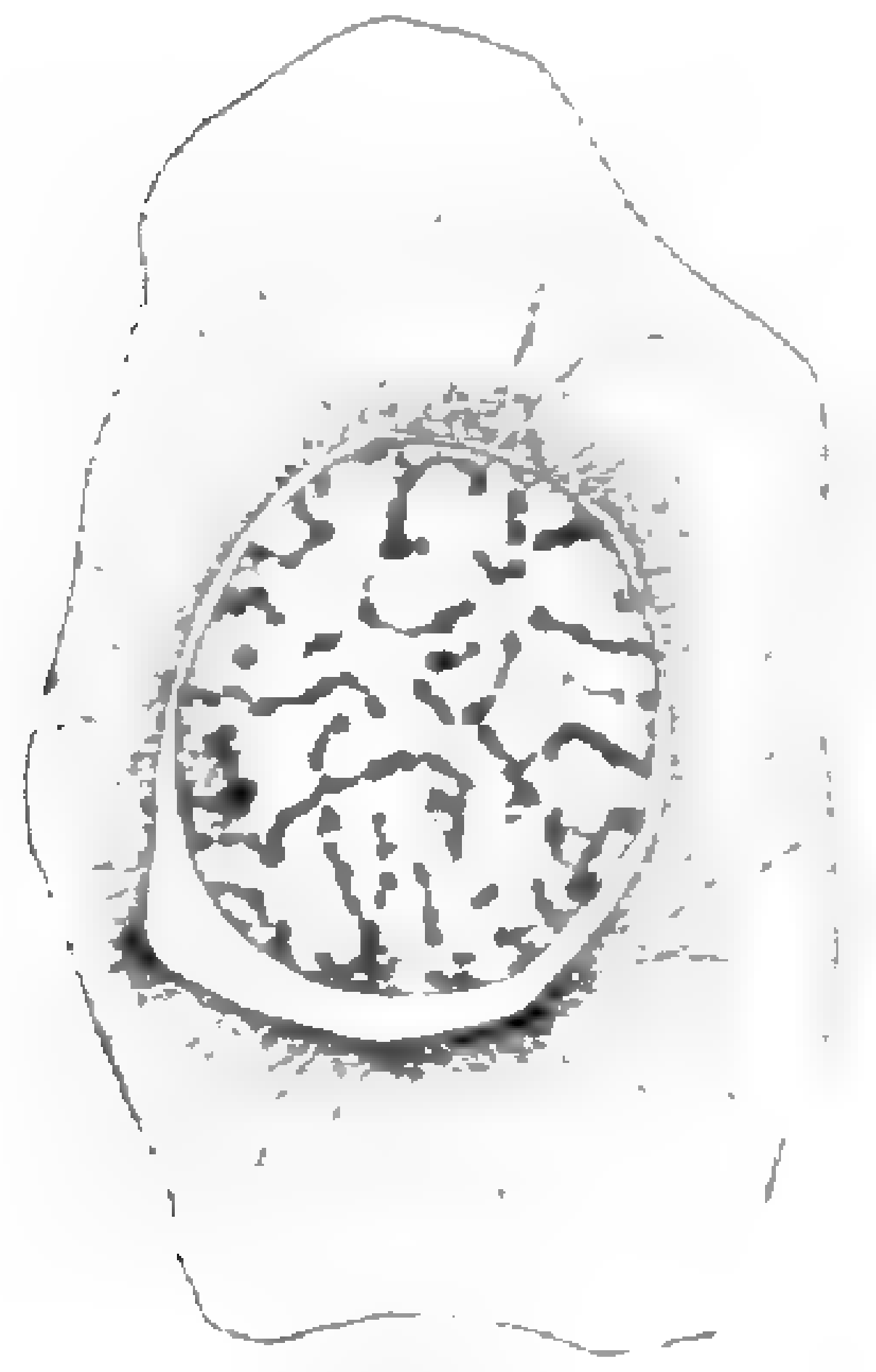
SCHAFFNER on ERYTHRONIUM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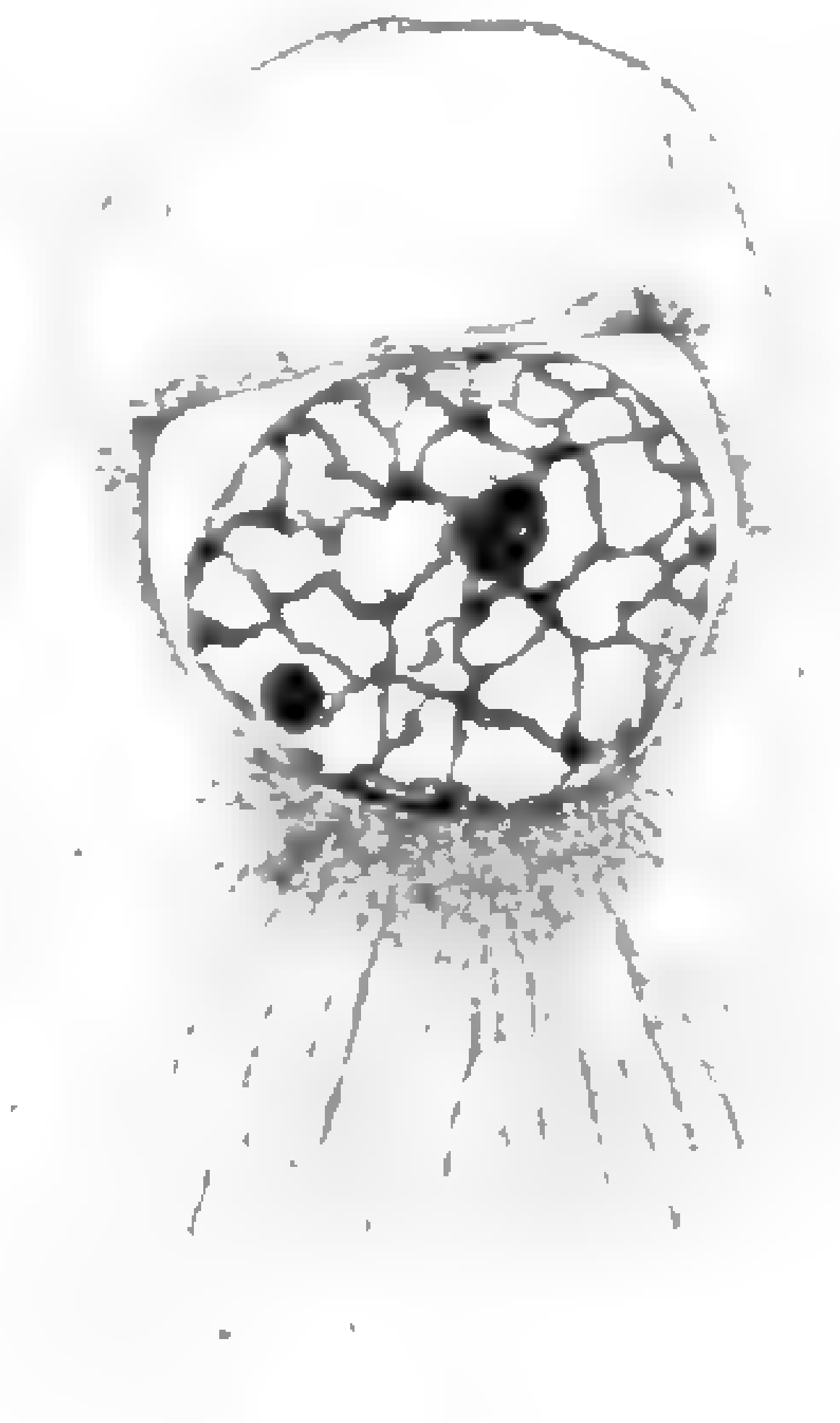
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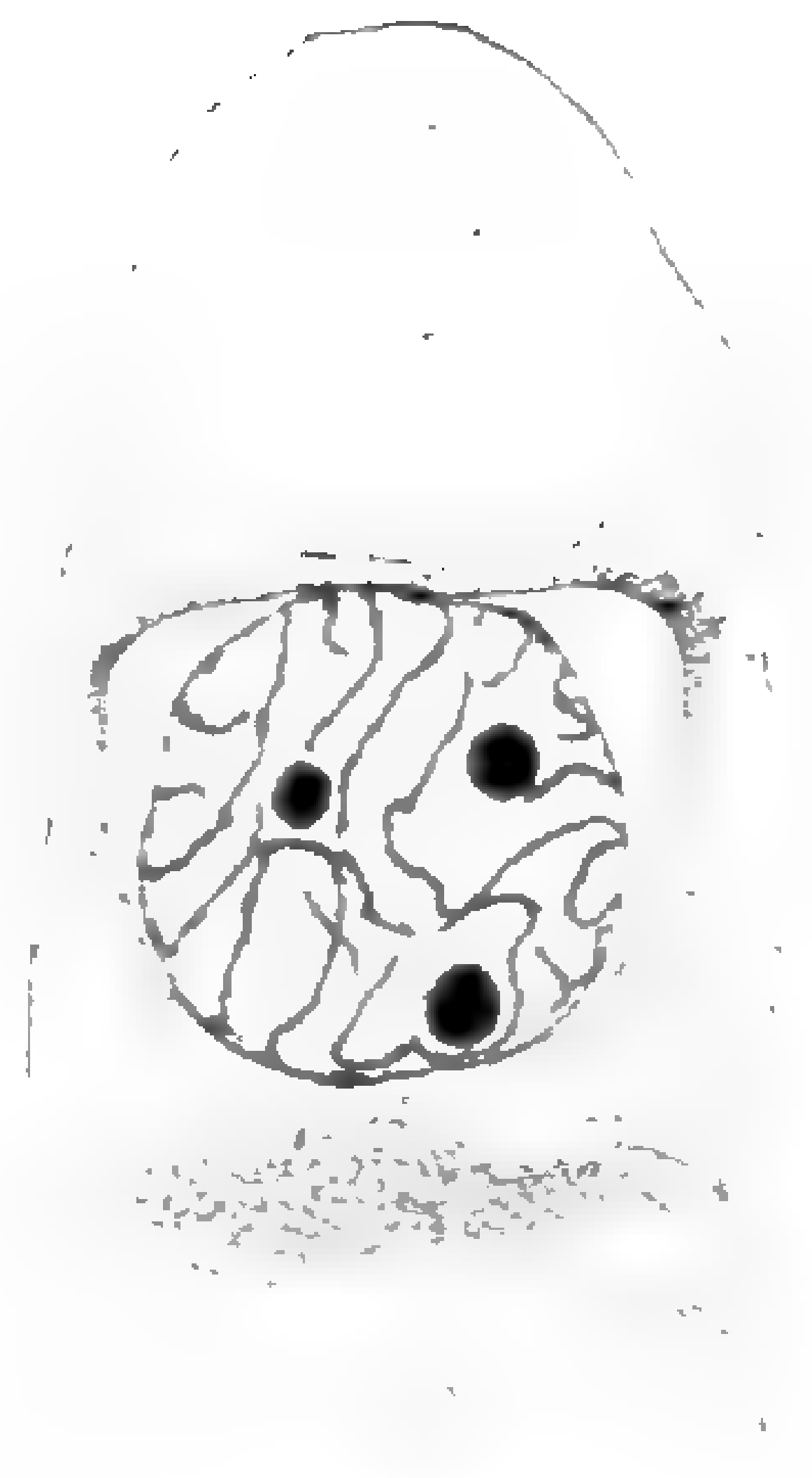
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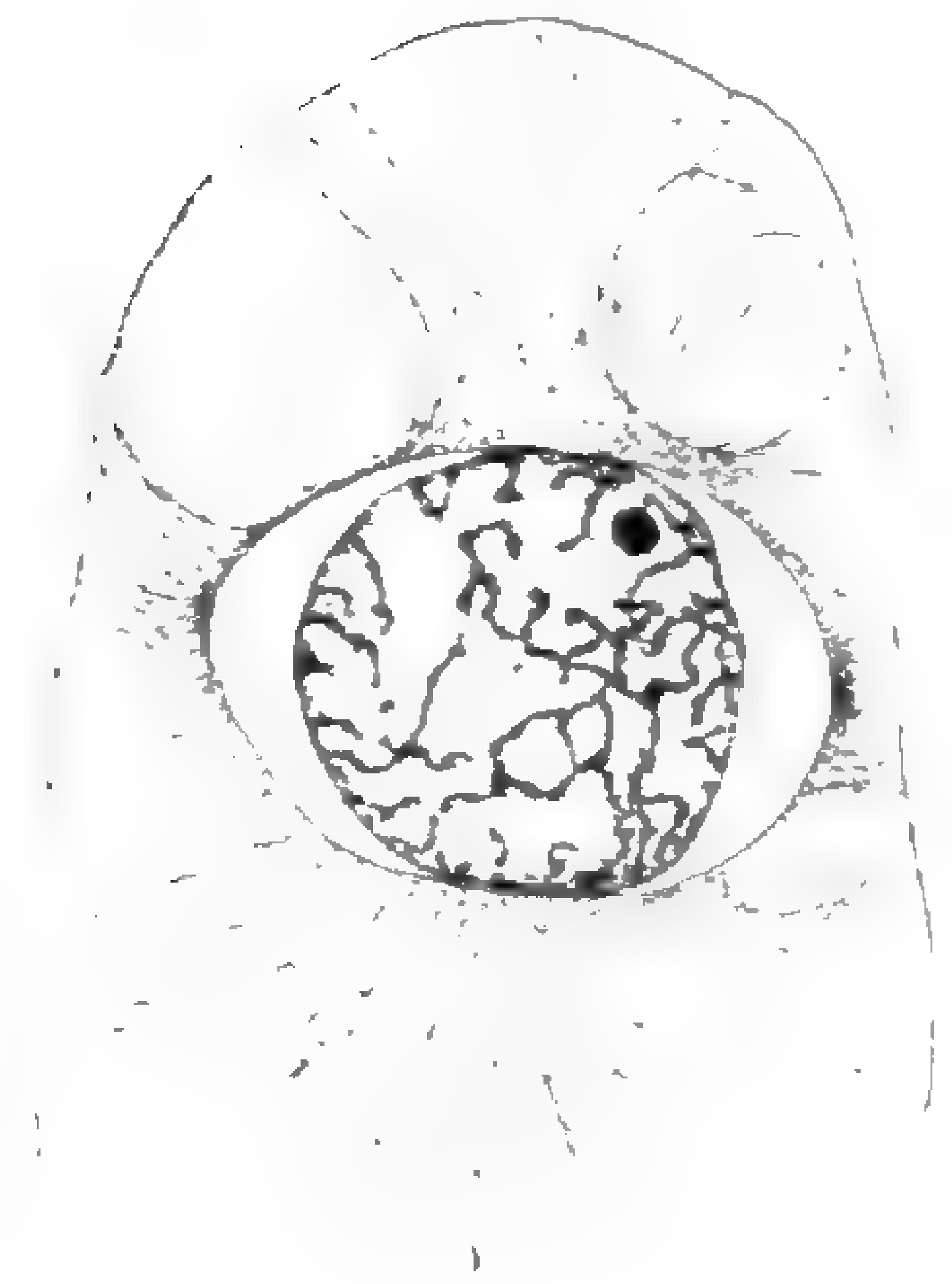
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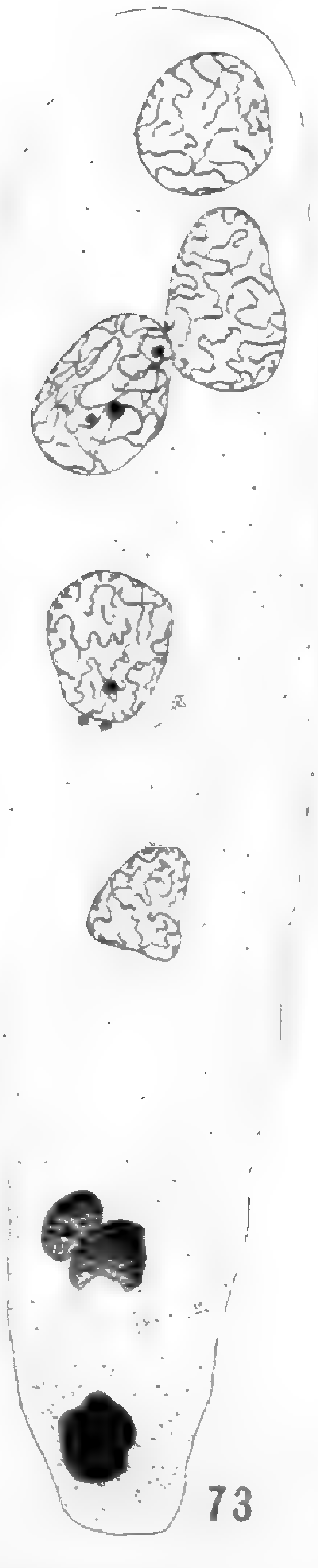
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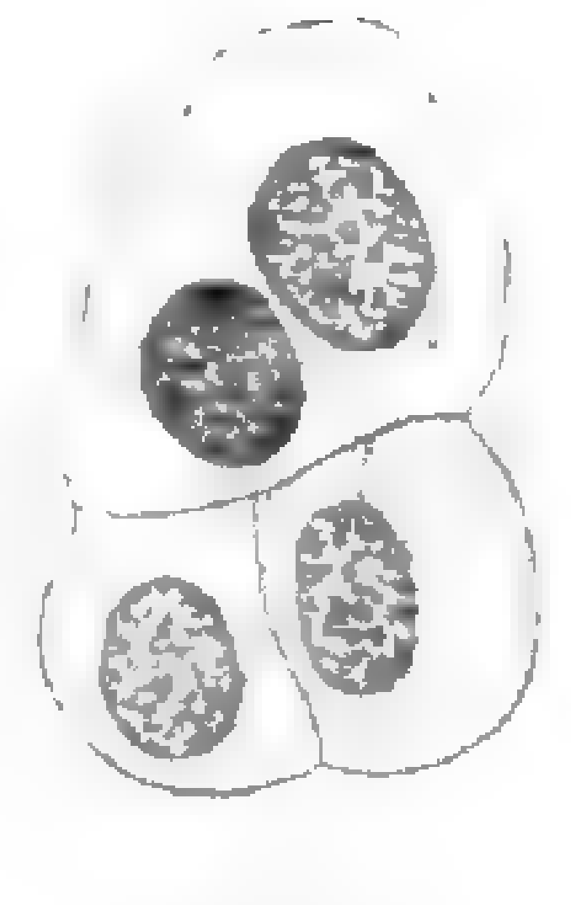
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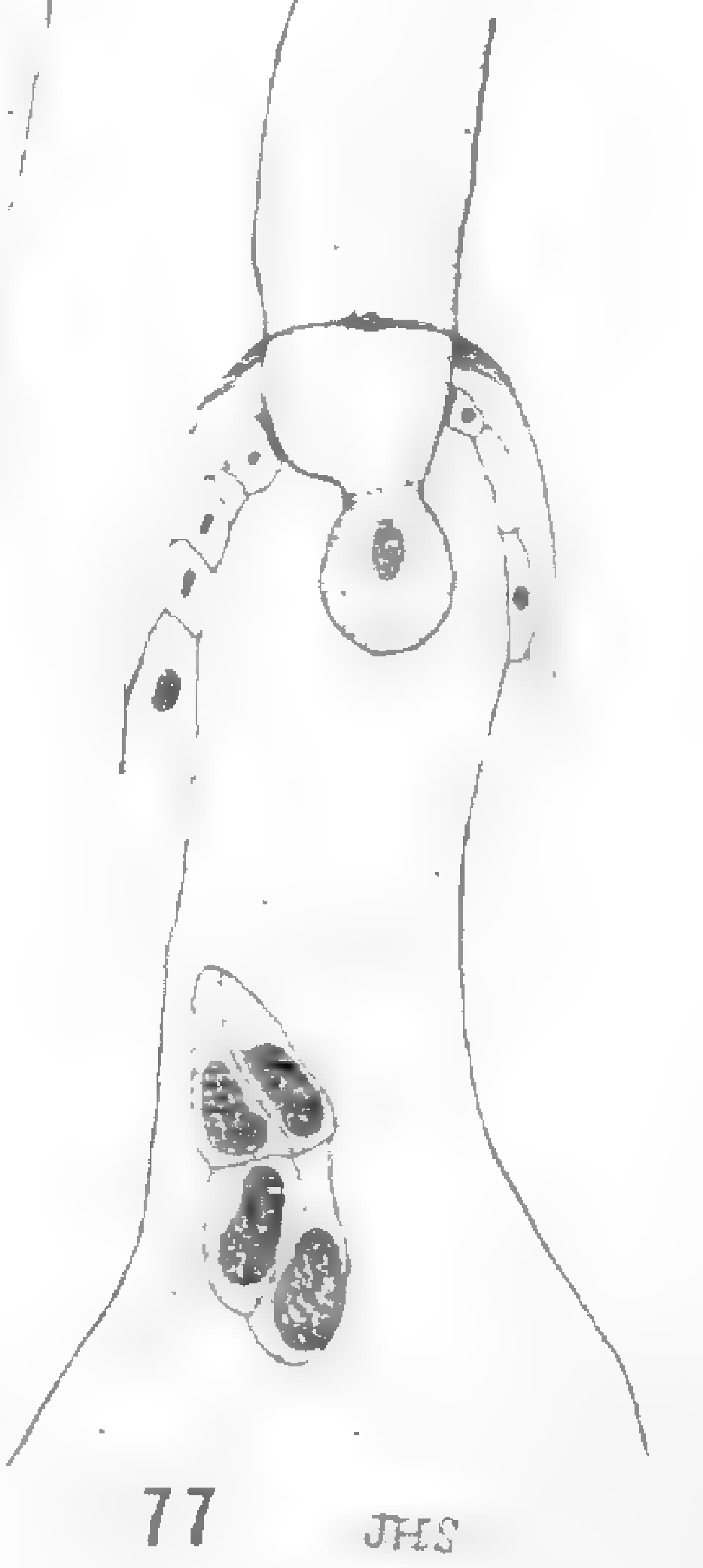
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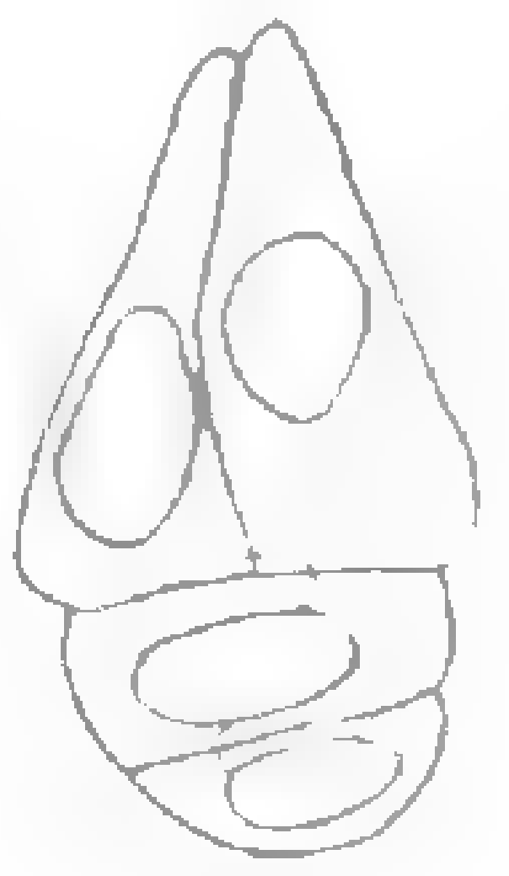

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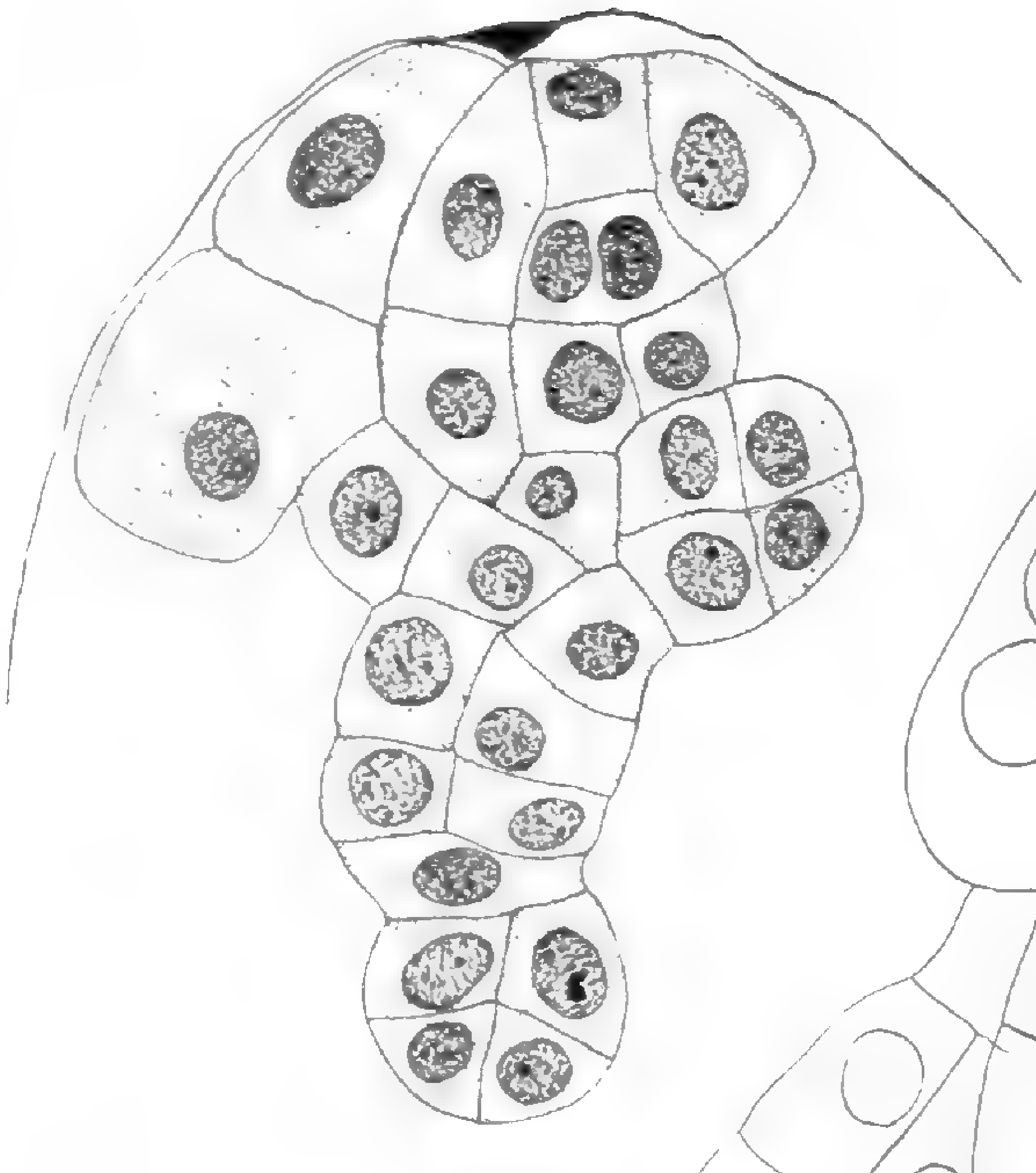

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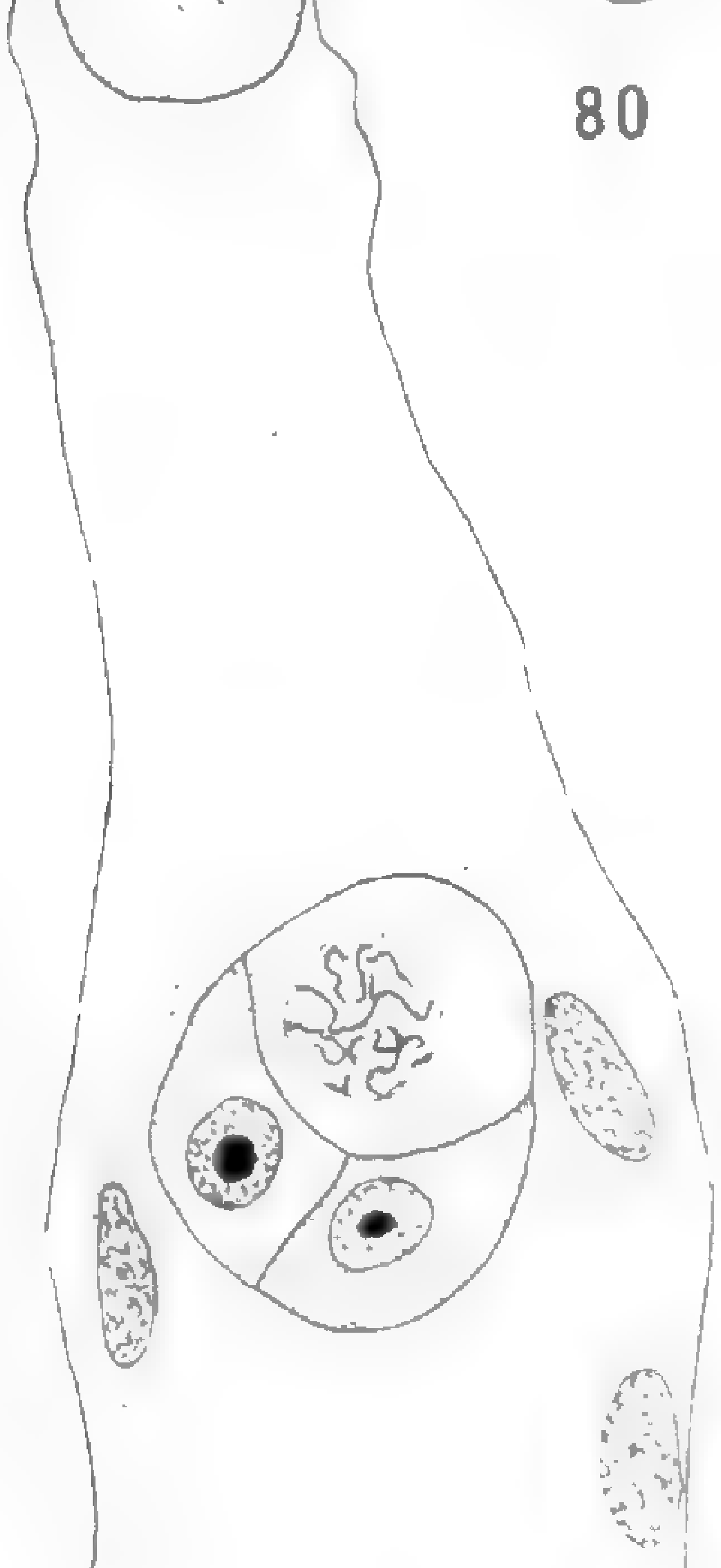

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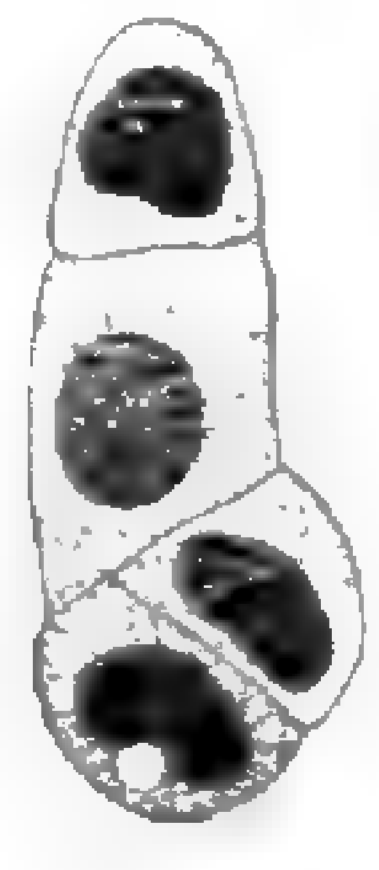

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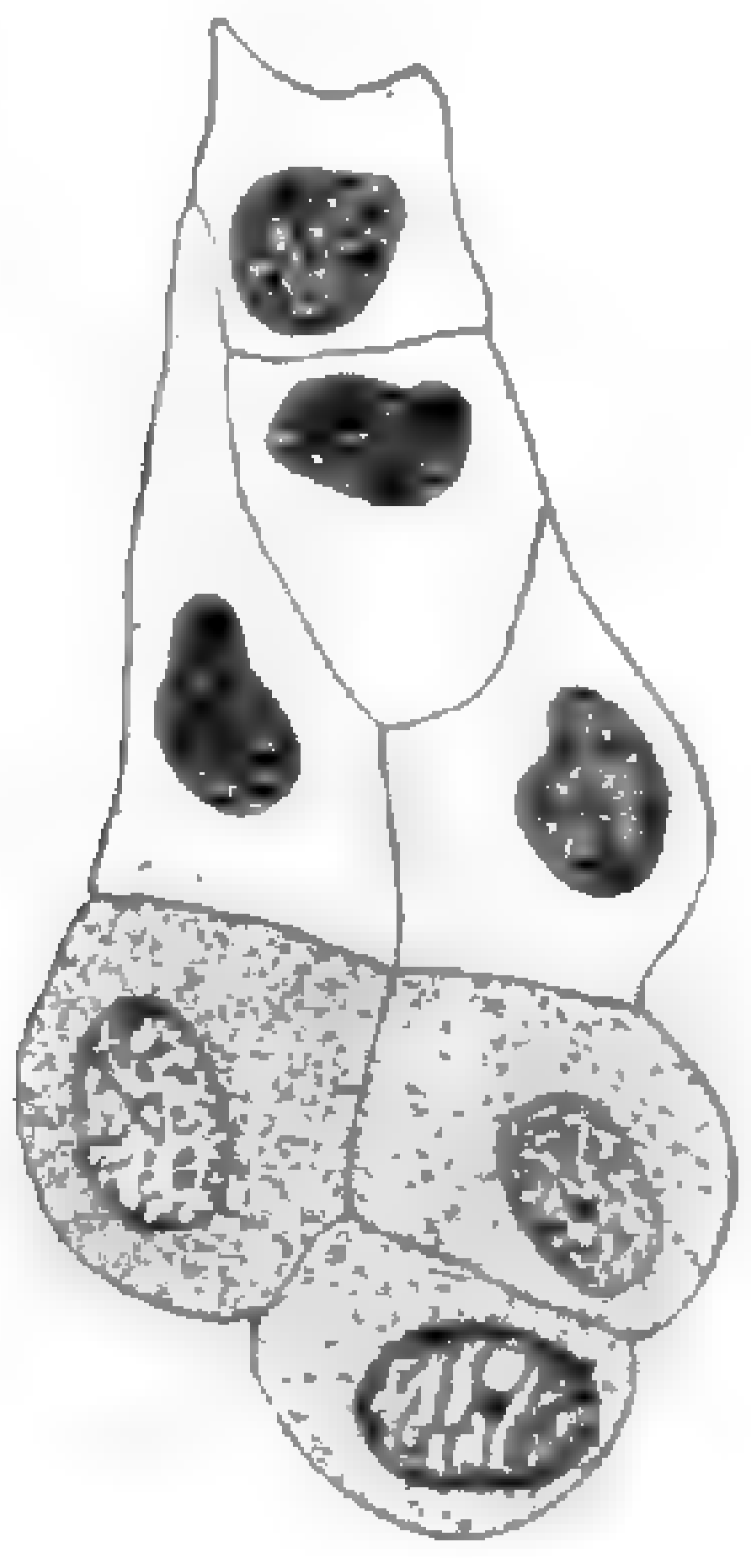

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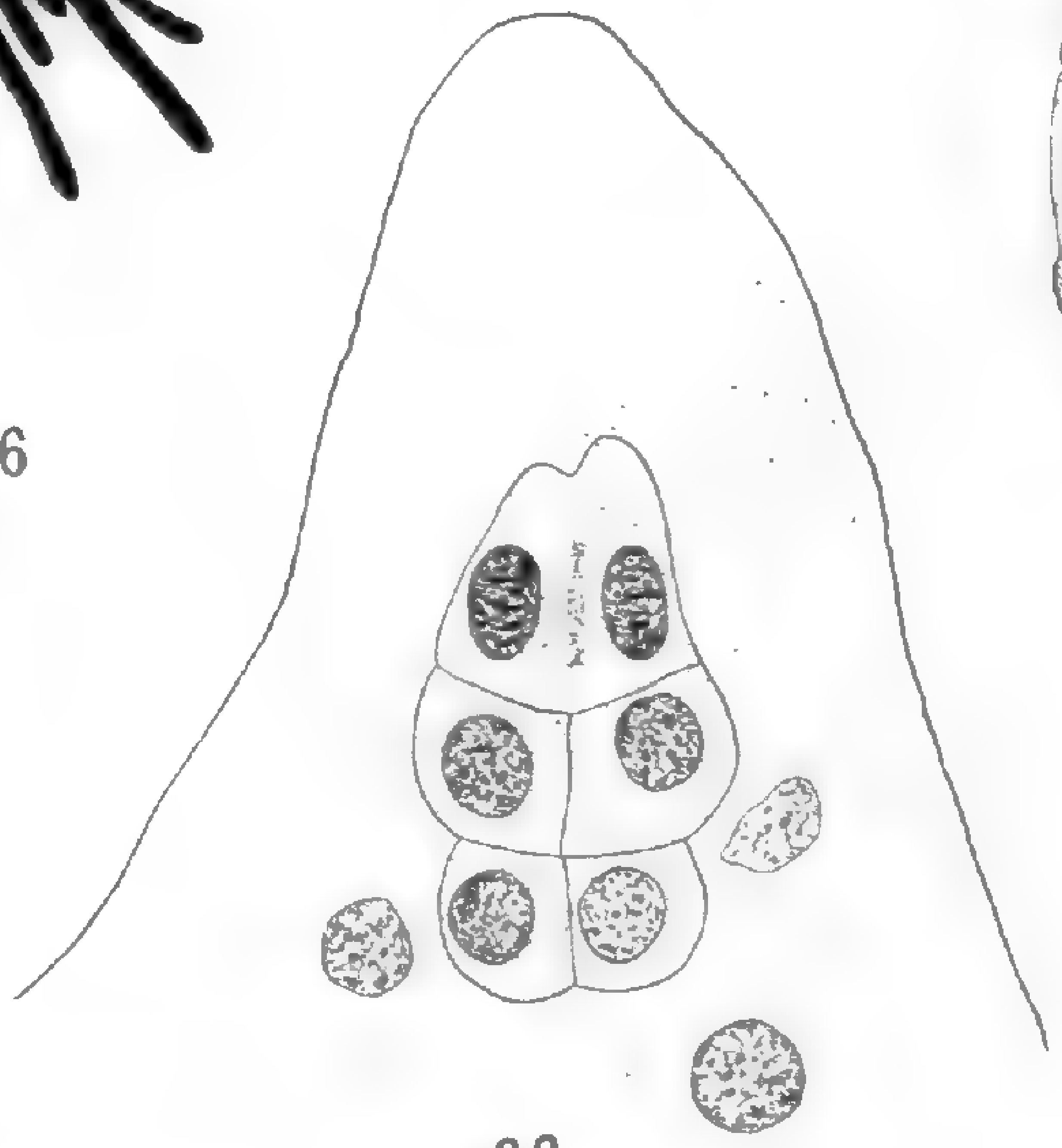

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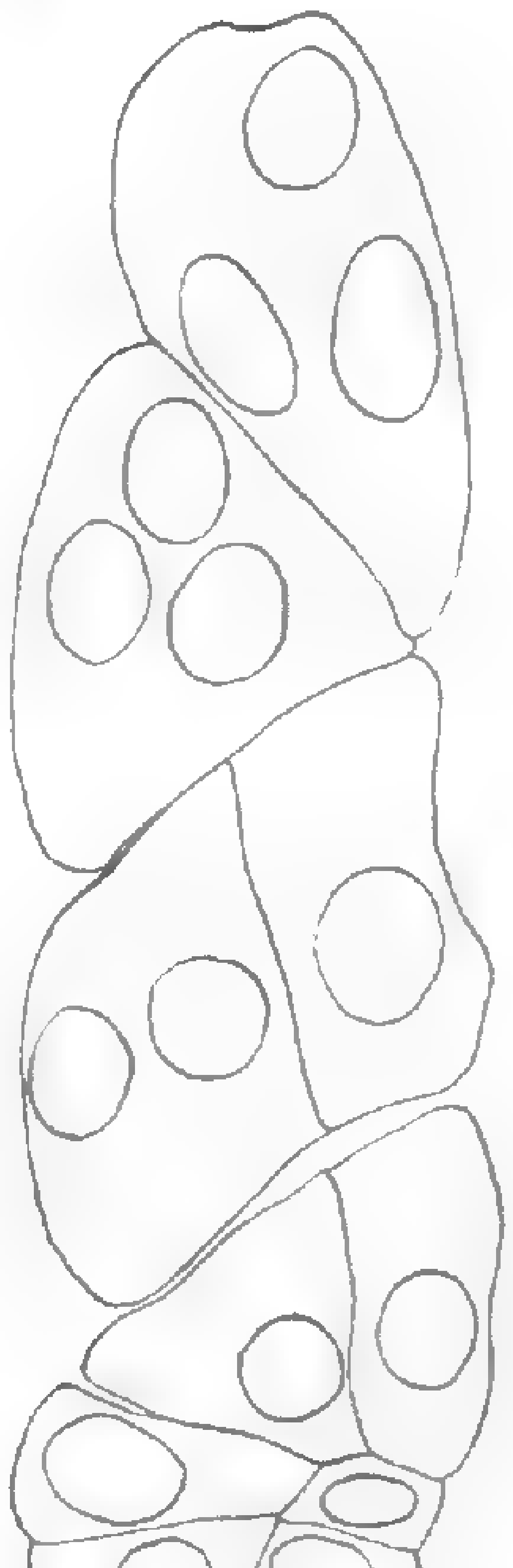

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JHS.

SCHAFFNER on ERYTHRONIUM

FIG. 14. Longitudinal section of style showing glandular cells. B. & L. $\frac{2}{3}$ Z. 18.

FIG. 15. Microspore of *E. Americanum*, December 1. L. $\frac{1}{16}$ Z. 4.

FIG. 16. Pollen grain of *E. Americanum*, April 15; anilin-safranin picronigrosin. L. $\frac{1}{16}$ Z. 4.

FIG. 17. Pollen grain; anilin-safranin gentian-violet. L. $\frac{1}{16}$ Z. 4.

FIG 18. Pollen grain; anilin-safranin gentian-violet. L. $\frac{1}{16}$ Z. 4.

FIG. 19. Pollen grain on stigma with short pollen tube; anilin-safranin gentian-violet. B. & L. $\frac{1}{12}$ Z 4.

FIG. 20. Pollen tube in the style canal showing plugs of dark-staining material. B. & L. $\frac{1}{12}$ L. 8.

FIG. 21. Tip of pollen tube. B. & L. $\frac{1}{12}$ L. 8.

FIG. 22. Young ovule of *E. Americanum* with archesporial cell, October 1. Z. 8 Z. 18.

FIG. 23. Young ovule of *E. Americanum* with archesporial cell, December 1. Flemming's triple stain. Z. 8 Z. 18.

FIG. 24. Young ovule of *E. Americanum* with archesporial cell developed directly into a megaspore, December 1; network beginning to form the continuous spirem; anilin-safranin gentian-violet. L. $\frac{1}{16}$ Z. 12.

FIG. 25. Megaspore nucleus in April; continuous spirem and pale-staining nucleolus; anilin-safranin gentian-violet. L. $\frac{1}{16}$ Z. 12.

FIG. 25 *a*. Another section of the same.

FIG. 26. Megaspore nucleus in looped mother skein stage; anilin-safranin gentian-violet. L. $\frac{1}{16}$ Z. 4.

FIG. 27. Megaspore showing effect of contraction; may be due to freezing; anilin-safranin gentian violet. L. $\frac{1}{16}$ Z. 6.

FIG. 28. Megaspore nucleus at close of close mother skein stage. L. $\frac{1}{16}$ L. 8.

FIG. 29. Megaspore showing twelve chromosomes after disappearance of nuclear membrane. L. $\frac{1}{16}$ Z. 4.

FIG. 30. Megaspore spindle with peculiar poles; anilin-safranin gentian-violet, iron-haematoxylin. L. $\frac{1}{16}$ L. 8.

FIG. 31. Megaspore spindle with one pole cut away and a centrosome at the other; the other pole was in the following section; anilin-safranin gentian-violet, iron haematoxylin. L. $\frac{1}{16}$ Z. 12.

FIG. 32. Megaspore spindle cut $18\,\mu$ thick; distinct centrospheres at the poles; anilin-safranin gentian-violet. L. $\frac{1}{16}$ Z. 6.

FIG. 32 *a*. The following section of the same spindle showing multipolar spindle because of longitudinal sectioning.

FIG. 33. Megaspore; multipolar spindle produced by diagonal cut; several of the chromosomes disturbed by the knife and some in following section; anilin-safranin gentian-violet, iron-haematoxylin. L. $\frac{1}{16}$ Z. 6.

FIG. 34. Another multipolar spindle produced by diagonal cut; one set

of spindle threads dragged out by the knife; anilin-safranin gentian-violet, iron-haematoxylin. L. $\frac{1}{16}$ Z. 6.

FIG. 35. Spindle sectioned near the middle; part of one pole remaining; anilin-safranin gentian-violet. L. $\frac{1}{16}$ Z. 12.

FIG. 36. Daughter star stage showing remarkable radiations around the poles; anilin-safranin-gentian-violet. L. $\frac{1}{16}$ Z. 12.

FIG. 36*a*. Another section of the same.

FIG. 37. Chromosome from reduction nucleus showing twisted condition and late transverse division of chromatin granules; loose mother skein; anilin-safranin gentian-violet. L. $\frac{1}{16}$ Z. 12.

FIG. 38. Mature typical chromosome; chromatin granules have disappeared; anilin-safranin gentian-violet. L. $\frac{1}{16}$ Z. 12.

FIGS. 39–42. Chromosomes at beginning of metakinesis, showing method of untwisting; anilin-safranin gentian-violet. L. $\frac{1}{16}$ Z. 12.

FIG. 43–47. Chromosomes in metakinesis stage showing method of untwisting and indicating transverse division; anilin-safranin gentian violet, iron-haematoxylin. L. $\frac{1}{16}$ Z. 18.

FIG. 48. Single chromosome showing apparent transverse division and tetrad character of the twisted chromosome; anilin-safranin gentian-violet. L. $\frac{1}{16}$ Z. 12.

FIGS. 49–57. Half chromosomes after division in early daughter star; the pole end is in each case at the top; anilin-safranin gentian-violet, iron-haematoxylin. L. $\frac{1}{16}$ Z. 18. Compare *figs. 57* and *44*.

FIG. 58. Daughter star in megaspore; two centrospheres at the poles from which extend a series of polar radiations; anilin-safranin gentian-violet. L. $\frac{1}{16}$ Z. 12.

FIG. 59. Daughter skein showing further development of radiations from the pole; dark bodies are probably micronucleoli; anilin-safranin gentian-violet. L. $\frac{1}{16}$ L. 8.

FIG. 60. Daughter skein showing final arrangement of polar radiations; anilin-safranin gentian-violet. L. $\frac{1}{16}$ L. 8.

FIG. 61. Close daughter skein showing disappearance of radiations and beginning of fusion of chromosomes to form the network; anilin-safranin gentian-violet. L. $\frac{1}{16}$ L. 8.

FIG. 62. Upper nucleus in a two-celled embryo-sac; beginning of division; remains of central spindle still prominent; anilin-safranin gentian-violet, iron-haematoxylin. L. $\frac{1}{16}$ Z. 12.

FIG. 63. Upper nucleus of two-celled sac, showing radiations probably coming from two poles; anilin-safranin gentian-violet, iron-haematoxylin. L. $\frac{1}{16}$ Z. 6.

FIG. 64. Lower nucleus of the same sac; the sections are diagonal.

FIG. 65. Upper nucleus of two-celled sac; incept of spindle and remains of central spindle; anilin-safranin gentian-violet, iron-haematoxylin. L. $\frac{1}{16}$ Z. 6.

FIG. 66. Beginning of second division, showing incept of dome-shaped spindle; also beginning of the collection of central spindle material; anilin-safranin gentian-violet, iron-haematoxylin. L. $\frac{1}{16}$ Z. 6.

FIG. 67. Upper nucleus of two-celled embryo-sac, showing incipient spindle; anilin-safranin gentian-violet, iron-haematoxylin. L. $\frac{1}{16}$ Z. 6.

FIG. 68. Section of two-celled embryo-sac showing two peculiar bodies probably formed from the remains of the central spindle; anilin-safranin gentian-violet, iron-haematoxylin. L. $\frac{1}{16}$ Z. 6.

FIG. 69. Chromosome from metakinesis stage of the second division showing longitudinal splitting; anilin-safranin gentian-violet. L. $\frac{1}{16}$ Z. 12.

FIG. 70. Upper spindle of second division showing the characteristic V-shaped daughter chromosomes; anilin-safranin gentian-violet. L. $\frac{1}{16}$ Z. 12.

FIG. 71. Embryo sac showing the third division; anilin-safranin gentian-violet. L. $\frac{1}{16}$ Z. 4.

FIG. 72. Upper two spindles of the third division; anilin-safranin gentian-violet. L. $\frac{1}{16}$ Z. 4.

FIG. 73. Mature but somewhat abnormal embryo sac; Delafield's haematoxylin-erythrosin. L. $\frac{1}{16}$ Z. 4.

FIG. 74. Embryo sac with fertilized egg and dividing definitive nucleus; anilin-safranin gentian-violet. Z. 8 Z. 12.

FIG. 75. Two-celled embryo. Z. 8 Z. 12.

FIG. 76. Two-celled embryo and dividing endosperm; pollen tube in the micropyle. Z. 8 Z. 4.

FIG. 77. Four-celled embryo; pollen tube above. Z. 8 Z. 12.

FIG. 78. Four-celled embryo. Z. 8 Z. 12.

FIG. 79. Section of five-celled embryo; two cells in upper tier and three below. Z. 8 Z. 12.

FIG. 80. Six-celled embryo. Z. 8 Z. 12.

FIG. 81. Six-celled embryo; two cells in the lowest tier cut away. Z. 8 Z. 12.

FIG. 82. Section of twelve to fifteen-celled embryo. Z. 8 Z. 12.

FIG. 83. Section of about twelve-celled embryo, showing marked difference in staining reaction between the upper and lower cells. Z. 8 Z. 12.

FIG. 84. Embryo considerably advanced, showing the large suspensor. Z. 8 Z. 12.

FIG. 85. Restored embryo showing much lobed suspensor about the same age as the preceding embryo. Z. 8 Z. 12.

FIG. 86. Daughter star from endosperm showing sharp pointed spindle ending in a centrosome; anilin-safranin gentian-violet, iron-haematoxylin; *E. Americanum.* L. $\frac{1}{16}$ Z. 12.

FIG. 87. Section of advanced embryo showing lobed suspensor. Z. 8 Z. 12.

FIG. 88. Section of embryo somewhat older than the preceding, showing the massive suspensor; remains of pollen tube in the micropyle. Z. 8 Z. 12.

STUDIES ON CALIFORNIAN PLANTS. I.[1]

H. M. HALL.

(WITH PLATE X)

SPECIES FROM SOUTHERN CALIFORNIA.

Frasera neglecta, n. sp.—Plant perennial, 3–6^{dm} high, with several slender terete glabrous stems arising from a single perpendicular tap root: leaves all opposite, thick and leathery, not at all succulent; the lowermost crowded, 13–18^{cm} long, 4.3–8.6^{mm} wide, interspersed with others only 5^{cm} or less long, tapering for nearly their whole length to the base which abruptly widens and unites with the opposite leaf to form a short sheath; the upper merely sessile by a broad base, those of the inflorescence gradually reduced to spreading or recurved linear-lanceolate acute bracts: inflorescence an elongated interrupted thrysus, the lower cymes on ascending peduncles 5–10^{cm} long, few-flowered, upper cymes short-peduncled or sessile and more densely flowered; pedicels varying from 1^{cm} in length to almost obsolete: sepals 4, lanceolate, cuspidate-acuminate, 6.5^{mm} long, the margins scarious: petals oblong, acute, 8.6–10.8^{mm} long, greenish-white, the veins purple; petaline gland replaced by a tubular nectary, which reaches from the base of the petal nearly to the middle where it appears on the inner surface as a circular cavity with an indenture on the upper side, the orifice surrounded by a raised membrane with finely divided margin forming a fringed border: stamens 4; filaments nearly as long as the petals, tapering from the broad base to the tip; anthers oval: ovary ovate, attenuate into the slender style which is as long as the stamens.

Collected at the head of Swarthout cañon, San Antonio mountains, altitude 2070^{m}, June 1900, 1495 *Hall* (type); Holcomb valley, San Bernardino mountains, August 1882, *Parish;* Rock creek, San Gabriel mountains, July

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[1] Contributions from the Botanical Laboratories of the University of California.

1893, *Davidson*. All these localities are on the north slope of the San Bernardino range. The specimens from Holcomb valley are not as thrifty as the type; the flowers are somewhat smaller and the leaves (all under 7^{cm}) are principally from the base, leaving the long internodes exposed. The type is in the Herbarium of the University of California.

This plant has been confused with *Frasera nitida* Benth., but it differs from that more northern species in the more open inflorescence, the more slender and acuminate leaves and bracts, and above all by the absence of the petaline gland, which in *F. nitida* is narrowly oblong and open for its whole length. The nectary in the proposed species is a pocket-like organ inserted within the tissues of the lower part of the petal, the opening surrounded by a narrow flap with ciliate margin. The raised tissues over the lower part of the nectary are ordinarily brown in color.

EXPLANATION OF PLATE X.—*Fig. 1.* A plant from a single root; × ½. *Fig. 2*, a flower; × 1. *Fig. 3*, petal showing nectary; × 2. *Fig. 4*, longitudinal section through petal and nectary; × 2. *Fig. 5*, a stamen; × 2.

ASCLEPIAS CALIFORNICA Greene, Erythea 1:92. *Acerates tomentosa* Torr. Two well-marked forms of this species are found in Southern California. In the more common form the leaves are broadly ovate and distinctly petioled, while the pedicels are short. The extreme of this form comes from Lytle creek cañon, altitude 1830^{m}, and has leaves $5–6.2^{cm}$ wide by 7.6^{cm} long, while the pedicels are all under 2^{cm} in length.

The second form has oblong-lanceolate slenderly acuminate sessile leaves and elongated pedicels. The extreme of this form was collected along the Temecula river and has leaves 5^{cm} wide by 15^{cm} long, while the spreading pedicels are 3^{cm} in length.

That these forms do not deserve even varietal rank is shown by the fact that many intermediate forms exist, and one may pass from one extreme to the other by merely ascending a few thousand meters on some of the mountain slopes. At 914 meters in Cajon pass the slender-leaved form prevails, while in passing up the mountains west of the pass various forms are encountered until the extreme of the broad-leaved form is met at 1830 meters.

Gilia modesta, n. sp.—Plant annual, 15^{cm} high or less, divaricately branching from near the base, the branches ascending, either glabrous or sparingly pubescent: leaves mostly opposite below, the upper alternate, 1^{cm} long, palmately 3–7-divided nearly to the base into rigid linear pungent-tipped lobes, these with strong midribs: flowers disposed singly or in pairs in the forks where they are short pedicellate, and clustered at the ends of the branches where they may be either sessile or short pediceled: bracts similar to the leaves but lobes usually only three, sparingly beset with loose cobwebby hairs: calyx pubescent, 8–11^{mm} long, about equaling the bracts, cylindrical with acute base, hyaline membranous with green ribs prolonged beyond the hyaline portion into pungent-tipped nearly equal lobes which are 2^{mm} or so long: corolla white, with the tube and throat yellow and with two purple lines at the base of each lobe; tube short; throat funnelform, 6–8^{mm} long, nearly equaled by the broadly obovate spreading lobes: stamens equally inserted near the base of the corolla tube, unequal in length, included: ovules in each cell 2 or 3; seeds oblong, developing spiracles only sparingly when wetted.

Gravelly hillsides of Lytle creek cañon along the trail to San Antonio peak, altitude 1830^{m}, June 1, 1900, 1443 *Hall* (type); Swarthout cañon, San Antonio mountains, altitude 2000^{m}, June 3, 1900; near Bear valley, San Bernardino mountains, altitude 2000^{m}, July 16, 1899. The type is in the Herbarium of the University of California.

This species is most nearly related to *Gilia demissa* Gray, but is easily distinguished from that by a number of important characters. *G. modesta* is a much larger plant, with a corolla fully 13^{mm} long, and nearly as wide when expanded, while *G. demissa* has a corolla only 6.5^{mm} long. The proposed species has a calyx of 5 narrow green ribs of equal width throughout, between which is stretched a hyaline membrane connecting them for three fourths their length, while *G. demissa* has a calyx of 5 lanceolate nearly distinct segments each with a scarious margin. The lobes of the leaves and bracts are more slender and rigid than in *G. demissa*, and the ovules are never more than three in each cell, as against seven in *G. demissa*. From *G. Parryæ* Gray it differs in many respects, principally in the absence of scales at the base of the corolla lobes. The general appearance suggests relationship with the members of the Linanthus section, but it differs from all those in the pubescence, in the funnelform corolla, in the small number of ovules, and in other characters.

COLLINSIA CALLOSA Parish, Erythea **7**:96, Richardson's ranch near Manzana in Antelope valley, May 1896, 2503 *J. Burtt Davy*. This was probably the first collection of this rare plant, the original description being drawn from specimens collected in the San Antonio mountains, June 1899.

CHÆNACTIS XANTIANA Gray. This species is well distributed along the mountains surrounding the western part of the Mohave desert, often at altitudes of 1800–2000^{m}. An exceedingly robust form has been collected at Manzana in Antelope valley, altitude 780^{m}, by *Mr. J. Burtt Davy* (no. 1512, May 1896). The stout fistulous stems are 3^{dm} high and terminated by heads 2^{cm} high; involucral bracts slenderly acuminate, 2^{cm} long; the inner pappus when fully developed longer than the corolla. It is hoped that collectors visiting that region may secure more material in order that the relation between this and the typical form may be more clearly understood.

CHÆNACTIS HETEROCARPHA CURTA Gray. Near Estrella in the Coast ranges of San Luis Obispo county, *L. Jared.* In these specimens the paleae of the pappus are reduced to mere rounded scales, which form a crown about the summit of the akene.

A TRIP TO THE SOUTHERN HIGH SIERRAS.

During the summer of 1900 Mr. H. P. Chandler and the writer spent some two months botanizing in the Sierras of Fresno county. Our first stop was at Ockenden, a small settlement on the ridge between the Kings and San Joaquin rivers, and well within the coniferous forests. Reaching here on June 12 we found the season just opening, many of the species still being in too young a condition to make good herbarium specimens.

After spending two weeks in that region we followed the trail to Tehipite valley, making side trips to the Dinkey grove of big trees and Bald mountain *en route.* Tehipite valley is a deep gorge several miles wide on the Middle fork of the Kings river. The floor of the valley is 1220^{m} in altitude, while the walls rise to over 2100^{m}. The flora was somewhat similar to that of the foothill region, and when we reached the valley (July 6) many of the annuals had already passed out of flower.

The Mount Goddard region was also visited, the route leading by Black mountain, Blaney meadows, and the South fork of the San Joaquin. On July 24 we camped at the very base of the mountain just above timber line. The only shrub seen here was *Salix glauca villosa*, but hardy thick-rooted perennials grew abundantly around the lakes, and fifty-seven species were gathered above 3350^m. Thirty-three of these were also found below timber line, leaving twenty-four strictly alpine species. Ascending the peak the vegetation grew more and more scanty, until at 4000^m only *Draba Breweri*, *Erigeron compositus*, and *Polemonium confertum* remained, while on the very summit, at 4130^m, the Polemonium was the sole representative of the whole series of phænogamous plants.

The following species collected on this trip seem worthy of note.

ERIGERON BLOOMERI Parish, Erythea **6**:87. Not rare in Tehipite valley, July 7, *Hall & Chandler*, no. 513. Determined by Mr. S. B. Parish.

ERIOGONUM NUDUM Dougl. An alpine form was collected near Mount Goddard at 3100^m. The slender stems are not over 2^{dm} high and are nearly always simple and monocephalous, July 1900, *Hall & Chandler*, no. 662.

AQUILEGIA PUBESCENS Coville, Contrib. U. S. Nat. Herb. **4**: 56. Among rocks on Mount Goddard at 3660^m, July 1900, *Hall & Chandler*, no. 671.

DODECATHEON JEFFREYI **redolens**, n. var.—Exceedingly robust, 4.5–6^{dm} high, the herbage redolent with a strong odor: leaves erect, lanceolate or spatulate, 2.5–4^{dm} long including the slender winged petiole: inflorescence glandular pubescent: flowers invariably 5-merous: lower part of stamens and capsule included in the corolla tube, which is not closely reflexed.

Along the lakes at the base of Mt. Goddard, 3400^m, July 25, 1900, *Hall & Chandler*, no. 676. Type in the Herbarium of the University of California.

This variety is easily distinguished in the field by the rank odor and by the shape of the corolla. The folding of the latter takes place well up on the tube, thus making the yellow band very prominent, while the purple ring at the base of the corolla in the species is lacking in the variety.

ERIGERON SALSUGINOSUS Gray. This plant, not rare at middle

HALL on FRASERA NEGLECTA, n. sp.

altitudes in the Sierras of Fresno county, exhibits a wide variation in the pubescence. Some specimens are covered with a close pubescence on the leaves and stems, while other are entirely glabrous except on the peduncles and involucres. These forms grow side by side and intergradations are plentiful.

CNICUS TROGANUS Congdon, Erythea **7**: 186. Blaney meadows on the South fork of the San Joaquin at 2320^m altitude, July 1900, *Hall & Chandler*, no. 721.

PHALACROSERIS BOLANDERI **coronata**, n. var.—Akenes with an evident pappus consisting of a crown with a divided margin. Otherwise as in the type.

Pine ridge, in the Sierras of Fresno county, altitude 1650^m, June 15–25, 1900, *Hall & Chandler*, no. 187 (type). Specimens were also examined from Mariposa county (*Congdon*, October 1896), Yosemite (*Mrs. Brandegee*, July 1883), and Fresno county (*Mrs. Peckinpah*, 1890), and in each case the akenes were found to bear pappus. In old akenes the pappus is not so evident as in the younger ones, as it is curved inward, due to its inability to keep pace with the growing akene. The type is in the Herbarium of the University of California.

The preparation of this paper has been greatly facilitated by the kindness of Miss Alice Eastwood of the California Academy of Sciences, Mr. and Mrs. T. S. Brandegee of San Diego, and Mr. S. B. Parish of San Bernardino, in sending specimens for examination; and of Mr. Merritt L. Fernald, of the Gray Herbarium, for notes on the type specimen of *Gilia demissa*. To Professor W. L. Jepson, of the University of California, I am under special obligations for his continued interest and valuable suggestions without which the paper would not have been prepared.

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Berkeley, Cal.

CONTRIBUTIONS FROM THE ROCKY MOUNTAIN HERBARIUM. II.

AVEN NELSON.

SOME COLORADO SPECIES.

AN interesting collection of Colorado plants, some 300 numbers, was kindly submitted to me for examination by Professor Ramaley, of the University of Colorado. They were largely of his own collecting, but some of them were by F. Y. Moseley, and yet others by Jennie M. Archibald, of Berwind, Colorado. Among them were many of much interest and a few novelties, upon which the following notes and characterizations are offered.

ZYGADENUS COLORADOENSIS Rydb. This interesting recently described ally of *Z. elegans* seems to be peculiarly a Colorado species, as I have not yet met with it in Wyoming.

CHEIRANTHUS sp. A peculiarly branched form, with petals almost rose-colored, was represented by two numbers. It was evidently not far from *C. asper* Nutt., but fruiting specimens may show it to be distinct.

CLEMATIS SCOTTII Porter. This rare plant was represented by rather young specimens, but even these indicated the distinctness of the species as compared with *C. hirsutissima* Pursh.

SAXIFRAGA RHOMBOIDEA **austrina**, n. var.—Size, habitat and foliage of the species: stems not rarely several from the short rootstock, pubescent with gland-tipped hairs as is also the inflorescence: inflorescence paniculately cymose, strict: calyx lobes obtuse, as long as the adnate base: petals elliptic, white, 3^{mm} long: carpels ovoid, the tips at length widely divaricate: seeds very numerous, brown, oblong, more or less subacute at both ends.

That this is a good species seems quite possible. The paniculate inflorescence and conspicuously gland-tipped pubescence is in strong contast to the usually spherical terminal cluster (which at most becomes only branched-thyrsiform) and the glandless pubescence of *S. rhomboidea* Greene, Pitt.

3:343. In the variety proposed the petals are not emarginate, the calyx lobes are longer than in the species; the presence of a rather conspicuous ciliate-pubescence on the margins of the leaf in the variety adds another point of contrast.

Excellent specimens are in hand from *Jennie M. Archibald*, Berwind, Colorado, 1900, no. 236.

Parosela Porteri, n. sp.—Caudex woody, with a deep-set woody root: stems numerous from the enlarged crown, prostrate-assurgent, quite unequal in length, 10–25^{cm} long (including the oblong spike), strigose, appressed-pubescent: leaves trifoliate, densely appressed strigose-silky, cuneately obovate or narrower, mostly obtuse, 8–14^{mm} long, the terminal one longer than the lateral pair, barely petiolulate, generally shorter than the slender petiole; stipules slenderly and stiffly setaceous, 5–6^{mm} long: spike dense, 2–5^{cm} long; bracts purple, lanceolate-acuminate, equaling or shorter than the calyx, silky-villous; calyx tube campanulate, membranous with ten greenish nerves, the triangular base of its lobes abruptly narrowed into long slender plumose setae which are twice as long as the tube; corolla lemon-yellow; the standard very short, reniform-triangular, acute, broader than long, shorter than the slender claw; the wings oval, short clawed; keel petals oval or even broader, surpassing the wings, the blade about 6^{mm} long and the claw about 2^{mm}; ovary silky, included in the calyx tube, half as long as the slender plumose style which is much exceeded by the calyx lobes.

The somewhat varying descriptions of *Parosela Jamesii* indicate that more than one species has been distributed under this name. That the species now proposed is the *Dalea Jamesii* of Porter, *Fl. Colorado*, seems probable, but from the original as described in T. & G. *Fl. N. Am.* 308, the following points seem to separate it. *P. Porteri* is more prostrate spreading, the leaves are narrower and are shorter than the petioles, the pubescence is coarser, it has purple bracts, the flowers are yellow not purple, and the wings and keel are oval not oblong as in *P. Jamesii.*[1]

Collected at Berwind, Colorado, 1900, by *Jennie M. Archibald*, no. 244.

Petalostemon pubescens, n. sp.—Roots woody; the crown thick, simple or branched: stems numerous, the exterior ones

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[1] Dr. Gray in redrawing the description for Pl. Wright. 49, seems to have so modified the original description as possibly to include *P. Porteri.*

prostrate-assurgent, the central suberect, 1–2^{dm} long, whitish with a sublanate pubescence: leaves neither glandular nor dotted, 5-foliate, nearly glabrous above, the pubescence underneath and on the petioles resembling that on the stems; leaflets spatulate-linear, sessile, 10–14^{mm} long; petioles about as long, often with a pair of diminutive trifoliate leaves in the axils; stipules filiform: spike oblong, dense, 2–5^{cm} long, 1^{cm} or less in diameter; peduncles short (1–5^{cm}): bracts scarcely equaling the calyx, obovate, abruptly acuminate, the dark purple tip obscured by the copious silvery lanate pubescence of the spike as a whole: calyx 4–5^{mm} long, the teeth shorter than the tube: petals light purple; the limb of the standard broadly cordate, about 3^{mm} in diameter, exceeded by the filiform claw: ovary and base of style softly pubescent.

Most nearly allied to *P. tenuifolius* Gray, from which it is at once to be distinguished by its very different habit, shorter broader leaflets, shorter peduncles and slenderer spikes, obovate short-acuminate purple tipped bracts, light purple petals, and the almost entire absence of glands or dots anywhere on the plant.

The species is founded on no. 247 from Berwind, Colorado, by *Jennie M. Archibald.*

Gentiana Moseleyi, n. sp.—Perennial from slender fleshy rootstocks, about 1^{dm} high, glabrous throughout, 1–2-flowered (possibly more): leaves about 4 pairs, two of which are basal and nearly verticillate, from narrowly oblanceolate and petioled below to broadly linear and sessile above, 2–3^{cm} long: the terminal flower subtended by a pair of foliar linear-lanceolate bracts often nearly as long as the calyx; additional flowers (if any) axillary in the uppermost leaves and smaller: calyx green with purple streaks, about 15^{mm} long; the lobes triangular-lanceolate, equaling or exceeding the tube: corolla dark blue, about 25^{mm} long; the lobes oblong, obtuse, exceeding the tube (15^{mm} long), 5–7^{mm} broad, conspicuously long setaceous-lacerate on the sides and often nearly to the summit which is obscurely dentate; the tube arachnoid woolly within especially toward the base: filaments stout, flattened, equaling the tube: stipe half as long as the elliptic-oblong capsule: style almost wanting.

The habit and general appearance of this excellent species is much like *G. elegans unicaulis* Aven Nelson. In fact at first glance I thought of it as that, but no one really stopping to look at it can possibly mistake one for the other. *G. Moseleyi* is certainly a perennial; the conspicuous fringe upon the corolla lobes which exceed the tube and the sessile stigmas at once mark it as distinct from the other.

The specimens were collected by *F. Y. Moseley* in Boulder county, Colorado, 1896. The exact locality is not known, but it probably was in some of the higher mountains.

Polemonium Archibaldae, n. sp.—Stems tall ($4–7^{dm}$), erect, slender, sparsely pubescent but not glandular except in the inflorescence: leaves glabrate, deeply pinnately divided, the midrib merely narrowly margined between the segments and on the very short petiole, $8–12^{cm}$ long; the segments subpaired, 13–19, oblong-lanceolate: inflorescence corymbose-cymose, minutely glandular-pubescent especially on the calyx; the small cymes (5–9-flowered) erect, congested (the pedicels very short); peduncles slender, the lower $5–10^{cm}$ long: calyx campanulate, $6–7^{mm}$ long, the lanceolate lobes as long as the tube: corolla rotate-campanulate, $10–14^{mm}$ in diameter, the lobes suborbicular, as long as the tube, from deep purple to much lighter: filaments filiform, a little shorter than the corolla, glabrous except at the insertion where they are densely and finely pubescent; anthers oblong, large, 3^{mm} long: stigmas scarcely exserted.

This species is closely related to *P. filicinum* Greene, but differs from that in the somewhat narrower leaves, in the ampler inflorescence, in orbicular (not acute) corolla lobes, in the relatively shorter calyx lobes, in its erect (not declined) stamens, and in its shorter style. The inflorescence is probably also much less glandular, for Dr. Greene characterizes *P. filicinum* as being densely glandular-viscid in the inflorescence.

The species is dedicated to Jennie M. Archibald, who secured at Berwind, Colorada, in 1900, a most interesting collection. The type is in the Rocky Mountain Herbarium, no. 220 of the collection mentioned.

Monarda Nuttallii, n. n.—*Monarda aristata* Nutt., Trans. Am. Phil. Soc. n. ser. **5**: 186. 1837; not *Monarda aristata* Hook., Bot. Mag. t. 3526. 1836. This has been for some time included in *Monarda citriodora* Cerv., but any suite of specimens of the two shows that they are distinct. *M. citriodora* is a larger, coarser plant, with broader leaves; the bracts more deeply colored, longer, more abruptly aristate and less strongly ciliate than in *M. Nuttallii.* The latter has the mid-nerve of the bracts relatively much more conspicuous than the others, and the aristate calyx lobes strikingly ciliate-bearded.

M. Nuttallii is well represented by the following specimens, all from Colorado: 166, *Professor Francis Ramaley*, Boulder, 1900; *C. S .Crandall*, Fort Collins, 1893; *Marie Holzinger*, Boulder, 1892; 614, *Baker, Earle*, and *Tracy*, Durango, 1898; 428 of the Hall and Harbour plants.

In this connection I would inquire why *Monarda aristata* Hook. should not be restored as a substitute for *M. clinopodioides* Gray?

Monarda Ramaleyi, n. n.—Rootstocks horizontal, rather slender, abundantly and conspicuously rootbearing: stems erect, or sometimes decumbent and somewhat flexuous, mostly simple and monocephalous, 3–6^{dm} high, glabrate below, softly lanately white-pubescent upward, densely so at the nodes, more or less purplish: leaves lanceolate or ovate lanceolate, broadly rounded or subtruncate at base, sharply but rather remotely serrate, softly pubescent especially below; petioles very short, less than 1^{cm}, the uppermost almost wanting, lanately pubescent as are also the midribs of the leaves: involucral leaves about 6 or, counting the approximated uppermost stem pair, 8, ovate, acute, entire, 2–3^{cm} long, obscurely tinged with purple: floral bracts slenderly linear-subulate, ciliate-hispid on the margins, about 1^{cm} long: calyx tubular, minutely puberulent, 8–10^{mm} long, the five equal subulate teeth very short and somewhat hispid-pubescent at base: corolla lilac-purple, softly pubescent, strongly bilabiate; the tube within the calyx very narrowly linear, dilating gradually above, the exserted portion exceeding the calyx; upper lip linear-lanceolate, but slightly curved, 10–12^{mm} long; lower lip oblong-elliptic, as long at the upper, obtuse and broadly emarginate at apex, with a short, broadly linear, cucullate, pubescent appendage from the notch; the appendage bidentate: stamens 2, exserted, exceeded by the pistil.

This species at once presents a very different appearance from the only two species with which it can be compared, viz., *M. menthaefolia* Graham and *M. stricta* Wooton. On suggesting to Professor Ramaley that it was probably new, he very kindly supplied me with a good series of specimens from which the characters are drawn. It may at once be distinguished by its rather low, strict, usually monocephalous stems, its unusual pubescence, its almost lavender corollas, and the peculiar appendage-like appearance of the middle lobe of the lower lip.

I am informed that it occurs rather sparingly in sandy soil near Boulder creek, Boulder, Colorado, where it was collected by *Professor Ramaley* (to whom it is dedicated) June 27, 1900, no. 92.

PHACELIA HETEROPHYLLA Pursh. The Rocky mountain specimens of this species seem somewhat aberrant, but the characters so far as made out do not seem to warrant separation.

MIMULUS LANGSDORFII TILINGI (Regel) Greene? A peculiarly pubescent form was sparingly represented. It seems probable that fuller material may show this to be distinct.

LITHOSPERMUM LINEARIFOLIUM Goldie was represented by several numbers and showed much diversity. However, since these numbers represented different localities and plants in different stages of maturity no dependence can be placed on the diversity shown. In this species and its allies successive collections should be made during the season from what is undoubtedly the same community of plants.

CHRYSOPSIS FULCRATA Greene. What seems to be a pretty good match for the type number of this species, originally described from New Mexican material, was collected near Boulder.

Oonopsis monocephala, n. sp — Caudex woody, its branches slender: stems one or more from each branch of the caudex, erect or ascending, 1–2^{dm} high, simple, uniformly leafy from base to summit, monocephalous: leaves glabrous as are also the stems, linear-oblong, sessile, acute, quite uniform in size and shape, 5–8^{cm} long, about 1^{cm} broad, the uppermost involucrating the large head: involucre hemispherical, about 15^{mm} high; the bracts oblong, rather abruptly short acuminate-cuspidate, glabrous but for some ciliate pubescence on the margins: heads rayless; disk flowers very numerous: pappus nearly as long as the corolla tube, the bristles widely spreading at maturity: akene oblong, about 3^{mm} long, sparsely and obscurely glandular.

I am aware in pronouncing this plant an Oonopsis that I am putting into this genus a monocephalous species and another rayless one, but the habit is thoroughly characteristic. The hue of the leaves, which retain their foliar character up to the heads which they surpass, the appearance of the involucre, and the floral characters are in perfect accord with the genus.

The specimens upon which the species is founded were submitted to me by Professor Ramaley, of the University of Colorado, and are the collection of *Jennie M. Archibald*, at Berwind, Colorado, in 1900, no. 257.

WESTERN EUPATORIEAE.

Eupatorium atromontanum, n. sp.—Tall, $1–2^{m}$ high: stems with an obscure short white puberulence, striate, greenish or mottled with purplish-brown: leaves verticillate in fours, short petioled, ample, from ovate-acute to lanceolate-acuminate on the same plant, $12–25^{cm}$ long, $4–10^{cm}$ broad, much exceeding the internodes, coarsely serrate, the teeth broadly triangular and apiculate, rather thin, prominently veined below, glabrate above and dark green, lighter and with a short fuscous puberulence underneath, sprinkled with minute, shining, resinous dots: inflorescence corymbose-cymose or more paniculate, equaled or more often overtopped by the uppermost leaves; the peduncles of the cymes arising from the axils of the leaves of the 2 or 3 uppermost verticils cinerous-pubescent as are also the numerous short slender pedicels: involucral bracts in 4 or 5 series; the outer short, elliptic; the second and third more broadly elliptic or oval, about 7^{mm} long, pubescent, with 3 greenish striae and scarious margins; the inner and longest becoming oblong and almost wholly scarious: heads about 15-flowered: corollas tubular (hardly at all dilated upwards): akene obscurely angled, dotted with resin particles, linear, but slightly shorter than the somewhat unequal pappus.

This finds its nearest ally in the somewhat polymorphous *E. maculatum* L. The more typical form of that differs from this in the thicker, usually rugose leaves which at the summit become smaller or bract-like, leaving the inflorescence naked (surpassing the leaves). That also has a harsher, more copious pubescence, different involucral bracts, and fewer flowers in the head.

E. atromontanum is represented in the Rocky Mountain Herbarium by two collections, as follows; 2251, Sheridan, July 10, 1896; 2553, Beaver creek, Black hills, Wyoming, July 30, 1896 (type).

Coleosanthus congestus, n. sp.—Roots fascicled, large, semi-fleshy, with a woody crown: stems several to numerous, ascending or nearly erect, simple, 3–6$^{\mathrm{dm}}$ long, minutely pubescent, obscurely striate: leaves opposite below, only the uppermost alternate, green and nearly glabrous, or obscurely roughened-scabrous, especially on the veins below, lightly sprinkled with resin particles, deltoid-triangular, with truncate or cordate base, from sub-acute to acuminate, 3–6$^{\mathrm{cm}}$ long, crenately-serrate, the apex entire; petioles variable, very short to equaling or surpassing the blade: inflorescence congested at the summit of the simple stems, the crowded cymes of the few heads subtended by foliar bracts, sometimes one or more additional cymes terminal on widely divaricate or ascending peduncles from the axils of the uppermost leaves: heads 10–12$^{\mathrm{mm}}$ high, subtended by a few loose long-acuminate bracts; the involucral bracts in about 5 series, the outermost ovate, acuminate, pubescent and ciliate on the margins; the succeeding rows passing from broadly lanceolate to broadly linear, green between the 3 or 4 raised white striae and ciliate on the scarious margin: flowers about 50: corolla narrow, tubular, about 7$^{\mathrm{mm}}$ long: anthers wholly included within the tube proper: style branches spatulate-clavate, the exserted portion about 3$^{\mathrm{mm}}$ long: akenes linear-cylindric, subglabrous, 10-striate, 3–4$^{\mathrm{mm}}$ long.

This is undoubtedly, in part, the *Brickellia grandiflora* of Gray, *Syn. Fl.* 105, but is certainly distinct from *Eupatorium(?) grandiflorum* Hook. *Fl.* 2:26, and probably from *Brickellia grandiflora* Nutt. *Trans. Am. Phil. Soc.* n. ser. 7:287. The original seems to have been a tall, probably single-stemmed plant, paniculately branched at the summit, with larger, fewer-flowered heads, and white corollas. This Oregon plant is probably in large part the *Coleosanthus grandiflorus* of the recent *Flora of N. W. America* 203, by Howell, who writes from near the type locality. The tufted habit, simple stems, congested inflorescence, and more numerous flowers of *C. congestus* seem to me to be specific characters.

The collections at hand are: 423, Fairbanks, July 10, 1894; 1687, Cummins, July 16, 1895; 4212, Battle lake, August 17, 1897; 7506, Antelope basin, July 8, 1900 (type); also Palmer lake, Colorado, August 12, 1896, by *Professor C. S. Crandall.*

Kuhnia Fitzpatricki, n. sp.—Stems 1–several, with a woody root, erect, 1^{m} (more or less) high: stems simple, rather slender, light green, obscurely striate, scarcely puberulent: leaves numerous, very uniformly distributed except near the base where they are early deciduous, green and appearing glabrous but puberulent or minutely scabrous especially on the margins or veins, thin, not impressed punctate and the resin particles microscopic, very uniform in shape and size, narrowly lanceolate, the cuneate base subpetiolate and with 1 or more linear bracts in the axils, $8–12^{cm}$ long, $8–15^{mm}$ wide, coarsely and somewhat uniformly toothed, upwardly becoming narrower, entire and in the short inflorescence somewhat reduced: cymes few and of few heads, crowded: pedicels and involucre softly pubescent; the outer bracts filiform; the inner broadly linear, acuminate: corolla purple(?), tube short, very slender, dilated at base, expanding into a much longer cylindrical throat: akene fusiform, 5^{m} long, equaled by the very fine white pappus.

This remarkably distinct species from the prairies of Iowa, I have from *T. J.* and *M. F. L. Fitzpatrick,* who collected it in Decatur county, September 25, 1899, where it is said to be common. It was distributed as *K. eupatorioides* L.: (var. ?).

Kuhnia Gooddingi, n. sp.— Perennial, from a densely caespitose-tufted caudex: stems very numerous, loosely spreading, $5–8^{dm}$ high, simple and almost leafless below, striate and minutely puberulent: leaves numerous, crowded on the middle portion of the stem, sparsely and minutely puberulent especially on the margins and veins, linear to narrowly lanceolate, $2–4^{cm}$ long, entire or nearly so, more or less revolute-margined, minutely impressed-punctate on both surfaces, those of the inflorescence gradually reduced and linear-bracteate: inflorescence loosely and widely paniculate, occupying the upper third of the plant: the pedicels and involucre finely pubescent: involucres turbinate, the bracts in about five series; the outer short, lanceolate; the inner broadly linear, with villous-pubescent setaceous tip, about 4-striate, sparsely sprinkled with shining resinous particles as are also the corolla teeth: disk $10–12^{mm}$ high, 15–25-flowered;

corolla ochroleucous or shading to brown, slender, tubular; akene linear, finely about 20-striate, only a little shorter than the white finely plumose pappus.

No western species of Kuhnia have heretofore been described. They occur but rarely, but at least two good species seem to belong to the eastern Rocky mountains. This species now proposed is one of the strongest of these, and differs so radically in habit, to say nothing of the other characters, that it seems unnecessary to call attention to the points of divergence from the well known species.

It was secured by *Mr. Leslie Goodding*, to whom it is dedicated, in a mountain valley, West Dry creek, Larimer county, Colorado, where it occurred in the greatest abundance, usually in stony places, but with the tufted stems and woody caudex imbedded in low mounds of loose drifting soil. The type number is 8202.

Kuhnia Hitchcocki, n. sp.—Tufted-suffrutescent, the lignescent stems decumbent-spreading, each divaricately branched from the base up, dark in hue but minutely puberulent as are also the leaves: stem leaves mostly wanting (or if but little branched, very numerous), nearly linear, with a few sharp teeth, 3–4^{cm} long; those of the rigid branches numerous, small, linear, 2–3^{cm} long, passing into the bractlets: involucre usually subtended by a few linear bractlets, its bracts in about 5 series, the short outer ones broadly lanceolate, the inner broadly linear with thin scarious margins and cuspidate apex: disk corollas 20–30, the tube nearly uniform: akenes small, about 10-striate, shorter than the dull-white to tawny distinctly plumose pappus.

This species seems to belong to the arid plains east of the Rocky mountains. It has been frequently collected by Professor A. S. Hitchcock (to whom I am pleased to dedicate the species) in several of the counties of Kansas. Among the large series of specimens that his courtesy has enabled me to examine, the following may be named as typical: *211a*, Meade county, September 1897; Edwards county, September 1897; Stafford county, September 1897; Clark county, August 1896; Kiowa county, August 1896; Barton county, August 1895.

Kuhnia reticulata, n. sp.—Caudex woody: stems several or many, ascending, 3–4^{dm} high, simple, light green, finely puberulent: leaves light green, appearing glabrous but puberulent on the upper face and on the veins and margins, closely impressed-punctate on both faces, the veins on the lower surface raised-reticulate, oblong-lanceolate, 2–4^{cm} long, subacute, from entire to irregularly few toothed, usually some small fascicled linear leaves in the axils, smaller upward and passing into the bracts of the short inflorescence: cymes of few heads, congested-corymbose or becoming paniculate: involucre turbinate-campanulate; the bracts in 4 or 5 series, softly pubescent, strongly nervose, resin-sprinkled, shorter than the 12–15^{mm} high disk; the outer short, lanceolate; the inner broadly linear, acute: flowers about 25: the corollas linear-cylindric, but slightly dilated at base, about 8^{mm} long: style tips compressed, linear, not dilated-clavate at summit: akenes 20-striate, some of the striae more prominent than the others, linear, about 5^{mm} long, exceeded by the white softly plumose pappus.

This species is perhaps most nearly allied to *K. glutinosa* Ell., but the points of distinction are so patent that to call attention to them seems unnecessary.

The only collection of it is no. 2771, Platte cañon, Laramie county, Wyoming, August 27, 1896. Some specimens of it were distributed as *K. eupatorioides corymbosa* T. & G.

Lacinaria alata, n. sp.—Tall, 8^{dm} to probably twice as high: stem stout, striate, puberulent: leaves numerous and crowded (especially on the middle portion of the stem), quite similar throughout (root leaves not seen), glabrous, closely and uniformly punctate, linear-oblong, acute; the lower 8–12^{cm} long, mostly less than 1^{cm} broad, deflexed on the short margined petioles, upwardly becoming smaller sessile and erect, passing into the large foliar bracts of the spike: spike 3–5^{dm} long, crowded: heads sessile or nearly so, numerous (30–50), about 15^{mm} high, equally broad, 35–45-flowered: the involucral bracts in about 6 series, minutely punctate, purplish; the outer very short, ovate, acute, green, rarely slightly scarious-winged near the summit; the succeeding 2 or 3 series similar as to the foliaceous center but conspicuously and broadly scarious-winged toward summit, becoming broadly obcordate in outline, the wings from entire to dentate or even lacerate, about 1^{cm} long and broad; the inner series longer and narrower, scarious margined all around: corolla resin-dotted throughout, 8–10^{mm} long, the broadly linear lobes half as long as the tube which is stiffly pubescent within near the base: style branches as long as the corolla; akene narrowly obovate, dark brown with short whitish spreading pubescence, about 5^{mm} long: receptacle nearly plane, with shallow alveolations.

The plants upon which this species is founded were collected by *J. H. Kimmons*, August 1895, in the Creek Nation, I. T., and distributed by Professor J. W. Blankinship as *Liatris scariosa* Willd. From this there are many characters to separate it, but attention need only be called to the reflexed lower leaves, the long foliar-bracted spike, and the alate bracts of involucre.

Lacinaria ligulistylis, n. sp.—Perennial, from an enlarged woody tuberous root: stems single, light green, glabrate below, lightly white pubescent above, striate, 4–5^{dm} high, uniformly leafy from the base up: leaves bright green, rather obscurely punctate, glabrous, usually minutely ciliate on the slightly thickened margin; the lower lance-oblong, 8–12^{cm} long, tapering into a usually much shorter margined petiole; upwardly becoming more lanceolate, the winged base shorter, gradually smaller, passing into the lance-linear bracts of the inflorescence: heads from few to several, racemose: peduncles 1–3^{cm} long, tinged with purple as are also the peduncle and rachis: involucre broadly campanulate, often 20–25^{mm} broad; bracts in about 6 series, foliar-green with dark purple scarious dentate margins; the outer short, from nearly orbicular to oval; the middle rows broadly obovate; the inner elliptic or oblong and 15–18^{mm} long: flowers 50–70, purple: corolla tube slightly dilated upward; the teeth lanceolate, one third as long as the tube, with a delicate marginal vein: exserted style branches flattened, as long as the corolla, light purple, conspicuous and superficially suggesting the slender rays of some Erigeron; akene flattened, finely pubescent, nearly as long as the corolla tube.

The Rocky mountain forms of Lacinaria that have passed as *L. scariosa* (L.) Hill are clearly distinct from the eastern forms. That, even with the Rocky mountain form eliminated, *L. scariosa*, as applied to the eastern forms, is still an aggregate seems to me more than probable. In spite of the extended synonomy of this species, the various names all seem to be associated with the forms of the eastern or the Mississippi valley states. Some of the descriptions of *L. scariosa*, however, probably cover or may even be founded upon the western or Rocky mountain form, notably that of Hooker, *Fl.* 1: 306.

The species now proposed is at once distinct from the *Serratula scariosa* L. and the *Liatris scariosa* Willd., and surely from the spicate forms of the Mississippi valley. The smooth leaves gradually diminishing upwards, the relatively short margined petioles also diminishing upward, the clearly racemiform purple inflorescence, the large heads, the appressed involucre, the very conspicuous style-branches, and the numerous flowers will serve to distinguish *L. ligulistylis*.

The following collections are cited as typical: 1651, Laramie peak, August 8, 1895 (type); 691, by *C. F. Baker*, Pagosa springs, Colorado, August 30, 1899; 4554, by *F. H. Snow*, Colorado; *G. E. Osterhout*, Steamboat springs, Colorado, August 24, 1899; less typical my numbers from Inyan Cara divide, August 20, 1892; and Buffalo, July 26, 1896.

STUDIES IN ARNICAS.

The collector and the student of the Rocky mountain Arnicas has in the past found many difficulties with which to contend. So many of the species attributed to this region were originally described from such widely different geographical ranges that it ought to have been expected that no close agreement would be found between our species and those of the earlier investigated localities. The recent activity in taxonomic botany is bringing to light many real novelties and separating many of the heretofore uncertain but well-known forms. It is perhaps inevitable that at such a time some confusion should result, but perhaps the sooner synonyms and homonyms are cleared up the better. The following have come under my observation:

Arnica multiflora Greene, Pitt. **4**: 162, evidently is *A. Columbiana* Aven Nelson, Bot. Gaz. **30**: 200, since both are, in part, founded on the same collections and the same numbers are cited. The latter name is the earlier by two or three months. Dr. Greene's *A. Columbiana* (Pitt. **4**: 159) having thus become a homonym it may become **Arnica Greenei,** n. n.

Arnica platyphylla, n. sp.—Perennial from woody rhizomes, 3–6^{dm} high, rather slender, the internodes subequal, nearly glabrous throughout, the leaves very thin and delicate in texture: the leaves that spring in fascicles of 3–5 from the rhizome oval to oval-subcordate, sinuately dentate as are also the stem leaves, obtuse or acute, ciliolate on the margins, 4–6^{cm} long, equaled by the slender petioles: stem leaves 2–4 pairs and a pair of sheathing scales at base, all closely sessile by broadly rounded or truncate base; if only 2 pairs, similar in size and shape; if 4 pairs, the upper and the lower smaller than the two middle pairs; from nearly orbicular to broadly ovate and subacute, 5–10^{cm} long: heads 3–5; if three, on slender nearly equal peduncles, subtended by ovate-acuminate bracts 2–3^{cm} long; if five, the lowest pair from the uppermost leaves and borne on elongated slender petioles: involucres somewhat turbinate, slightly glandular-pubescent as are also the peduncles; scales thin, narrowly obovate-acuminate, in one series: rays few, long, bright yellow: tube of disk corollas pubescent, very slender, abruptly dilated into a wide cylindrical glabrous throat with slender erect teeth: akenes narrowly linear, 5^{mm} long, equaling the fine white hardly scabrous pappus.

This is seemingly a well marked species, occurring in the moist woods of the northern Rocky mountains. I have seen four collections of it as follows: *Henderson*, Cascade mountains, Oregon, July 18, 1896, distributed as *A. latifolia; Sandberg* and *Leiberg*, Stevens pass, Washington, distributed as *A. Chamissonis*, August 1893; *R. S. Williams* (no. 443), Columbia falls, June 18, 1894; Belt mountains, Montana, July 24, 1899. Of the latter two I cannot be very certain, as they are not now at hand. This species seems nearest to the recently described *A. ventorum* Greene (based upon one of my numbers), a species of which I now have several collections.

Arnica stricta, n. sp.—Very erect with gradually tapering stem, 2–3^{dm} high, tomentose pubescent throughout: leaves about 5 pairs, the lower pairs exceeding the internodes, gradually smaller upward, the upper half of the stem nearly naked; the lowest pair lanceolate, acute, 3–5^{cm} long, tapering into a slender petiole usually shorter than the blade; the next 1 or 2 pairs similar but with shorter petioles; the upper and smaller pairs sessile by a broad base: inflorescence of about 5 heads subtended by a pair of ovate-lanceolate bracts, 1–2^{cm} long, in a close rounded corymb, the terminal head and the first pair very short peduncled: terminal head much the largest, 10–12^{mm} high and about as broad: involucral bracts in 2 series, shorter than the disk, narrowly oblong, obtusish, the tip tinged with purple and tomentose-ciliate: rays few, short, broad, slightly narrowed at apex: tube of disk corollas pubescent, the glabrous throat scarcely dilated: akenes very minutely pubescent; pappus dirty-white, minutely scabrous.

The specimens on which this species is based were collected in 1892 by Mr. J. D. Parker, somewhere in southern Wyoming. Specimens were sent to the Gray Herbarium for determination. The name returned was *A. foliosa* near var. *incana* Gray. Now that Dr. Greene has helped us to a more definite knowledge of *A. incana* (Pitt. **4**: 169), this may with safety be designated by a name.

Arnica celsa, n. sp.—Perennial from horizontal rootstocks and fleshy roots, erect, tall, 4–6^{dm}: the strict stems lightly striate, sparsely pubescent with flat spreading hairs, upwardly becoming also obscurely glandular-viscid: leaves (exclusive of the foliar bracts) 6–8 pairs, puberulent and sprinkled with microscopic shining resin particles, narrowly oblong or oblanceolate, tapering to both ends, many of them 3-nerved; the lower small, 2–3^{cm} long, equaled by the slender petioles which abruptly dilate into the equally long ocreae; ocreae and leaves gradually shorter upward; middle stem leaves longest (8–10^{cm}), sessile or with short petioles and ocreae; the uppermost sessile and partly clasping: lower internodes short, much exceeded by the leaves, gradually longer upwards and above much exceeding the leaves: heads 3–5, on rather slender leafy-bracted peduncles; involucre and peduncles moderately glandular-viscid; the bracts approximately uniserial, oblong, much shorter than the 12–15^{mm} high disk: rays 12–20, about 7-nerved, 2 or 3-toothed, 10–14^{mm} long: tube of disk corollas slender and pubescent below, gradually dilated into an equally long glabrous sub-cylindric upper portion with short spreading glabrous teeth: akenes sub-glabrous, nearly linear, tapering downward, the scabrous pappus equaling the corolla tube.

This excellent species was found growing in abundance on the wet, meadow-like banks of a mountain streamlet at an altitude of 8000 feet. The nearest ally known to me is *A. ocreata* Aven Nelson, from which it differs in its pubescence and wholly different disposition of its leaves. The habit of the inflorescence, too, is very unlike, which in the species now proposed consists of subequal heads always corymbosely disposed.

No. 7643, Tie city, Albany county, July 20, 1900, is the type.

Arnica rhizomata, n. sp.—Conspicuously rhizomatous, the creeping rootstocks slender, sheathing-bracteate at the nodes, giving rise at intervals to the erect leafy stems and a few fleshy roots: pubescence whitish, soft, almost arachnoid, minutely granular-glutinous underneath the pubescence on the inflorescence: stems 2–5$^{\mathrm{dm}}$ high: leaves 5–7 pairs, rather uniformly distributed, oblong-lanceolate, from obtuse to acute; the lowest pair with short scarious-margined petioles, early deciduous; the next 1 or 2 pairs 6–9$^{\mathrm{cm}}$ long, about 2$^{\mathrm{cm}}$ broad, on short margined petioles which dilate at base to form the short ocreae; the upper pairs sessile, shorter: heads 3–5, 10–12$^{\mathrm{mm}}$ high, or sometimes more numerous and then smaller: peduncles mostly short, erect, the lateral often exceeding the terminal: involucre campanulate, the bracts much shorter than the disk, narrowly oblong, obtusish: corolla long-pubescent on the tube, sometimes a few straggling hairs on the lobes: akenes linear, almost glabrous, the pubescence short and scattering, half as long as the 8$^{\mathrm{mm}}$ corolla: pappus fulvous or dirty-white.

This species has been collected several times and has been held as a form of *A. foliosa*, or rather as variety *incana*. Such a disposition is no longer tenable, neither am I able to refer it to the species (*A. foliosa* Nutt.). It seems rather to belong to a section of which *A. ocreata*, *A. celsa*, and this are the principal members. In so far as this region is concerned, the following collections represent it: 8012, Lincoln gulch, Albany county, August 8, 1900 (type); 1417, *B. C. Buffum*, Pine creek, 1892; Green mountain, July 6, 1896; 3587, North Vermillion creek, July 17, 1897.

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STUDIES ON THE GEOTROPISM OF STEMS. II.[1]

EDWIN BINGHAM COPELAND.

(WITH THREE FIGURES)

THE review of my earlier papers on this subject, written by Czapek for the *Botanische Zeitung*,[2] is in error on a point of priority and on the interpretation of the results. Sachs never showed that if a stem be split and the halves placed horizontal the under one would grow faster. In Sachs' experiment referred to in the review the average elongation of the two faces of the upper half stem was 9.7^{mm}, that of the lower half only 9.0^{mm}. If the experiment had been continued longer (see footnote BOT. GAZ. **29**: 189. 1900) the relation would have been reversed. The review concludes:

> Insbesondere kann der Ref. sich der Ansicht des Verf. dass diese Erscheinung alle Theorien, welche den Sitz der geotropischen Reactionen in beiden Längshälften annehmen, ausser Kraft setze, nicht anschliessen.

I do not hold and have never expressed such a view. The phenomenon in question proves that both halves *do* share in the reaction, which therefore does not take "place entirely in *either* half." As Czapek construed my conclusion, it is no wonder that he disagreed.

3. Positive geotropism in the hypocotyl or cotyledon.

The descending axis of a plant must grow and become fast in the ground before the negative geotropism of the ascending axis can result in the erection of the growing tip. That the former does break first from the seed is a matter of universal observation. In the popular conception this first outgrowth is simply the "root;" but that this idea is not exact is recognized, for

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[1] The first number appeared in BOT. GAZ. **29**: 185–196. 1900.

[2] Bot. Zeit. **58**: 200. 1900.

instance, by the disposition in many texts to substitute the word caulicle for radicle for the part of the embryo below the insertion of the cotyledons. In all Dicotyledons a part of the stem is distinguishable below the cotyledons, and in a majority it elongates to carry the cotyledons into the air. The elongation of the caulicle is the first visible growth. When the caulicle is largely a stem structure, and only the tip represents the future root, the beginning of growth is in the stem. In all cases the caulicle promptly bends downward. We have here apparently, then, positive geotropism of the hypocotyl, which so far as I know has not hitherto been recognized or investigated.

Lupinus albus, in the size and uniformity of the seedlings and their rapid growth, is the best material I have found for this work. Both in the seed and on the seedling there is usually a well-defined line where the root merges into the stem. In the first cultures I marked this line with India ink on the swollen embryos, to be certain that it was the same one separating root and shoot in the seedling, and found that such was constantly the case. In order to have the entire descending axis free to curve, I usually removed the seedcoats, after swelling, but before any considerable growth. This was not necessary for the mere demonstration that a part of the hypocotyl bends downward, but when germination took place within the coats a part of the hypocotyl was often constrained by them. Their removal was probably without effect on germination or growth, though in an experiment to ascertain its influence the peeled plants grew slightly faster.

One culture of plants is reported upon here in detail, to show the constancy of the results, and the range of variation that may be expected. The seeds were put into water October 1. On October 2, 9:00 A.M., the coats were removed. Fifteen very uniform embryos were selected and pinned with the axis horizontal. The length of the hypocotyl was 6^{mm}, of the root 1.8^{mm}. The table shows the result after 24 hours. The last column, showing how far above the base of the hypocotyl the curve of least radius occurred, is the significant one.

	Hypocotyl length	Root length	Curve above base of hypocotyl
1	8.$^{\mathrm{mm}}$	6.$^{\mathrm{mm}}$	5.$^{\mathrm{mm}}$
2	10.	8.	7.
3	8.	9.	4.
4	8.	9.	4.
5	8.	10.	5.
6	8.	5.	4.
7	8.	5.	5.
8	10.	10.	7.
9	9.	7.	6.
10	9.	7.	6.
11	10.	9.	7.
12	9.	7.	6.
13	9.	4.	5.
14	9.	5.	6.
15	9.	7.	7.
Av.	8.8$^{\mathrm{mm}}$	7.2$^{\mathrm{mm}}$	5.6$^{\mathrm{mm}}$

In all except three plants, in which it fell at the middle, the sharpest curve was above the middle of the hypocotyl (*fig. 1*). In several of the plants the curve began immediately at the insertion of the cotyledons. Two of the plants of this series were put into water culture vessels, and when the elongation of the hypocotyl was finished, in a south window, the points where the radius of curvature had been least were 20 and 22$^{\mathrm{mm}}$ above the foot of the hypocotyl. *The curve had disappeared.*[3] In three plants of another experiment the part of the hypocotyl below the sharpest curve elongated to 17.5, 18.0, and 19.0$^{\mathrm{mm}}$, the curve being eliminated.

With somewhat older seedlings the result is less uniform. With twelve plants whose hypocotyl was ca. 10$^{\mathrm{mm}}$ and the root ca. 2.0$^{\mathrm{mm}}$ long, placed horizontal for twenty-one hours, the result was that the sharpest curve in three hours was in the hypocotyl, in six hours at the line of separation, and in three hours in the root. Before the experiment the plants had been in imperfectly saturated air, which shortens the growing region, as compared with plants grown in water or saturated air.[4]

The first attempt at an explanation of the behavior of the hypocotyl was by a study of its anatomy. If the transition from stem to root character in the internal tissues or their arrangement occurred higher up than the external line of demarcation, there would be a fine prospect of demonstrating the relation of

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[3] From clinostat experiments I know that both negative geotropism and rectipetality are concerned in this straightening.

[4] SACHS, J.: Ueber das Wachsthum der Haupt- und Nebenwurzeln. Gesammelte Abhandlungen 807. From Arb. bot. Inst. Würzburg **1**. 1874.

POPOVICI, A. P. (Bot. Centralbl. **81** : 33. 1900) shows that several but not all factors checking growth shorten the growing region. For influence of insufficient water see p. 95.

the particular tissues concerned in it to the geotropic irritability. With this idea in view, I made a careful study of the histology of the root and hypocotyl. Seedlings which have just curved are not satisfactory material because of the immaturity of the tissues and the amount of plastic material present, and the observations on maturer stems which had formerly shown themselves positively geotropic make much study of very young plants superfluous. The apparent line of separation between root and hypocotyl is the real one, as to the epidermal tissues; the stomata[5] descend to it, and root hairs occur only below it. In the cortical parenchyma there is no sharp distinction between stem and root, nor between different parts of the hypocotyl, not even when, as it matures, chlorophyll becomes more abundant in the normally better lighted upper part. In the stele[6] the rotation in the arrangement of phloem and xylem is gradual, but usually begins below the transition line in the epidermis, and is completed at some distance (in one very extreme case 17^{mm}) down in the root. There is then nothing at all in the histology of the hypocotyl that can give a clue to its geotropic variability. This does not prove, however, that the explanation is to be sought in the finer structure of individual cells.

FIG. 1.—Young seedling of *Lupinus albus*, showing downward curve in the hypocotyl.

The truth is rather that the downward curve occurring in the hypocotyl is a response to a stimulus perceived by the root tip. This is not easy of absolute proof, but the evidence seems to warrant fully the conclusion. The "bent tube" method of demonstration is inapplicable because it is during the very first growth that the phenomenon in question occurs. Decapitation

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[5] Near the base of the hypocotyl most of the stomata are considerably elevated above the general surface.

[6] I use the word as a matter of convenience for the bundles and pith. It is not sharply delimited from the cortex.

experiments are at best unsatisfactory, or they would have definitely determined the functions of the root tip without controversy decades ago. Mine were as consistent as they are likely to be, or as can be expected from a method which does great violence to the health of the plant, and in which any unsteadiness in the operation may entirely alter the result. When no traumatic bending occurred, the growth of horizontal decapitated plants was straight for more than twenty-four hours, and nearly always for more than forty-eight. In the end there was usually a downward curving in the basal part of the hypocotyl, but never farther up, where the curve, if any, was in the other direction. The downward curve usually occurred before a new growing point became evident, as is the case too when the response is by the root.[7] In every respect the part of the hypocotyl which would execute a positively geotropic curvature is influenced by removal of the root tip, just as the responsive zone of the root would be in older plants. The interval during which a wound suspends the geotropic perceptivity in older hypocotyls is a very few hours at most, instead of about two days.

Better evidence than decapitation can yield is obtained from a careful study of the distribution of growth in length along the young root and hypocotyl, and its relation to the location of the curve. For a basis of comparison this relation is first shown with older plants, in which the root alone curves. The plants had been germinated two days, and were marked off in 1^{mm} zones and placed horizontal at 10:30 A. M., November 19. The result at 4:00 P. M. the same day is tabulated. The first column is the length of the roots at the beginning of the experiment.

After twenty-nine and a half hours the average growth had been 20^{mm} and the curve was 90°, at about the same place. After five and a half hours, at the first measurement, the most growth had been in zones 3 and 4, but I could not measure it accurately enough to include it in the table. The experiment, like all in which the contrary is not stated, had been carried on in saturated air.

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[7] Literature in CZAPEK: Ueber den Nachweis der geotropischen Sensibilität der Wurzelspitze. Jahrb. f. wiss. Bot. **35**: 314–5. 1900.

	Root length	Growth	Zone most curved	Curve	Growing zones
1	20.$^{\text{mm}}$	2.0$^{\text{mm}}$	3–4	75°	5
2	19.	1.5	5	70	5
3	5.	1.8	4	90	5
4	14.	1.4	4	90	5
5	24.	1.8	4	60	5
6	19.	1.0	3–4	65	5
7	15.	2.6	4	60	5
8	22.	1.6	3–4	70	5
9	14.	2.4	3–4	50	5
10	33.	3.5	3–4	50	6
Av.	18.5$^{\text{mm}}$	2.0$^{\text{mm}}$	4	70°	5

The subjects of the experiment whose result is next tabulated had been soaked twenty-four hours. The coats were removed and the "caulicle" was marked off into 1$^{\text{mm}}$ zones, and the embryos were fastened horizontal. The first column gives the total length of the descending axis; of this the rudimentary root was 1.9–2.5$^{\text{mm}}$. Figures in italics are the zones of sharpest curvature. All zones of the hypocotyl grew in length, but the growth reached a minimum at some distance from the tip which I have construed as limiting the growing region of the "root." The experiment began at 10:30 A. M., November 19. At 4:00 P. M., November 20, all seedlings were curved 90°.

	Length	4 p. m. November 19		4 p. m., November 20	
		Growth	Curve	Growth	Growing zones
1	9$^{\text{mm}}$	0.6$^{\text{mm}}$ *3*	20°	17$^{\text{mm}}$ *5*	6(+)
2	9	0.8 *5*	40	16 *5*	5
3	7	0.8 *4*	30	16 *4*	5
4	7	0.2 *3*	20	16 *5*	5
5	8	0.4 *4–5*	30	17 *4–5*	5
6	7	? *2–3*	10	11 *4*	4
7	7	? *3–4*	10	14 *5*	5
8	8	? *3*	15	18 *4*	4
9	9	0.4 *4*	15	15 *4*	4
10	8	0.5 *4*	40	15 *4*	4
11	7	? *2–4*	15	13 *4*	4
12	9	0.3 *4–5*	15	13 4–5	5
Av.	8$^{\text{mm}}$	0.3$^{\text{mm}}$ *3*	21°	15$^{\text{mm}}$ *4–5*	4–5(+)

The older plants, subjects of the preceding experiment, were growing so rapidly that the first observation (after five and a half hours) was too late to show the gradual retreat from the tip of the region of curvature. But in roots it always happens,[8] as in the base of the stem in these very young plants, that the curve first appears near the tip and gradually moves farther away. Of course if the growth is rapid so will be the development of the curve.

In the base of the hypocotyl, then, the downward curve occurs only in a zone not separated from the root tip by any mature tissue, and not at most as remote from the tip as the extreme limit of what may fairly be considered the apical growing region. In these points, and in all other visible details of the execution of the response, it agrees with the familiar manifestations of positive geotropism in roots. From this and the decapitation experiments, and from the subsequent elimination of the curve by later growth, the conclusion seems obvious that the response is to a stimulus received at the root tip.

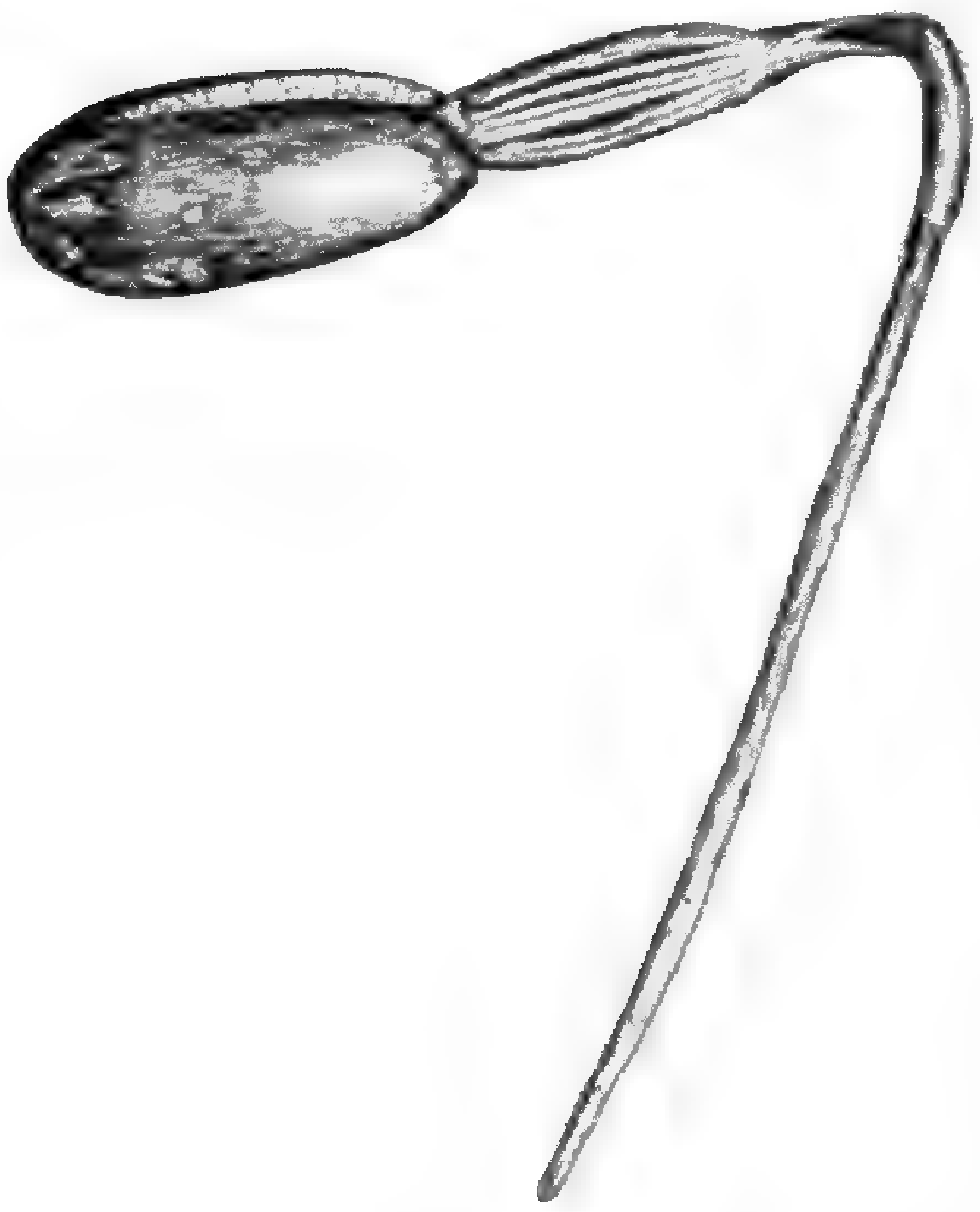

FIG. 2.—Young seedling of *Pinus Sabiniana*, showing downward curve in the hypocotyl, the curve having been increased a little to form the arch which pulls the cotyledons from the seed.

Similar but less complete observations have been made on *Robinia Pseudacacia*, *Helianthus annuus*, *Cucurbita Pepo*, *Eucalyptus globulus*, and *Pinus Sabiniana* (*fig. 2*). The embryos of Robinia, with radicles 0.5^{mm}, and hypocotyls 2.0^{mm} in length, were fastened horizontal. In one day the hypocotyl became 5.4^{mm} (average of ten plants) long, and the root 5^{mm}, the curve of least radius being 3^{mm} above the line of separation, that is, it was above the middle of the hypocotyl. Two plants were placed in water culture and the curve grew out. My observations on the anatomy have no value here, for the reason explained in the treatment of Lupinus. Decapitation was tried on Helianthus

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[8] SACHS, *l. c.*, pp. 831, *seq.*

and Cucurbita, with results unsatisfactory, but, so far as they showed anything, agreeing with those on Lupinus.

Uninjured Cucurbita freed from its coats behaves at first exactly like Lupinus, but later the hypocotyl sometimes becomes concave below, even when the root tip has grown some centimeters away from it. The behavior of these older Cucurbita hypocotyls is exceedingly various, but can in no instance be closely related to the positive geotropism of very young hypocotyls. Sometimes the hypocotyl becomes concave on the side where the peg forms, apparently under the peg's influence.[9] This is not geotropism at all, though the concave side is normally beneath, because the peg grows there. Later the stem may become concave below, next to the cotyledons, in an attempt to form the arch which in nature breaks through the ground, pulling the cotyledons after.[10] This is real and fixed geotropism, not epinasty or nutation (unfixed geotropism). Frank, Vöchting, and others have described similar behavior in the peduncles or pedicels of various plants. That it is not dorsiventrality in Cucurbita is shown by its occurring independently of the plane in which the cotyledons are placed. But they subsequently become erect on the clinostat. The curve in the other direction (negatively geotropic), described for Cucurbita in the first of these studies, is also early evident. Double curves are very common, often about equaling each other and leaving the direction of the root unchanged. The whole subject is not really relevant here, and I leave it in the hope that promised papers by Pollock[11] and Noll[12] will explain my diversity of results.

The phenomenon which this paper describes shows anew that the structure of stems does not demand that the geotropic response they execute shall be negative, and that root structure

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[9] DARWIN and ACTON: Physiology of plants, 193 *fig. 38A.*

[10] DARWIN and ACTON: *l. c. fig. 38B.*

[11] Prelim. paper before Soc. Plant Morph. and Physiol. Dec. 1899.

[12] Sitz. ber. Niederrhein Ges. f. Naturf. u. Heilkunde zu Bonn (S. A.) p. 3. 1900; also Jahrb. f. wiss. Bot. **34**: 461. 1900.

is not essential to the positive response; but that the more characteristic feature in both organs is the perception. The clearness of the distinction between perception and response demands that we discriminate in the use of words to name the two processes. Tropism itself is the disposition to *respond* by turning or bending, and has no necessary reference to the place or manner of the perception of the stimulus, more than that the two processes be some way connected in space and time. The young hypocotyl bends downward, and is therefore prosgeotropic. For the act of perception Czapek proposes the word "aesthesis."[13] The root tip is prosgeoesthetic; it cannot possibly be geotropic because it cannot actively turn. The very young hypocotyl seems not to be directly irritable at all by gravity, but when it becomes so it always bends upward, that is, it is apogeoesthetic. With perception and execution, and transmission when the two other processes do not occur in the same place, the performance is complete. Czapek's introduction of a "Reflex-centrum[14] as a potential link between the organ of perception and that of response, and as a seat of interpretation and decision, seems to me unnecessary,[15] and is without any empirical support. It is simpler and hence preferable to suppose that the organ of perception itself in the act of perceiving determines the direction of the response, whether or not it itself executes it. The manifestations of irritability in plants, like those of instinct in animals, are very short-cut psychic processes, and constantly dispense with steps which would be necessary to the attainment of the same end by the exercise of intelligence. On many grounds, the perception should be regarded as the characteristic and decisive though invisible feature of the entire phenomenon in plant irritability.

There is supposed to be a considerable number of instances

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[13] Weitere Beiträge zur Kenntniss der geotropischen Reizbewegungen. Jahrb. f. wiss. Bot. **32**: 285. 1898.

[14] *L. c.* 294. Tropisms were called "Reflexbewegungen" by Oltmanns (Ueber die photometrischen Bewegungen der Pflanzen, Flora **75**: 265. 1892), but the elaboration of the idea is Czapek's.

[15] NOLL: Ueber Geotropismus. Jahrb. f. wiss. Bot. **34**: 492–496. 1900.

of alteration or reversal of irritability during the development of plants or their parts, independent of any changes in external conditions. At first sight the young hypocotyl of Lupinus seemed to present such a case, but investigation shows that there is no change in the nature of the perception in any esthetic tract, but merely change in the zone controlled. Very possibly, renewed study of some other cases, such as the erect tip of runners, or the tips of many climbers—at first seemingly positively heliotropic, but later appressed to the support—will show that no esthetic center undergoes any essential change; but rather that different parts of the growing region are under different control, or that the development of new members introduces automatic curvatures (nastie), or that the tendency to symmetry (autotropism, rectipetality) eliminates curves in parts which grow out of the zone of influence of an esthetic center. Nutations too suggest themselves here.

Most intimately related to the positive geotropism of the hypocotyl is that of the cotyledons of numerous monocotyledons, serving at the apex as organs of absorption in the endosperm, but elongating at the base and carrying the remainder of the embryo out of the seed. These have long been known to be positively geotropic.[16] I have made the same experiments on these as on Lupinus, and so far as the initial downward curve is concerned with strictly analogous results. Several seeds were tried, of which Phoenix and *Yucca angustifolia* were found most suitable subjects.

The growing region of Phoenix is rather long, though elongation is considerable throughout most of it. The root begins to develop after the elongation of the cotyledon is about complete. The first table of results is from six plants of very different size, on four of which the root was still only a rudiment. The

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[16] SACHS: Ueber die Keimung des Samens von Allium Cepa. Gesamml. Abh. 646–647; from Bot. Zeit. February 1862.

FRANK: Lehrbuch **1**: 465.

There is a paper, which I know only by a very brief notice in Bot. Jahresb. **15**: 622, by M. Lewin (Bidrag till hjertbladets anatomi hos Monocotyledonerna, in Sv. V. Ak. Bih. III. **12**: —. 1887), giving a list of plants with such cotyledons.

experiment began November 30, at 12 noon, the plants being marked into 1^{mm} zones and placed horizontal. In the first plant the growth was in the root; in the second, in the cotyledon and root; and in the others in the cotyledon. In the larger plants, with more rapid growth, the execution of the curvature was prompter, and with the longer growing region the curve was farther from the tip; but it very evidently made no difference whether the curve was in the root or the cotyledon. In either case it was obviously in the apical growing region, in immedidiate connection with the sensitive tip. It is interesting to note that in the youngest plants, when the cells of the apical meristem are probably not yet dividing actively, they already exercise their function in irritability.

	Length	December 1, 9 a. m.				December 2, 9 a. m.				December 3, 9 a. m.			
		Growth	Zones grown	Zone curved	Curve	Growth	Zones grown	Zone curved	Curve	Growth	Zones grown	Zone curved	Curve
1	67.0^{mm} (root=5.5)	2.5^{mm} 1.0	1–5 5–10	3 most	70° 10	5^{mm}	1–5	3–4	80° 10	7^{mm} 1.5	2–5 5–10	3–4 ...	90°
2	46.0^{mm} (root=1.6)	trace	1–10	3	trace	1.6	2–7	3–4	70	3.5	....	3–4	90
3	17	1.3	1–5	3–4	50	3	2–5	3–4	90	5	....	3–4	90
4	10	......	....	....	....	0.5	....	....	....	0.8	....	2	20
5	5	......	....	....	....	1.0	2–3	3	10	1.5	2–3	2–3	45
6	2	......	....	....	....	1.0	....	....	....	1.5	....	....	15

The next table contains nothing new, but is introduced to emphasize by numerous instances the fact developed in the preceding experiment that the curve in the cotyledon is in exactly the same position in the apical growing region that it would be in older plants where the growing region is all in the root. In most of these plants the rudimentary root was less than 1^{mm} long. The experiment began January 16, 9:00 A. M., when sixteen seedlings were marked and fastened horizontal; one proved unsound. The curve is a little farther from]the tip than the most elongated zone, just as occurs in roots when the experiment lasts more than a few hours.

	January 16	January 17, 9 p. m.			
	Length	Growth	Zone most grown	Zone most curved	Curve
1	11^{mm}	3^{mm}	3	4	90°
2	12	7	3–4	3	75
3	6	4	2	3	90
4	11	7	2–3	3–4	80
5	14	7	3	3–4	90
6	14	6	3	4	90
7	19	3	3	4	95
8	7	5	2	3	70
9	2+	3	2	2+	50
10	15	5	3	4	70
11	9	7	2–3	4	90
12	9	1	1	2–3	70
13	5	3	2	2–3	90
14	4	3	2	3	85
15	10	6	3	4	85

The root of Yucca begins to grow earlier than that of Phoenix, and a considerable part of the growth of the cotyledon takes place afterward in the development of the elbow from whose inside the plumule breaks, as shown in *fig. 3*. Yucca is more like Allium than is Phoenix, but in neither does the cotyledon develop visible chlorophyll. Experiments with a considerable number of Yucca plants were perfectly harmonious during the first growth, and it will suffice to report on three typical plants. The first two seedlings were marked and placed horizontal November 9, 5:00 P.M.

1. Length 9^{mm}, of which root is 4.5^{mm}. November 10, 11:00 A.M.: growth in zones 1–3, 2.5^{mm}, mostly in zone 2; curve 85° in zone 2; in zone 6–9 growth 0.8^{mm} without curve. November 12, 11:00 A.M.: growth in zones 6–9 is 1.4^{mm}, still straight.

2. Length 5^{mm}, of which root is 2^{mm}. November 10, 11:00 A.M.: no appreciable change. November 11, 12:00 A.M.: growth in zone 1, 0.4^{mm}; curve 15°; trace of growth throughout; growth above zone 5, 2.0^{mm} without curve. November 12, 11:00 A.M.: growth 1^{mm} in zones 1–3; curve 40°; growth above 5, 2.8^{mm}, still straight.

3. Began November 22, 9:00 A.M. Length 3^{mm}, of which root is 1^{mm}.

November 23, 3:00 P.M.: growth 6 ^{mm}, mostly in zone 1; but curve of 90° mostly in zone 3, doubtless made before most of the growth in the root.

In Yucca, as in Phoenix, the downward curve takes place in root or cotyledon, in whichever the most rapidly elongating part of the apical growing region falls. But the elongation of the more remote parts of the cotyledon is not at first accompanied by any curve at all. Afterward, in the formation of the elbow, a combination of curves develops. These are in part probably geotropic, but are in part not under the direct influence of gravity, being executed in the development of structures whose initial position gravity determines. For the same reason as in the case of Cucurbita, a further treatment of these later curves is unnecessary here.

The common statement is literally true, that these cotyledons are positively geotropic. But the meaning that has been conveyed by the words is only half correct. They do curve downward, but cannot perceive the gravity stimulus in a way that would make them curve so. As in the hypocotyl of Lupinus, any positive geotropism they may exhibit is under the control of the *punctum vegetationis* of the root, which alone is positively geoesthetic.

FIG. 3.—Older seedling of *Yucca angustifolia.*

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BRIEFER ARTICLES.

NOTES OF TRAVEL. VI.[1]

THE BOTANICAL INSTITUTE OF NETHERLANDS INDIA.

THE gardens of Buitenzorg, Java, have been described so often that their name should by this time be familiar to every American botanist, The institution has grown so rapidly in the last few years, however, that a short description of the improvements made may be of interest to any one who expects to visit Java, and to all who are interested in the development of tropical botany. Although the Institute bears the name "botanical," it has many decided agricultural features, and on account of its various divisions and the nature of the subjects under investigation would be called by many Americans a most unusually well equipped station.

The impression made upon the writer in 1896, during an eight months stay in these gardens, was that they offered unrivaled opportunities for study, a wealth of interesting material, and surroundings full of the most interesting oriental sights. After three years' absence, much of which time has been spent in a study of other botanical gardens and institutions, I find that Buitenzorg still possesses the charm and offers even greater opportunities than in 1896. During the last three years, under Dr. Treub's excellent management, five new buildings have been erected. They consist of a double laboratory in which tobacco and coffee are investigated, a very comfortable pharmaceutical laboratory, a new library building which now holds the most complete collection of botanical works in the tropics, a luxuriously appointed office building, and a very pretty tropical bungalo for Dr. Treub. The construction of the laboratories is very substantial. They are all one story buildings with concrete floors, projecting tile roofs, and numerous large windows which in this latitude let in a flood of light and require white shades.

Tables, desks, cases, and shelves are kept scrupulously clean and neat, and in this regard are in strong contrast with most tropical institutes, in which a musty smell pervades everything. Dr. Treub has given in the first number of his *Bulletin de l'Institut Botanique de Buitenzorg*, published in December of 1898, an excellent sketch of the gardens and

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[1] No. 5 of this series was lost in transit.—ED.

their personnel. He has included also a description of the publications of the Institute, an estimate of the necessary expenses of a stay at the gardens, and the cost of the sea voyage from Europe. This first number of the *Bulletin* will be sent to any botanist who writes for it with the idea of preparing for a stay at the gardens.

The new quarter, to which Mr. Wigman, the head gardener, had transferred nearly all of the climbing plants, was in 1896, like all such newly planted ground, unsatisfactory to look at. It has now grown until it is an attractive portion of the gardens, and the new avenue of canary trees in it, which was planted to rival the old avenue (for which the gardens are famous in the eyes of travelers), is already very handsome, with its regularly rounded tree tops and light gray trunks. A water-garden which had just been laid out in 1896 is now indistinguishable from older parts of the garden, and the fern quarter and collection of Pandanus, of which photographs have been so often published, have grown more interesting with their coatings of epiphytic algae. The small nursery, which was large enough three years ago to reproduce all the plants needed in the gardens, has been more than trebled in size, and packages of seeds and cases of plants are being sent all over the archipelago (2294 packages and cases in 1897), as well as in exchange with all the principal botanic gardens of the world.

Native labor is being utilized in a new printing office in the gardens, where all small forms and even scientific periodicals are printed, the compositors being Javanese who do not understand a word of what they set up. The work is done very slowly, and the proof reader's patience is taxed to the utmost, but because of the low price of labor and the inconvenience of having the work done in Batavia or Amsterdam is very great, the office is a great convenience.

I had the pleasure of accompanying Dr. Treub and Mr. Wigman in one of their early morning strolls, in the course of which they bargained with two neatly dressed Javanese land owners for some paddy fields of which to construct experimental plats. In response to Dr. Treub's and Mr. Wigman's inquiries the Javanese replied with respectful salaams and remained sitting on their heels as they would before a raja. These new plats which were purchased are to be under the supervision of a newly appointed specialist, whose acquaintance with Javanese vegetables and other native food plants will enable him to select and improve them, and to distribute information among the natives regarding the best methods of their culture.

The new laboratory for pharmaceutical research is a model of compactness and convenience. The library building, which was the generous gift of Mr. Janse, of Amsterdam, has now not only the increased library of the gardens but the considerable collections of books formerly belonging to the scientific society of Batavia. The removal of the library from the herbarium building gives Dr. Boerlage greater space for his rapidly growing collection, and the old building, formerly occupied as the pharmaceutical laboratory, is to be utilized for an exhibition of economic plant products.

A lively interest in the fruits of the island has been awakened among the planters, and a horticultural society with more than 300 members has been formed. The first exhibition of fruits, which was held in December last, was a great success, and the garden authorities hope through cooperation with members of the society to secure a collection of the best varieties of fruits, and by distributing grafts from these, to replace the inferior seedling kinds, which now furnish the fruit for the tables of the Europeans. A seedless doekoe (*Lansium domesticum*) has already been found, and other superior varieties are known to exist in the island. Almost everywhere in the tropics fruit trees are wild, and it is one of the curious observations which a traveler makes that little is done to improve fruits which are evidently capable of very great improvement. There are mangosteens which without selection are nearly or quite seedless, and yet Europeans choose to plant seeds instead of grafts, and still have a strange fear that a grafted tree will be a short-lived sickly thing and not repay for the extra trouble taken with it. The new horticultural society should do much to enlighten the planters and enable them to plant and breed better fruits, even in a country noted for its delicious pineapples and incomparable mangosteens.

There are doubtless many other lines along which the gardens at Buitenzorg have improved. The selection of sugar cane seedlings, the hybridizing of coffee, the establishment of a new zoological museum to be under the management of Dr. Konigsberger and to contain mounted specimens of all the many interesting animals and cases of the injurious and biologically interesting insects of the archipelago, were all propositions under consideration at the time of my short visit in January. I am thoroughly convinced that to any one who expects to make a thorough study of tropical plants a visit to this Botanical Institute will be of the greatest advantage. Its opportunities surpass those of any other in the world.— DAVID G. FAIRCHILD, *Department of Agriculture.*

THE CARDINAL PRINCIPLES OF MORPHOLOGY.[2]

ALTHOUGH botany has made remarkable advances in America during the past few years, there is still one phase in which it remains singularly backward, namely, in its treatment of the morphology of the higher plants. There still prevails among us, with little modification, the old formal idealistic morphology, whose founder was Goethe, and whose great exponent in this country was Gray; while we give scant consideration to the newer natural realistic system, now more or less fully accepted elsewhere, and recently given greater extension by its leading advocate, Goebel. We have, it is true, some literature of the newer morphology, of which an example is Professor Barnes' discussion of the Flower in the *Cyclopedia of American Horticulture*, while the treatment of the homologies of the higher with the lower plants is good in most of our recent text-books; but from these there is every gradation backward. Happily the newer standpoint is becoming generally accessible to American students through the publication of Goebel's *Organographie der Pflanzen* (Jena, Fischer, 1898–1900), now being translated into English under the title *Organography of Plants* (Part I, Oxford, Clarendon Press, 1900). In the present paper I propose to summarize what seem to me the principles upon which the newer morphology is based.

The difference between the idealistic and the realistic morphology, while partly one of fact, is mainly one of point of view. The idealistic system is based principally upon comparative anatomy; it concentrates attention upon the steps, or stages, in morphological changes, or metamorphoses, but is largely indifferent as to the processes, or mechanics, by which the metamorphoses have been brought about; metamorphosis is therefore to it chiefly a phylogenetic operation, whose exact ontogenetic basis is of secondary consequence. The realistic system, while giving great weight to comparative anatomy, lays especial emphasis upon the testimony of embryology, particularly seeking the actual ontogenetic origin and development, the mechanics, of metamorphoses, only through which, it maintains, can the true nature of metamorphosis be understood; metamorphosis is, therefore, to it primarily an ontogenetic process which later and secondarily becomes fixed in the phylogeny. The former, the idealistic or phylogenetic system, predisposes one to generalized and abstract conceptions, while the latter, the realistic or

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[2] Read before the Society for Plant Morphology and Physiology, Johns Hopkins meeting, December 28, 1900.

ontogenetic, leads to more definite and concrete conclusions. Both views equally assume the fact of evolution in the phylogenetic fixation of metamorphoses, but both are equally independent of the exact method (the dynamics) by which that evolution is brought about, whether this be through natural selection involving the whole organism, or through germinal selection, or through organic selection, or through the accumulation of transmitted effects of individual irritable responses, or through some other method still unknown. The realistic system, however, brings us more nearly face to face with the problems of the dynamics of evolution than does the idealistic system.

We pass next to an attempt to deduce the fundamental or cardinal principles of morphology. Of these, some are not peculiar to morphology alone, but belong equally to other phases of evolution and adaptation, while others are especially characteristic of morphology.

FIRST, the principle of *continuity of origin*, that is, no functional structure ever arises *de novo*, but only from the modification of a preexisting structure, which in turn arose from a still earlier, and so on backward through a longer or shorter chain ending only in the original protoplasmic variation, or in whatever it is which does lie at the beginning of specialization. This principle is axiomatic for both systems of morphology.

SECOND, the principle of *opportunism*, that is, the direction taken in metamorphosis is not determined by obedience to any pre-formed plan, but, except for the influence of the inertia of the heredity of the particular part, follows the factors potent at the moment. Heredity of itself cannot impose any plan, for it is but the summation of the interaction of past experiences with original properties. Theoretically this principle should be as acceptable to the idealistic as to the realistic morphology. In practice, however, the idealistic conception of metamorphosis as a whole is that of a play of a very few highly plastic "members," which, however much they may vary and combine, retain a sort of fundamental immutability of nature, as witness the efforts to explain all parts of the flower in terms of "leaves" and "stem," and the use of the expression "disguised" often applied to metamorphosed parts. There is thus imposed upon metamorphosis a sort of ideal plan, a plan implying that modification keeps within certain limits, determined by the possibilities of permutations and combinations of those members. The realistic morphology is bound by no such conception, for the members are unlimited in number and have no ideal nature or limitations to be consulted.

THIRD, the principal of *functional domination* in metamorphosis, that is, it is function which takes the lead and structure follows. It is of course true that function and structure are reciprocally related; there are cases where structure determines function; there are other cases in which non-functional factors, especially an aggregation of them, may outweigh a functional factor; nevertheless, it must be true that in a broad way it is function which determines structure, function often hampered, and even sometimes thwarted by other influences it is true, but function dominant in the long run. If this is not true, adaptation is but an accident if not a myth, and our whole idea of it but a vain vaporing of the imagination. This principle in general is necessary to both systems of morphology, but it is more prominent in realistic than in idealistic discussions.

FOURTH, the principle of *indeterminate anatomical plasticity*, that is, in all anatomical characters (size, shape, number, position, color, cellular texture) plant-organs, or, if one pleases, plant-members, are not limited by anything in their morphological nature, but, under proper influence, may be led to wax and wane indefinitely in any of these respects. Of course this plasticity is hampered by innumerable practical considerations, and by many hereditary "tendencies," and many generations may be (though they are by no means always) necessary to produce a marked and permanent result; but the point is that limitations to anatomical plasticity do not come from the morphological nature of the part concerned. The principle may also be stated thus, that there is no causal relationship whatever between morphological nature and anatomical structure; stipules are usually smaller than the leaves they accompany and markedly different in form; yet they may become as large as the leaves and indistinguishable from them (as in Galium), or much larger, as in some Leguminosae; there is obviously therefore nothing in the nature of a stipule as such to limit its size or shape; that it is usually smaller than its leaf is a purely functional and non-morphological matter. So, stems may lengthen immensely as in climbers or shorten to apparent disappearance as in rosette-plants, and so on with all other parts. This principle is equally true for both systems of morphology, and is perhaps the most clearly recognized of them all.

FIFTH, the principle of *metamorphosis along lines of least resistance*, closely related to opportunism mentioned above. This means that when, through a change in some condition of the environment, the necessity arises for the performance of a new function, it will be assumed by the part which happens at the moment to be most available for that purpose, regardless of its morphological nature, either because that part happens to have already a structure most nearly answering to the demands of the new function, or because it happens to be set free from its former function by change of habit, or because of some other non-morphological reason. It is due to the operation of this principle that structures of the most different morphological origin may come to serve the same function, and correlatively, structures of the same morphological origin may come to serve the most different uses. The genus Pereskia, in the Cactaceae, includes mesophytic climbers with true broad leaves, from which all gradations in reduction of leaves and condensation of stem may be traced even to the typical desert forms of Cereus. Now, one division of Cereus returns to a life in the woods, where the demand for an increase of green surface is felt; no attempt, however, is made to restore the old leaves (now reduced to tiny scales), but the stem enlarges and branches, while the vertical ribs, developed during the desert habit, are expanded farther and made to function as leaves. As the mesophytic habit becomes more extreme, the ribs become larger in size and fewer in number until finally, in Phyllocactus, but two remain, and these become so flattened and arranged in such a manner on the branch that they form a physiological and anatomical leaf. Here we have a case, indubitable because abundant intermediate steps persist, in which a physiological leaf has been developed from a morphological stem, purely by following the line of easiest accomplishment, or least resistance, at the moment; no single step is in itself remarkable, but the sum total yields a very remarkable result. This principle is, of course, equally applicable to both systems of morphology.

SIXTH, the principle of *metamorphosis by transformation*, as contrasted with metamorphosis by differentiation, which means that when, in response to any influence, a new function and hence structure (function-structure) is assumed by any part, this always comes about, both ontogenetically and phylogenetically, through the transformation or alteration of a previously existing function-structure in that part, and never through the differentiation of a new function-structure out of a previously functionally-indifferent or unspecialized structure. In other words, since all parts of the plant actually are organs (that is have some meaning in the life of the plant), new organs can arise only by the transformation of previously existing ones. We face here a sharp contrast in the two systems of morphology. The idealistic system, laying as it does great stress upon members in distinction from organs, comes to regard these members as if they had a real existence, forgetting that the conception of the member is a pure abstraction of the mind, a sort of mental composite photograph, with no objective equivalent, and that members apart from organs do not really exist. The conception of the member as an entity having once been formed, metamorphosis is naturally regarded as the differentiation of an organ out of a member, and this not only phylogenetically but also ontogenetically; so that by those who carry the idealistic system into ontogeny at all, the ontogenetic unfolding of any organ is viewed as a differentiation from primordia (Anlagen) which, after the analogy of the members, are supposed to be indifferent in their nature. Not only, however, is this view untenable upon philosophical grounds, but it is negatived by the fact that in cases where metamorphoses are experimentally brought about, embryology shows that the process is actually one of transformation of one function-structure into another, and not of differentiation of a function-structure out of a neutral or indifferent primordium (Anlage). But this subject is so clearly treated by Goebel in the Introduction to his *Organography* that it needs no further consideration here. How these, in their origin purely ontogenetic, metamorphoses become fixed in the phylogeny, is an entirely separate question, the solution or non-solution of which does not in the least affect the truth or non-truth of this principle. The idealistic conception, that an organ is formed by differentiation from a member, implies as a corollary that each organ is but one step, so to speak, from a member, and should be readily reducible to it; hence arise the attempts to explain all parts of such complex and specialized structures as epigynous flowers in terms of leaf and stem, necessitating the adnate calyx theory with its requirement of extraordinary assumptions as to growing together of parts, etc., entirely unsupported by the facts of development.

SEVENTH, the principle of *gradation in morphological membership*, involving the existence of degrees of morphological independence, culminating in the attainment of full morphological membership with full independence. Or, it may be expressed thus: in the progressive development of metamorphoses, difference of degree passes over gradually into difference of kind. This principle, in my opinion the most fundamental in morphology, marks far more sharply than any other the difference between the two systems, for it is fundamental to the realistic, but inconsistent with the idealistic conception. It means that, as an organ gradually acquires a new function-structure, and the old function-structure is gradually lost, new powers of variation, adaptation, etc., are acquired which become more and more independent of those formerly possessed by the organ, until finally the change may become so complete that the new organ not only acts itself quite independently of its old nature, but becomes a new starting point or center of metamorphosis, that is, it becomes a new morphological member. New metamorphoses, however, are not confined for their starting-point to the full members, but may originate from any of the points along the lines of gradation. Hence, not only may any organ become a member, but the members grade into one another indefinitely and any of the gradations may act as members. This is in great contrast with the conception of the idealistic system as applied to the higher plants, for that conception not only limits the number of the members to a very few (at the extreme root, stem, leaf, plant hair, exclusive of the sporangia), but practically views these as sharply distinct, not recognizing intermediate transition from which new metamorphoses may originate. In fact the idealistic morphology, while admitting the original evolutionary origin of its members, ignores evolution in their subsequent interrelationships; it views its members much as species were viewed in pre-evolutionary times, while the realistic system applies the idea of evolution throughout. The idealistic system views the morphological members much as a chemist does his elements, which may combine in many ways, but retain their identity throughout; the realistic system regards them more as a physicist does the colors of a spectrum, as a series of stages in a graded sequence of phenomena.

As an example of an organ which has attained to full morphological membership and independence we may consider the spines in the Cactaceae. Research has shown much evidence for the belief that these structures have arisen by the metamorphosis of leaves; the only competing theory is that they are a form of "emergences;" no investigator has ever seriously supposed they were anything else. Now, despite much long-continued observation and special search, no one has ever been able to find transitions between these spines and either leaves or emergences (except in the case of a few monstrosities which may have another meaning), nor have repeated experiments succeeded in making the spines return to leaves or emergences. Now, the cactus spines are immensely variable, becoming very big and hard on the one hand, or weak and small even to disappearance on the other, cylindrical and erect to ribbon-like and contorted, plain or variously ornamented, smooth or beautifully plumed or fringed, curved into hooks useful for climbing, or altered entirely into nectaries. But, throughout all of these variations it is distinctly and unquestionably a spine, an anatomical spine that is varying, and not a disguised leaf or emergence. We must conclude from all these grounds that the cactus spine has attained to full morphological membership, is itself a member, a center of modification and metamorphosis. The mamillae, or tubercles, in the same family, originate by a union of the leaf-base and its axillary bud, but the identity of these two parts becomes completely lost in the new identity of the tubercle, which becomes a member and acts as such through many genera. The ribs in Cactaceae arise by the running together of vertical lines of tubercles; once formed, however, they pay little attention to their mode of origin but proceed to act as independent members, as one may clearly see when he considers their performances (particularly their independent increase or reduction in number) in the development of the cladophylls of Phyllocactus already cited in this paper. In some genera, however, particularly Echinocactus, the ribs have not attained to full independence, for they occasionally revert to lines of tubercles. But we need not go so far afield for our illustrations of the attainment of independent membership, for the members commonly accepted by the idealistic system (root, stem, and leaf) illustrate it perfectly. Most of us no doubt believe that the present-day foliage leaf and stem arose through the sterilization of sporogenous tissue in a primitive very simple sporophyte; but whether we believe it or not does not matter for our present purpose, for we must believe, if we accept evolution at all, that leaf and stem have become specialized out of a simpler structure which did not show those distinct parts. All morphologists accept the foliage leaf and its stem as of full morphological membership and independence, to such a degree indeed that they stand in most minds as the very types of morphological members. Now, in their case, even the idealists never attempt to interpret their morphological behavior in the light of the nature they had before they were leaf and stem. Why, then, does the idealistic morphology insist, for example, upon reducing everything (excepting the sporangia) in a highly specialized flower to the categories of leaf and stem ? In fact, the flower has been so long an independent organ that it has had time to progress far toward independent morphological membership, as witness its ability to suppress circles, to alter the number of their parts, and to rearrange their phyllotaxy quite independently of any actions performed by leaves on a stem. Moreover, various parts of the flower (in some flowers, not in all) have become more or less independent members, as we may clearly see in those which are epigynous. The ovary of such a flower, for example, unquestionably originated in sporophyllary leaves standing upon a conical receptacle, precisely as in numberless flowers today; gradually, however, as embryology proves, the formation of the ovarian cavity was given up by the carpels, and assumed by the receptacle, which grew up in the form of a cup carrying the other parts upon its rim, while the carpels finally came to form simply a roof over the cavity. But, and here is a crucial point, it must not be supposed that during this process the receptacle and carpels retained their old carpel and receptacle nature (much less their "stem" and their "leaf" nature); on the contrary, the new kind of ovary acquired an identity and a character of its own, and in that new identity and character the old identity and character of receptacle and carpel gradually melted away, and lost their distinctness, so that such an ovary has become a new member and is not simply a compound of receptacle and carpel. It is useless, therefore, to expect that such an ovary will build placentae, partitions, style, or stigma according to the rules in vogue with ordinary receptacle and carpel, and useless also to discuss whether in such an ovary the cavity is lined with carpel or not, for the ovarian wall is no longer either receptacle or carpel or both, it is ovarian wall; carpel and receptacle have not fused to form it; their tissue has melted away, so to speak, into the tissue which does form it. For simplicity I here treat this attainment of membership by such an ovary as if it were complete, though in fact it is not so in any ovary known to me, for in all of them some features of both carpel and receptacle may be traced, especially at top and bottom of the ovary. So also, with other parts of the flower; the placenta, which originated in the manner still shown by many flowers, as swollen edges of carpels, has become independent of its carpellary origin in many flowers, as in those with free central placenta, where no trace of the old leaf nature may be found in its entire ontogeny. The tube of gamopetalous flowers is another structure which in some cases has attained to approximate independence, and the style and stigma yet another. All of these parts may become centers of independent (though usually limited) metamorphosis, altering in size, shape, number, building new structures (as the corona) all independently of anything they did before they acquired their present more or less completely independent membership. It is so with the ovule, originating in a macrosporangium, but now an independent member. The same is true of the embryo-sac, which, originating unquestionably as a germinated macrospore, has, after a long history, become a new member with a high, though not a complete independence. Some of its features are to be explained as a persistence of its ancient nature, but it is useless to attempt to interpret all its actions upon that basis, for it does some new things upon its own account — as a new member, the embryo-sac. To return for a moment to the flower as a whole, it is important to notice that the study of its morphology is in one sense complex and difficult, partly because it is a composite structure with various degrees of independence in its component parts, partly because its development in different families has been so independent that it has given rise to homoblastic rather than homogenetic homologies. Hence it is impossible to make distinct categories of members applying to all flowers, but each group must be considered by itself, a feature indeed which applies not to the flower alone but to the vegetative parts as well. Hence we must in theory recognize as potential members all organs, one may even say all recognizable parts, although in practice it is needful to take account for the most part only of those most conspicuous and distinct.

The realistic system, with its infinite gradations and limitless possibilities, is much harder to grasp and to apply, and is less pleasing to teach than the idealistic system, with its few distinct categories and their involved limitations. But it is truer to nature, more stimulating to research, and more replete with promise of great results.— W. F. GANONG, *Smith College, Northampton, Mass.*

CURRENT LITERATURE.

BOOK REVIEWS.

A Californian manual.[1]

THIS manual by Professor Jepson deserves more than a passing mention, for in a certain sense it is constructed on new lines. The average manual is chiefly a compilation of scattered literature checked by more or less herbarium study. The result is merely an approximation to the facts and never quite satisfactory to the field student. Professor Jepson has met his plants in the field and has described them as they live. He has recognized literature so far as it fits his material, but has not allowed it to bias or handicap him. As a consequence, the descriptions are remarkably fresh and telling, and have no flavor of stereotyped diagnoses. Not only is the wonderfully diverse Californian flora set forth, but numerous ecological notes suggest the factors that lie behind the diversities. Repeated attention is called to the variations in vegetative characters which a single species may undergo in different situations. The following statements from the preface are worthy of quotation, since they are of general application:

> 1. Near the ocean a species is often more depressed or condensed than in the interior, and more fleshy.
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> 2. In swamps or wet soils the plant tends to become succulent and of ranker growth, and also glabrous.
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> 3. In valley soils the growth is commonly much more rank than elsewhere.
>
> 4. On hilltops plants tend to become dwarf and acaulescent; often far more pubescent also.
>
> 5. In saline or subsaline soil the stems and foliage in many species are far more vigorous and the flowers larger than on stiff clays or adobes.
>
> 6. In the shady woods leaves become thinner and larger, often conspicuously so.
>
> 7. At high altitudes the flowers are larger in proportion to stature and brighter in color.

Such facts are known to the ecologist, but it seems hard to get the taxonomist to give them due weight. The region covered lies west of the Sacramento and San Joaquin rivers, south of the counties of Mendocino and Colusa, and north of the Pajare river and Pacheo pass. Several such manuals will be needed to present the flora of California, and it is daily becoming more evident that no one is competent to prepare them who has not lived among the plants. The numerous analytical keys are prepared with special

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[1] JEPSON, WILLIS LINN: A flora of western middle California. 8vo. pp. iv + 625. Berkeley, California: Encina Publishing Company. April 16, 1901. $2.50.

care, and the verbiage of pedantry has been eliminated. A number of new species are described, but from the statements made the field seems to be white for the harvest. Professor Jepson is to be congratulated upon producing a useful, rational, and modern manual.—J. M. C.

The Cyclopedia of American Horticulture.

The third volume of Bailey's *Cyclopedia of American Horticulture* has just come from the press of the Macmillan Company. It includes the letters N–Q.[2] Aside from the articles on important genera, among which the most noteworthy are those on Nepenthes, Nymphaea, Odontoglossum, Oncidium, Opuntia, Pinus, Prunus, Pyrus, and Quercus, the following articles are of special interest. The botanical treatment of *Orchids* is by H. Hasselbring, the culture of orchids by Robert M. Grey, with a general introduction by the editors. On the *Peach*, the general article is written by Professor Bailey, peach culture in the south is treated by J. H. Hale, peach culture in the far north (northern Vermont) by J. T. Macomber, the Michigan peach industry by R. Morrill, peach culture in Delaware by Charles Wright, the peach in California by H. Culbertson. Professors Bailey and T. T. Lyon contribute a general article on *Pear*, C. L. Watrous writes about pears on the northern plains, E. J. Wickson on the pear in California, John S. Collins on the Kieffer pear, L. T. Yeomans on dwarf pears, and George T. Powell on pears for export. The horticultural capabilities of the *Philippines* are described by F. E. Gannett. A somewhat unexpected article is the one on *Horticultural photography* by J. Horace McFarland. It ought to be very helpful and to result in the great improvement of the illustrations in our experiment station reports and other similar publications. A compact article upon the general *Physiology* of plants is contributed by Dr. B. M. Duggar. The article on *Plant breeding* by Mr. H. J. Webber will attract attention. The principles of the art are well set forth, but it is unfortunate that he unnecessarily insists on calling stamens and pistils the male and female organs of plants. On the *Plum* Professor Bailey writes the general article, Professor F. A. Waugh discusses the cultivation of native plums, and Mr. A. V. Stubenrauch gives an account of the plum in California. The article on *Pomology* is naturally handled by the editor, an appendix on Russian fruits being contributed by John Craig. The work maintains the high standard of the preceding volumes.[3] —C. R. B.

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[2] BAILEY, L. H.: Cyclopedia of American Horticulture, comprising suggestions for cultivation of horticultural plants, descriptions of the species of fruits, vegetables, flowers, and ornamental plants sold in the United States and Canada, together with geographical and biographical sketches. Vol. III. N–Q. 4to, pp. xv+1055I–486, *figs. 1454–2059, pls. 20–29.* New York: The Macmillan Company. 1900. $5.

[3] Bot. Gaz. **29**: 282; **30**: 277. 1900.

MINOR NOTICES.

Dr. G. N. Best has revised the North American species of Heterocladium[4] recognizing four species, of which two, *H. Macouni* and *H. heteropterioides* are new. Three Kindbergian species are in the "doubtful or excluded" list. —C. R. B.

Emma J. Cole[5] has published a catalogue of the native vascular plants growing in the vicinity of Grand Rapids, Michigan. The introduction presents the general physiographic and ecologic features of the region, and in the list all known stations are carefully recorded. The number of native plants recorded is 1111, of introduced plants 176.—J. M. C.

V. K. Chesnut and E. V. Wilcox have published a valuable preliminary report (Bull. 26, Div. of Bot., U. S. Dept. Agric.) of their investigation of the stock-poisoning plants of Montana. It contains not only a detailed account of their observations and experiments, but also summaries of symptoms and remedies. The most important plants poisonous to stock in Montana are the death camas (*Zygadenus venenosus*), tall larkspur (*Delphinium glaucum*), purple larkspur (*D. bicolor*), Wyoming water hemlock (*Cicuta occidentalis*), white loco weed (*Aragallus spicatus*), and various lupines (*Lupinus* spp.).—J. M. C.

The first fascicle of what promises to be a very excellent treatise on botany by Bonnier and DuSablon has just been published.[6] The work is intended specially for advanced students in the universities and schools of medicine, pharmacy and agriculture. The first section discusses such general matters as the characters of plants, the members of the plant body, the large divisions of plants, the cell and the tissues. The second section, entitled the morphology of angiosperms, concerns itself with the primary and secondary structure of stamens, leaves, and roots. The illustrations are fresh and in the main excellent, though the anatomical ones are better than those representing external features. We reserve further notice of this work until its completion.—C. R. B.

William R. Maxon[7] has published a very useful list of the pteridophytes of North America north of Mexico. Eaton's *Ferns of North America* and

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[4] Bull. Torr. Bot. Club **28**: 123–131. *pls. 13, 14.* 1901.

[5] Grand Rapids flora, a catalogue of the flowering plants and ferns growing without cultivation in the vicinity of Grand Rapids, Michigan. 8vo. pp. xxii + 170. Grand Rapids: Lyon, Kymer & Palmer Company. 1901. $1.00.

[6] Bonnier, Gaston, and DuSablon, Leclerc: Cours de botanique; anatomie; physiologie; classification; applications agricoles, industrielles, médicales; morphologie expérimentale; géographie botanique; paléontologie; historique; à l'usage des élèves des universités, des écoles de médecin et de pharmacie, et des écoles d'agriculture. Vol. I, part 1. 8vo, pp. 384, *figs. 553*. Paris: Paul Dupont. 1901. Complete in 6 parts. 25 fr. Each part singly 6 fr.

[7] A list of the ferns and fern allies of North America north of Mexico, with principal synonyms and distribution. Proc. U. S. Nat. Museum **23**: 619–651. 1901.

Underwood's *Our native ferns and their allies* have been the only works of sufficient scope to include this territory. The former is more than twenty years old, and the latter is essentially a popular treatise in which there are no citations. As a consequence, a list of the known ferns and their synonymy has been a *desideratum* for some time, and this Mr. Maxon has supplied. Besides his careful bibliographic work, the author has included the recorded geographic range of each species, thus adding very materially to the value of the list. What may be called the Underwood nomenclature and sequence are followed.—J. M. C.

A LABORATORY MANUAL[8] has recently been published by F. E. Clements and I. S. Cutter. It is of special interest as being "an authoritative expression from the Department of Botany of the University of Nebraska upon the kind and amount of elementary botany that should be taught in the accredited schools and colleges of the state." The directions for work are clear and compact, and based upon long experience in handling the material. Granted that such material is best suited to high-school courses, no exception can be taken to the way in which it is presented. A question might be raised, however, as to the "kind of elementary botany" that this book calls for. To start high-school pupils with a short course in histology is probably not commended now as much as formerly. The part devoted to structure and classification would seem to be a more fitting introduction to the use of plant material. A good set of physiological experiments is also included, and it is interesting to note that a certain amount of work in ecology is called for. The book must be of great service to the schools of Nebraska in so far as it relates them to the work of the University.—J. M. C.

THE PROCEEDINGS of the twenty-first meeting of the Society for Promotion of Agricultural Science, recently distributed, form a volume of 183 pages, containing articles of botanical interest. The president's chair was occupied by a botanist, W. J. Beal, of Michigan, but the annual address dealt chiefly with matters of general interest to the society. A "syllabus for a short course on grasses and other forage plants" by the same person is of decided pedagogical value. "The development of a tomato hybrid" by W. M. Munson is an account of the production of a desirable hybrid variety by crossing the common and the currant tomato. "The chemical function of certain soil bacteria" by Frederick D. Chester, "Seven years of experiments with bush beans" by Byron D. Halsted, "The value of willows in retaining the banks of streams" by W. W. Rowlee, "The course in cryptogamic botany" by L. H. Pammel, "The weedy plants of Iowa," also by Mr. Pammel, contain botanical matter with practical applications of the facts. H. L. Bolley corrects some errors of microscopic interpretation occurring in his

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[8] A laboratory manual of high school botany. 8vo. pp. 123. Lincoln, Nebraska: The University Publishing Company. 1900.

bulletin no. 27 from the N. Dakota Experiment Station. Two very interesting articles are "Twenty years progress in pathology" by B. T. Galloway, and "The botanic garden as an aid to agriculture" by William Trelease.—J. C. ARTHUR.

A NEW LABORATORY GUIDE for bacteriology by Mr. W. D. Frost, of the University of Wisconsin, is a convenient combination of directions for experiments, blank pages, charts, and outline drawings in which results may be recorded, together with some general information.[9]

The first part of the book is devoted to general bacteriology with the usual description of technique and laboratory methods. The medical part of the book is more complete than usual for an elementary text book.

General information is given in the form of brief notes wherever a germ is mentioned for study, relating its source, time of isolation and discoverer, with references to the original and other descriptions. A chapter on taxonomy includes Chester's scheme of nomenclature of cultural characters and Migula's valuable classification of bacteria.

The most striking features of the book are the well-outlined and systematic arrangement of material, and the unusual and deserved attention given to one of the most important problems in the study of bacteria today, the effect of environmental action. The chart blanks are excellently designed for the record of the numerous physiological and morphological characters of a culture under study. A useful supplement to these detailed record blanks would be a few charts such as those recommended by Fuller for recording definite position and negation reactions in comparative form. The book as it stands, however, is very complete and will be welcomed in many laboratories.—MARY HEFFERAN.

NOTES FOR STUDENTS

THE great prevalence of potato blight (*Phytophthora infestans*) in the state of Washington for the past two years has led to the publication of a bulletin[10] on the subject by the Agricultural Experiment Station, based on experiments made at the Puyallup station. Bordeaux mixture applied before the disease began to be apparent and again after about two weeks was found to decrease materially the injury from the disease.—ERNST A. BESSEY.

PROFESSOR CONWAY MACMILLAN has been studying the growth periodicity of the potato tuber[11] by the method described in this journal (**16**: 149. 1891) which he has improved upon by employing a second wheel to magnify

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[9] FROST, WILLIAM DODGE: A laboratory guide in elementary bacteriology. 4to pp. viii + 200. Published by the author. Madison, Wis. 1901.

[10] BRODIE, DAVID A.: Potato blight and its treatment. Bull. 46, Washington Agricultural Experiment Station, pp. 15, *figs. 5*. 1901. Pullman, Washington.

[11] Bull. Minn. Acad. Nat. Sci., **3**: 355–362. 1901.

more the tracing of the auxanometer. He finds the increase in diameter rhythmic, with maxima once or twice or oftener in 24 hours, followed by minima when growth ceases or nearly so. There are indications of a grand period, and some connection between the periodic growth of the aerial parts and tubers.— C. R. B.

MISS MATHILDE GOLDFLUS[12] finds that chlorophyll not only persists under the cork of many branches, but that it is present in the medullary rays, in the pith, and is even formed in the cortex of trunks of trees at the bottom of the crevices in a ridgy bark, as in Quercus and Robinia. Indeed it may develop in any living tissues. Photosynthesis by this chlorophyll is active, more than counterbalancing the production of CO_2 in respiration, though no quantitative determinations seem to have been made. Inasmuch as the area exposed by branches is considerable, and as photosynthesis continues in winter, it is evident that it is of considerable importance to the plant. Miss Goldflus and Mr. Miyake[13] have thus called attention to hitherto overlooked activity of the chloroplasts.—C. R. B.

S. KUSANO (Bot. Mag. Tokyo **15**:42–46. 1901) has published a short account of the parasitism of *Buckleya Quadriala*, one of the Santalaceae of Japan. Its haustoria apparently attack the roots of almost any plant, as witnessed by the artificial cultures made. As a result of the attack the activity of the cambium of the host-root seems to be much increased, since a transverse section of that part shows the greatest diameter of wood and cortex. "If the age of a haustorium may be estimated from the annual rings of the host-root which overlie the sucking process, it is safe to conclude that the same organ of Buckleya can maintain its activity during fifteen years, and probably longer." The author found no difficulty in cultivating these green parasites by sowing the seeds in the same pots with the seeds of other plants which might serve as hosts.—J. M. C.

IN A RECENT PAPER Noll[14] takes up again the much discussed subject of polarity among the marine algae. Beginning with the statement that in *Bryopsis muscosa*, on which he worked, the polarity is as pronounced as in Pinus, he states as a result of his experiments that very few of his plants reversed their root and shoot poles when inverted. By measurements and dates he ascertained that the young and actively growing plants were so strongly polarized as to resume the original manner of growth; that only the older more slowly growing forms succumbed to the force of external conditions and turn root into shoot and shoot into root. Hence the inherited polar-

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[12] Revue gén. de Bot. **13**:49–92. 1901.

[13] Bot. Mag. Tokyo. **14**:44. 1900. See Bot. Gaz. **30**:141. 1900.

[14] On reversion experiments on Bryopsis, with remarks on energids. Ber. d. deut. bot. Gesell. **18**:444–451. 1900.

ization is lost with age. These results agree with those of Winkler of an earlier date. To the definition of an "energid," as given by Sachs, Noll takes exception, and calls the Siphoneae "single but multinucleate energids," laying stress rather on the *Hautschicht* than on the nucleus with its dominated mass of protoplasm. He therefore defines the energid as a "one or many-nucleate plasmatic body enclosed in a definite wall."—PHILIP GRAEME WRIGHTSON.

"A rhizomorphic root-rot of fruit trees"[15] is the title of a recent bulletin of the Oklahoma Agricultural Experiment Station. For a number of years a serious root trouble, especially of the apple, has been attracting the attention of fruit growers and botanists in Missouri, Illinois, Oklahoma, and Texas, as well as in other regions. This has been shown by von Schrenk and others to be caused, in all probability, by a hitherto unidentified rhizomorph-producing fungus. In the present bulletin, based upon work taken up since last June, the disease is shown to attack other trees also than merely fruit trees, and is ascribed to a species of Clitocybe which is described as new under the name *C. parasitica*. This was found at the base of many diseased trees and was accordingly considered to be the cause of the disease. Most of the bulletin is given up to a discussion of previous work on diseases of trees caused by agarics, to a host index of these fungi as they affect trees, and to a long bibliography. The discussion of the disease under consideration is really limited to four or five pages.—ERNST A. BESSEY.

THE SUBJECT of asparagus rust is one that continues to attract attention. A recent bulletin by F. A. Sirrine[16] discusses the disease and its treatment in New York. All the stages of the rust are found to occur in the state. The variations in the distribution of the disease ascribed by some investigators to soil conditions seem rather to be due to the occurrence or non-occurrence of dews or dense fogs which furnish the moisture necessary for the germination of the spores. The measures usually recommended in combating this disease, viz., cutting and burning the affected fields early in the fall, are shown to be injurious to the plants and not of appreciable value in reducing the amount of rust next year. Using a specially devised spraying machine, which enabled the operators to wet all parts of the plants thoroughly, was found in two years trials under unfavorable conditions to effect a gain in the crop of 69.5 per cent. for the first year and of 47.8 per cent. for the second year. The best results were obtained with a Bordeaux mixture to which was added a solution of

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[15] WILCOX, E. MEAD: A rhizomorphic root-rot of fruit trees. Bulletin 49, Oklahoma Agricultural Fxperiment Station. p. 32. *pls. 11.* February 1901. Stillwater, Oklahoma.

[16] SIRRINE, F. A.: Spraying for asparagus rust. I. Tests with resin-Bordeaux mixture. II. The Downs power asparagus sprayer. N. Y. Agric. Exper. St. Bull. no. 188, pp. 233–276. December 1900.

resin. Spraying was not found to be profitable where the disease had so weakened the plants that they gave less than one third of the normal crop.—ERNST A. BESSEY.

ATTENTION is called to a group of fungus diseases hitherto almost unnoticed in this country in a joint bulletin by B. M. Duggar and F. C. Stewart entitled "The sterile fungus Rhizoctonia as a cause of plant diseases in America."[17] The genus Rhizoctonia is a so-called form genus, *i. e.*, it consists of fungi whose spore forms are unknown but which agree generally in their vegetative characters. The fungus is characterized by a peculiar method of branching of the hyphae, by the formation of sclerotia, and by its usually parasitic habit on roots and underground parts of plants. The authors find that this fungus is present on many different hosts, including among the most important the potato, beet, bean, carnation, lettuce, and radish. Whether the same species affects all these plants still remains to be determined by cross-inoculations. In most if not all of the plants mentioned, the fungus causes a severe root-rot, which often results in the death of the host. That the fungus is the cause of the disease was proved in some of the cases by repeated inoculations with pure cultures. As the paper is in a measure only preliminary the discussion of the special morphology and physiology as well as of the taxonomy and relation to European forms is reserved for a later paper, in which will also be taken up the results of inoculation experiments. —ERNST A. BESSEY.

PROFESSOR G. J. PEIRCE[18] has published some interesting studies on *Sequoia sempervirens*, chiefly in connection with the development of suckers, a very unusual habit among Gymnosperms. The claim is made that reforesting is entirely possible if suckers and seedlings are not destroyed by fire. In the tendency of the suckers to fasciation the author confirms Frank's view that it is in consequence of an excess of food substances in available form. The most prominent feature of the paper, however, is the discussion of the albinism of certain suckers. These are by no means uncommon, and they differ decidedly in rate of growth, in resistance to cold, in leaf structure, etc., from green suckers. The author thinks that the albinism is due to the fact that the leaves form and attain nearly or quite full size when there is insufficient warmth for the formation of the chromoplasts and the chlorophyll, though enough for growth. One interesting feature of the albinism is that when a sucker begins white it always remains so, no matter how favorable

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[17] DUGGAR, B. M. and STEWART, F. C.: The sterile fungus Rhizoctonia as a cause of plant diseases in America. Bull. 186, Cornell University Agricultural Experiment Station, Ithaca, N. Y. Bull. 186, New York Agricultural Experiment Station, Geneva, N. Y., p. 28, *figs. 9*. January 1901.

[18] Studies on the coast redwood (*Sequoia sempervirens* Endl.). Proc. Calif. Acad. Sci. III. Bot. **2**: 83–106. *pl. 14*. 1901.

the later conditions may be for the development of a green sucker. The author suggests as an explanation that the sucker is in unbroken connection with an abundant food supply, and that there is not the stimulus of need for a later production of chromoplasts and chlorophyll. The contribution closes with an interesting discussion of parasitism and heredity from the standpoint of white suckers. Attention is called to the fact that in this case absolute parasitism in habit and structure is developed by the environment in a single generation from a long line of independent plants It would seem to the author, therefore, that the influence of heredity is less powerful than the power of reaction to certain immediate stimuli, and he closes as follows: "May not this always be the case? May it not be that what we call heredity is really the response to similar stimuli and combinations of stimuli occurring in orderly succession in the course of nature?"—J. M. C.

BOTANICAL ARTICLES in annual reports of Agricultural Experiment stations, not heretofore noticed in these pages, are as follows: Report of the New York station for 1900 contains reprints, with admirable plates, of bulletins 161, 162, 163, 164, 167, 169, and 170, all of much interest to students of plant diseases and of some other topics. Report of the Wisconsin station for 1900 contains a number of original articles. S. M. Babcock and H. L. Russell discuss the "Causes operative in the production of silage," and arrive at the conclusions that the presence of bacteria is unessential and even deleterious, that the chief action is intramolecular respiration of the plant cells, producing carbon dioxid and organic acids in proportion to the length of time the cells remain alive and active, and that the aroma is due to the action of enzyms. These are unexpected and important results. The same authors describe with illustrations an excellent "Closed circuit respiration apparatus," which would be most useful in a laboratory of physiology. E. S. Goff reports on "Investigations of flower buds" and concludes that "in favorable seasons of flower formation, many of the buds formed that season, and nearly all those formed the preceding two seasons, that have not already flowered, will become flower-buds; an excessive apple crop results, which is necessarily followed by a light one, because the supply of reserve buds is exhausted." The same writer treats of "The resumption of root growth in spring" and "The effects of continued use of immature seed;" while F. Cranefield writes upon "Duration of the growth period in fruit trees." In the 7th Report (1899) of the Wyoming station are excellent "Alkali studies," dealing with the germination and growth of seeds, by B. C. Buffum and E. E. Slosson, and in the 10th Report (1900) Aven Nelson gives a list of "The cryptogams of Wyoming," including the algae, fungi, and mosses. Other botanical articles in these reports have previously been published as bulletins. The report of the botanists, George E. Stone and Ralph E. Smith, in the 11th Report of the Hatch (Mass.) station deals with a variety of fungal and physiological disorders of plants. In the 12th Report the same writers discuss a number of fungous diseases, especially tracing a relation between the abundance of asparagus rust and the physical character of the soil in conserving water. In the 19th Report of the New Jersey station, B. D. Halsted presents a varied annual report (80 pp.), similar to those of a number of years back for which he is so justly famous. Among the numerous topics taken up probably the most interesting are "Experiments with asparagus rust" and "Fungi as related to weather." In the 11th Report of the Rhode Island station (1898) H. J. Webber and J. A. Tillinghast present a large amount of interesting data upon the feeding of plants with chemical fertilizers, especially the use of lime on acid soils, the articles being well illustrated. The third part of the 22d Report of the Connecticut station (1898) opens with four articles by Wm. C. Sturgis on diseases of melons, lima beans, tobacco, peach, and use of fungicides. In the 14th Report of the Maine station W. M. Munson has interesting articles on "The blueberry in Maine," "A comparison of large and small radish seed," "The effect of sub-watering radishes," and "Pollination and fertilization of flowers." The botanists of the Vermont station, L. R. Jones and W. A. Orton, give in the 12th Report (1899) a valuable account of potato and apple diseases and their remedies, of killing weeds with chemicals, and of parasitic fungi of Vermont, being the second list.—J. C. ARTHUR.

WE ARE TO HAVE from Dr. Blackman, of the University of Cambridge, a series of papers on the algae, that will aim to give a critical account of the work that has accumulated since Wille's treatment in "Die natürlichen Pflanzenfamilien" of Engler and Prantl in 1890. The first paper[19] has recently appeared, and, excluding the Cyanophyceae, takes up the simpler types of algae, discussing the possible relationships and lines of evolution. The author starts his lines of development from the level of the Protococcoideae, and lays special stress on the Chlamydomonas-like forms, finding in their varied life histories several possibilities of evolution, worked out in different groups of the Chlorophyceae. There are three conspicuous tendencies, resulting in the well-known types of vegetative organization called by him the *volvocine*, *tetrasporine*, and *endosphaerine*.

The volvocine tendency lays emphasis upon the motile phases in the life history, and leads to the specialization and segregation of the ciliated cells in the complex coenobia of the Volvocales. A tendency on the part of resting cells to form filaments, cell plates, and membranes is termed tetrasporine, and results in forms like Tetraspora, Hormidium, etc., and through them leads to the thallus of the Confervales. In the endosphaerine condition vegetative division is reduced to a minimum, and in its place is found the

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[19] BLACKMAN, V. H.: The primitive Algae and Flagellata. An account of modern work bearing on the evolution of the Algae. Ann. Bot. **14**: 647. 1900.

peculiar form of multiplication illustrated by Pediastrum and Hydrodictyon. This is essentially a method of spore-formation with the peculiarity that the zoospores, unable to escape from the sporangium, settle down to form a new individual within the mother cell. These three conditions have been recognized by several phycologists, and probably express the history of events fairly correctly for this region of the algae, where the original conditions and later modifying factors seem relatively clear.

The Conjugales, Siphonales, and Diatomales form natural groups that cannot be closely related to the Protococcales or Confervales. They have not been treated in this paper, which deals chiefly with the Chlamydomonas-like organisms, flagellates, and a certain assemblage of forms termed the "Heterokontae." It is doubtful whether most botanists realize that the immense group of the Flagellata resembles the lower Volvocales so closely that no hard and fast line can be drawn between them and the algae. This relationship is treated at some length, and should be welcomed. In his remarks upon the primitive Phaeophyceae Dr. Blackman enters a field of acknowledged difficulty, and while he presents certain possibilities the reader cannot but realize that he is speculating in a region where there is a conspicuous paucity of knowledge.

The author of a paper of this character naturally lays himself open to criticism, for his is an attempt to connect and relate groups as definitely as possible with confessedly fragmentary evidence at hand. Certain difficulties are presented in this paper which cannot be easily overcome. Is not Chlamydomonas much too high a type on which to pivot so many evolutionary lines? What is to be done with the simplest of the Pleurococcaceae? There is little or no real evidence that they are degenerate forms, and this view seems to have its chief *raison d'être* as an assumption to dispose of a troublesome difficulty. Chlamydomonas is very complex as a cell, with its differentiated activities, sex, etc. There were, of course, immense stretches of simpler forms below this level, perhaps rising out of the Cyanophyceae. We know almost nothing of the cytology of the Pleurococcaceae, the Cryptomonadineae, and other border groups. It seems to the writer that we may hope for important results from this field of investigation. We shall probably have to go much farther back than Chlamydomonas before we can hope to clear the maze of relationships in the Pleurococcaceae.—B. M. DAVIS.

OPEN LETTERS.

USE OF FERN NAMES.

WHILE Messrs. Fernald and Pollard are discussing the names by which our American ferns should be known, a few observations upon another side of the subject may be in season. I refer to the practice of fern students in the use of these names. There are in America about two thousand persons at present engaged in the study of our ferns and fern allies. Of this number I am confident that fully nine tenths are committed to what may be called a conservative nomenclature. Granted that the names given in the sixth edition of Professor Underwood's *Our Native Ferns* are correct according to the Rochester code, the mass of fern students see in this no argument for adopting them. The reason why they do not is easily found. In adopting most of the names proposed, the student would be departing from almost world-wide usage and bringing confusion into a part of the study that has thus far practically escaped. A single instance will illustrate. *Cystopteris fragilis* is a plant of almost world-wide distribution. It is found in the West Indies, South Africa, India, and Alaska, as well as the United States, and is everywhere known by the name I have here given it. The question may be fairly asked, then, what it would avail American students to unite with Professor Underwood in calling it *Filix fragilis.* They would only succeed in making themselves misunderstood to fern students in other parts of the world. On the other hand, certain changes, such as Athyrium for part of Asplenium, and Polystichum for part of Aspidium, have been readily adopted, because these names are in common use abroad, and by accepting them the American student comes more into harmony with universal usage. In thus rejecting some names and accepting others, the fern student is really consistent, although at first glance he may not seem to be.

The fact that many of our ferns are common to the old world, also, puts a slightly different aspect on the subject of their nomenclature in the opinion of the student; we cannot "go it alone" in the matter of names. And, after all, those interested in the plants themselves care very little for improvements in their names. At the same time, the value of knowing what names have been proposed for our ferns in the past is not underestimated; these names are a part of the plant's history. But the proposal to adopt them is quite another matter. Just as we have agreed not to go beyond Linnaeus for specific names, although there were such names before his day, so the fern student prefers not to go back further for his fern names than, say, the fourth edition of Professor Underwood's book or the sixth edition of Gray's *Manual*. In doing this he is essentially adopting the brand of nomenclature advocated by Mr. Fernald, without attempting it.

I am aware that in adhering to certain names regardless of anything but common usage the student is open to the charge of being unscientific, but this does not alter the fact that he does adhere to them. Moreover, by a very few changes in his nomenclature, he can come into harmony with the great majority of students who happen to be following practically the rules suggested by Mr. Fernald, and so avoid being unscientific. The whole question resolves itself into which style of nomenclature will give us stability and uniformity *throughout the world*, with the least change. Some indication of how the tide is setting may be found in the fact that no less than three books on ferns to be issued in the United States this year will use the conservative fern names.—WILLARD N. CLUTE.

NEWS.

Dr. Wm. Benecke, privat docent in botany in the University of Kiel, has been appointed to an associate professorship.

Dr. B. Nemec has been appointed Director of the new institute for Plant Physiology of the Imperial Bohemian University of Prag.

According to *Science*, the extensive herbarium of the late Dr. T. Bernard Brinton has been presented to the Botanical Garden of the University of Pennsylvania.

Edward W. Berry a member of the Torrey Botanical Club has been awarded the Walker prize of fifty dollars by the Boston Society of Natural History for a memoir on Liriodendron.

The transfer of the late Dr. J. G. Agardh's herbarium of algae to the University of Lund is made on the express condition that no specimens be loaned. While this will doubtless tend to preserve a valuable collection of types, it seriously restricts its usefulness.

A recent number of *Plant World* announces that the herbarium of the veteran collector, Mr. A. H. Curtiss, containing about 16,000 sheets, was destroyed in the recent great fire at Jacksonville, Florida. His early collections for this year's distribution were saved.

A summer school for nature study is to be held at the Rhode Island College of Agriculture and Mechanic Arts, Kingston, from July 5th to 20th. A course on trees and garden plants will be given by Professor Fred W. Card and Mr. George E. Adams; on flowering plants by Professors W. W. Bailey and H. L. Merrow; on seaweeds and fungi by Dr. A. B. Seymour.

It is with great regret that the Botanical Gazette records the death of Professor Thomas Conrad Porter of Easton, Pa. He died April 27, 1901, at the age of seventy-nine. Since 1866 he has been identified with Lafayette College, and has long been one of the best known American taxonomists. A biographical sketch will be published in an early number of the Gazette.

The biological station of the University of Montana, established in 1899 on Flathead lake, will be opened this year on July 22. The University supplies books, chemicals, glassware and microscopes for use free; students are charged only for material used and breakage. The botanical work will be in charge of Dr. D. T. MacDougal and Mr. R. S. Williams, of the New York Botanical Garden.

GENERAL INDEX.

The most important classified entries will be found under Contributors, Personals, and Reviews. New names and names of new genera, species, and varieties, are printed in **bold-face type**; synonyms in *italics.*

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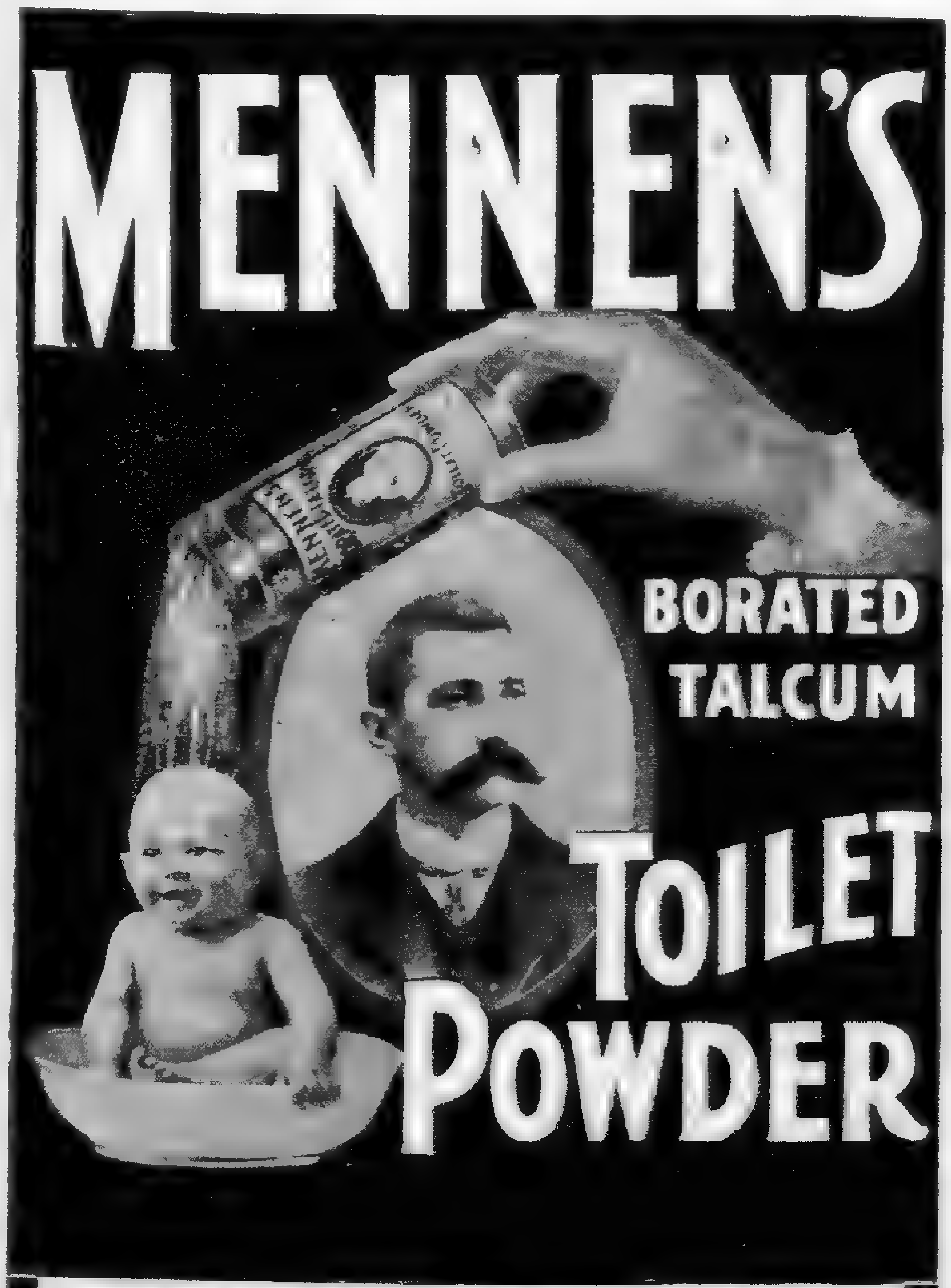
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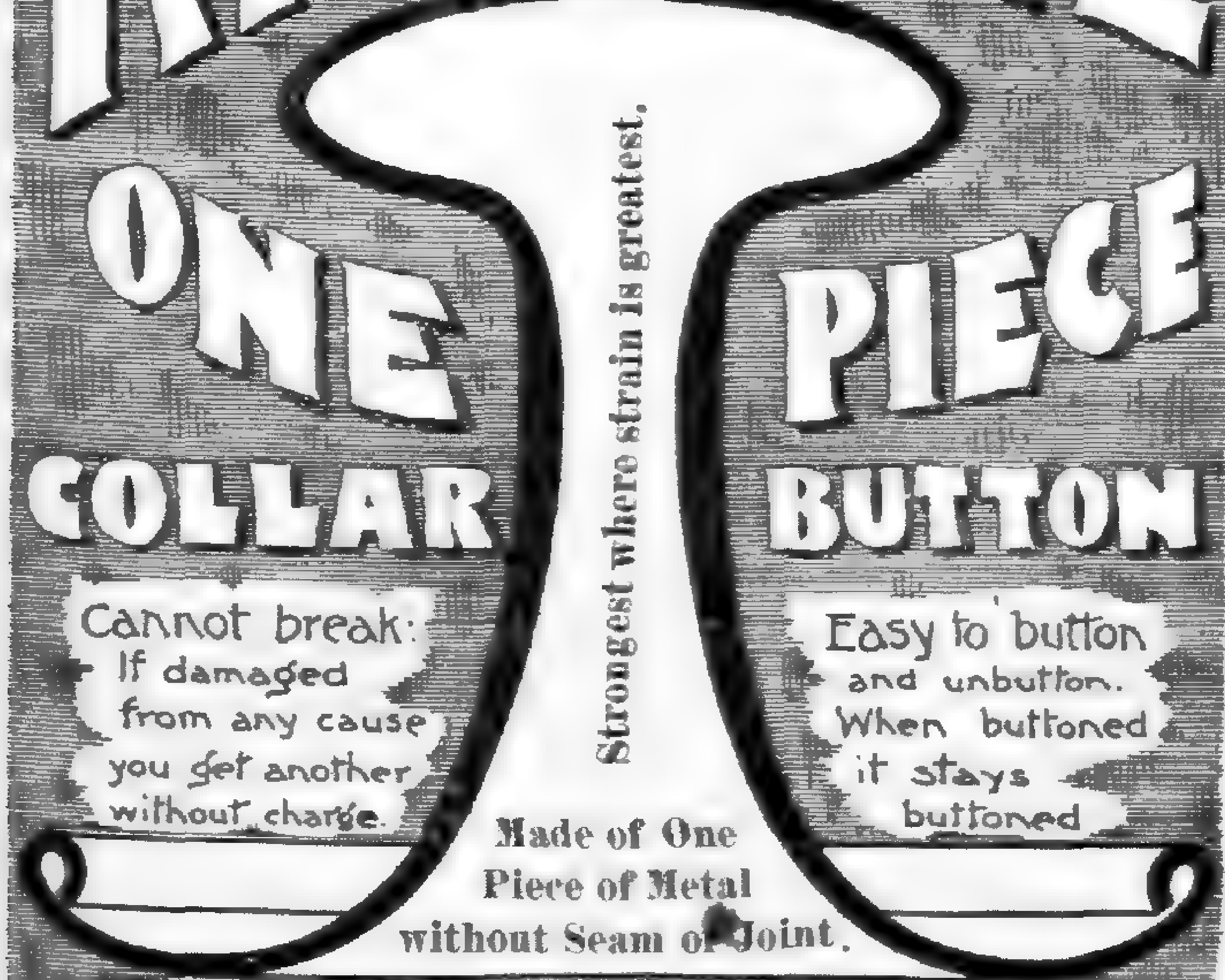

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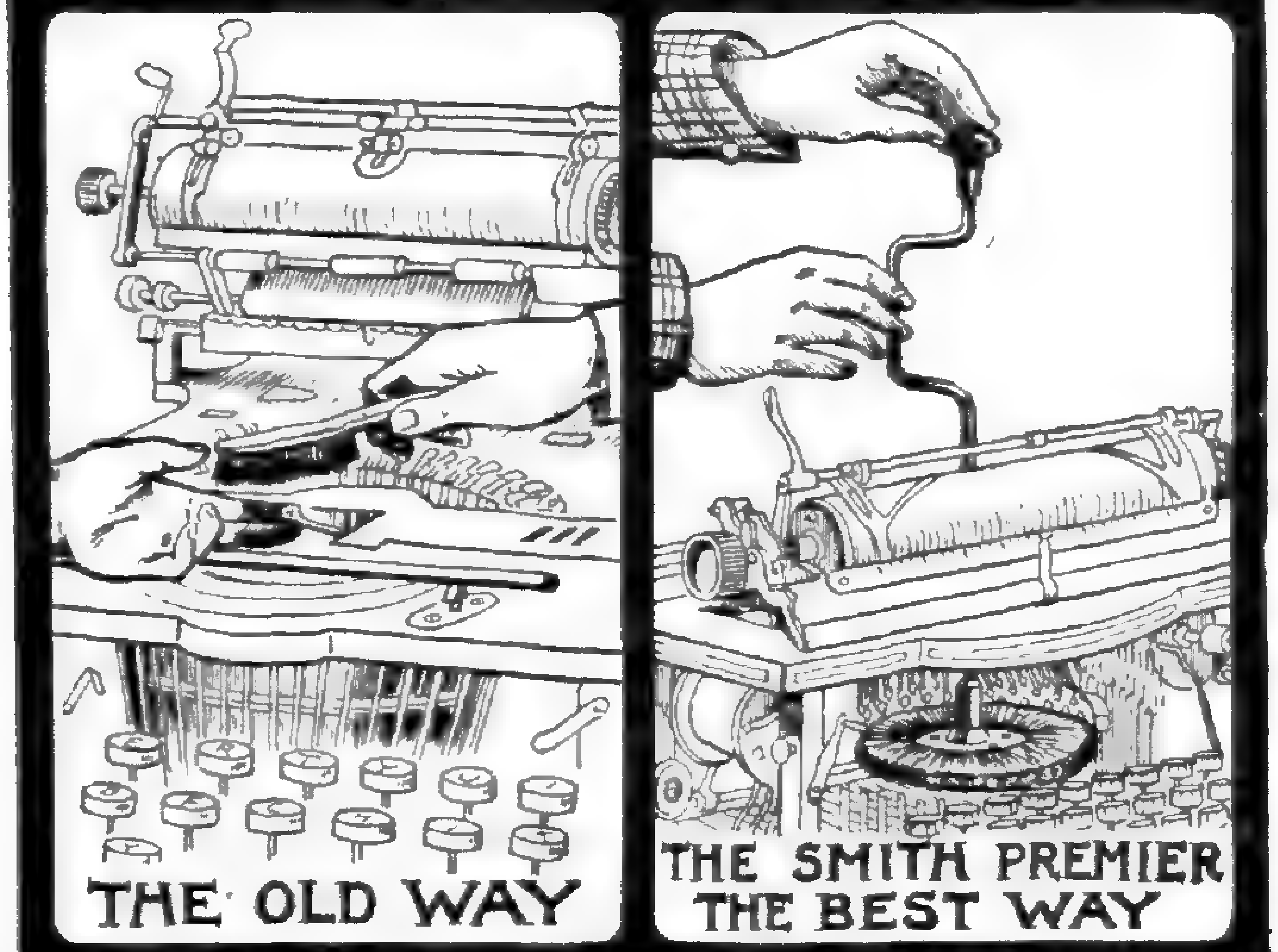
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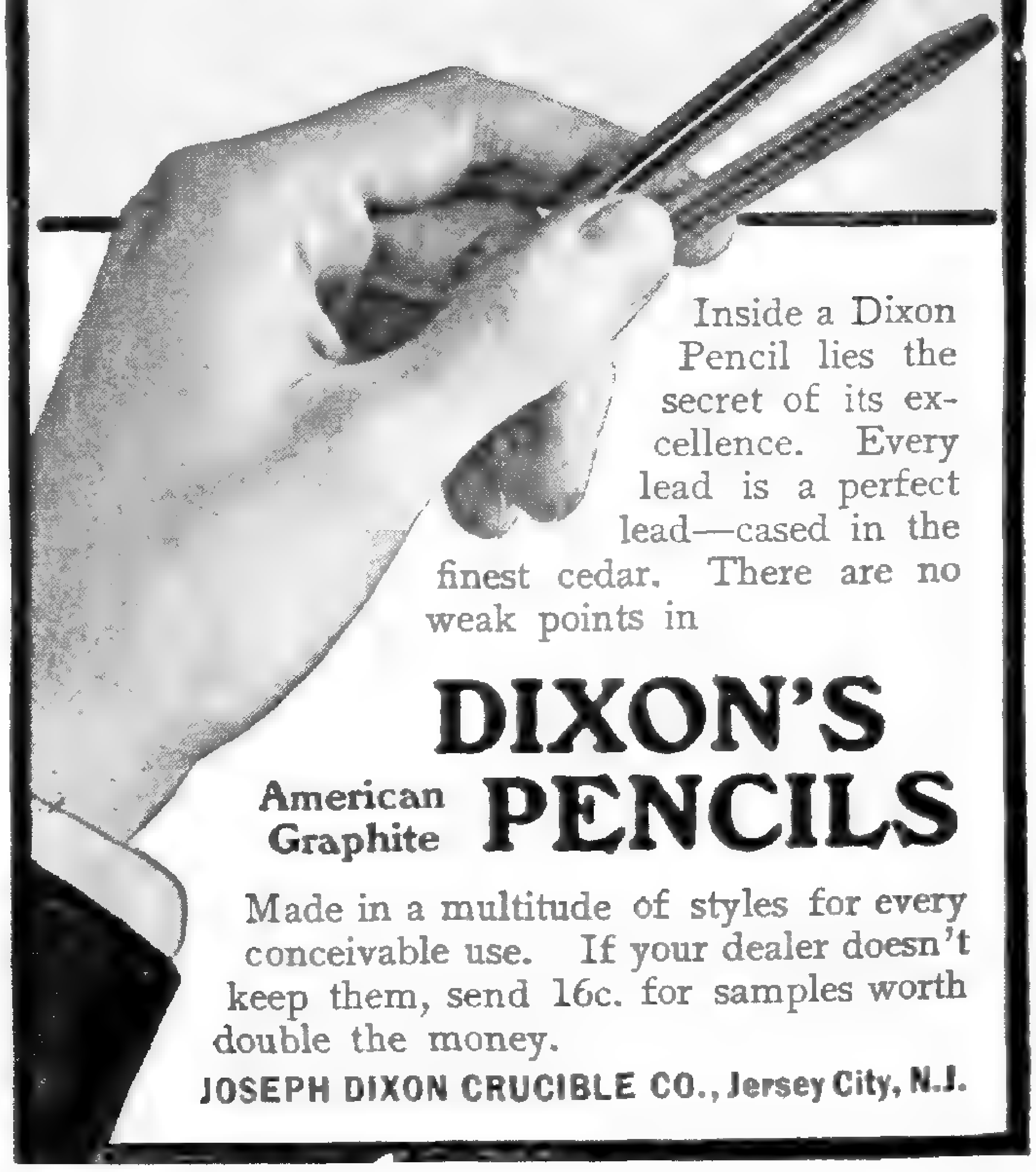

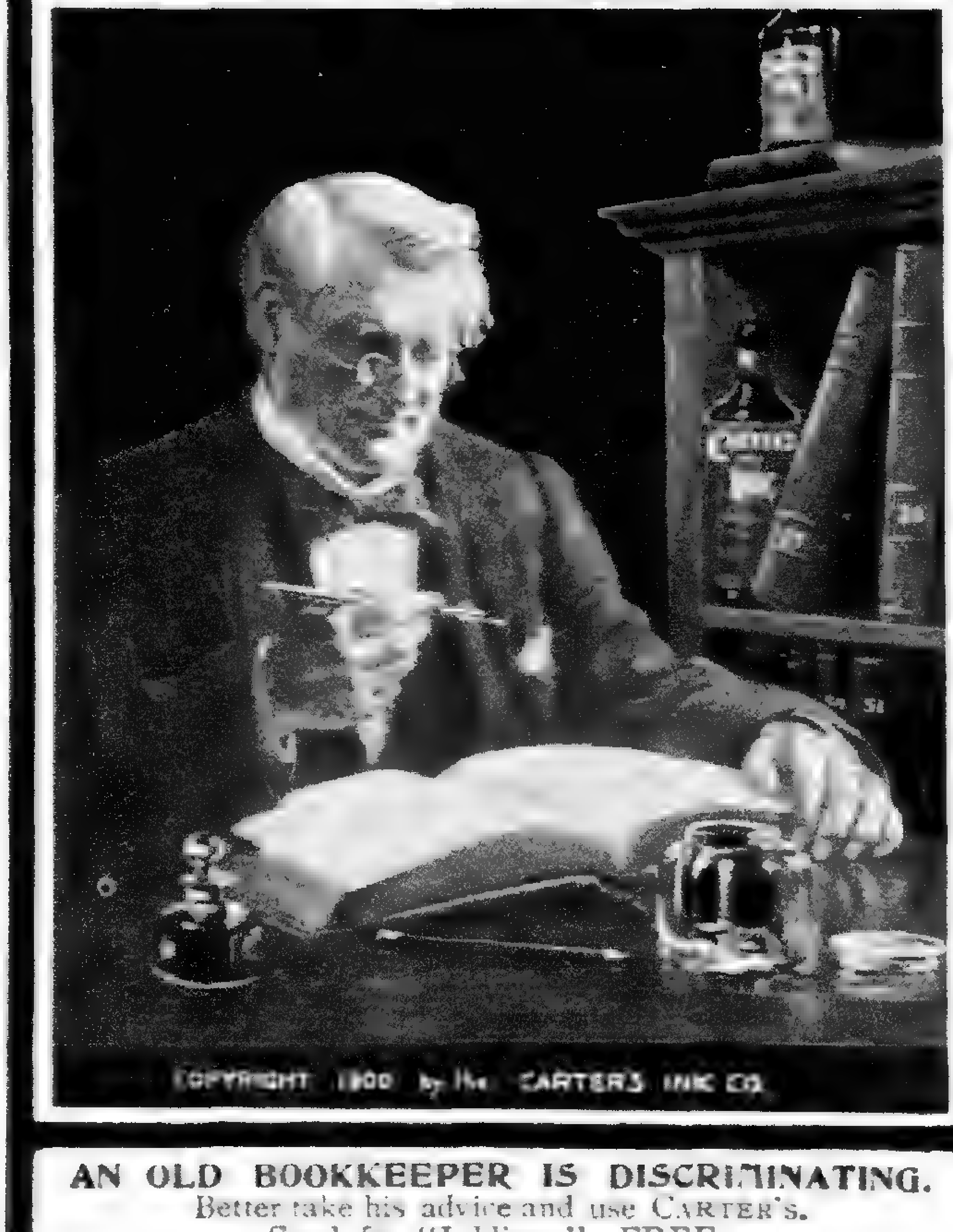
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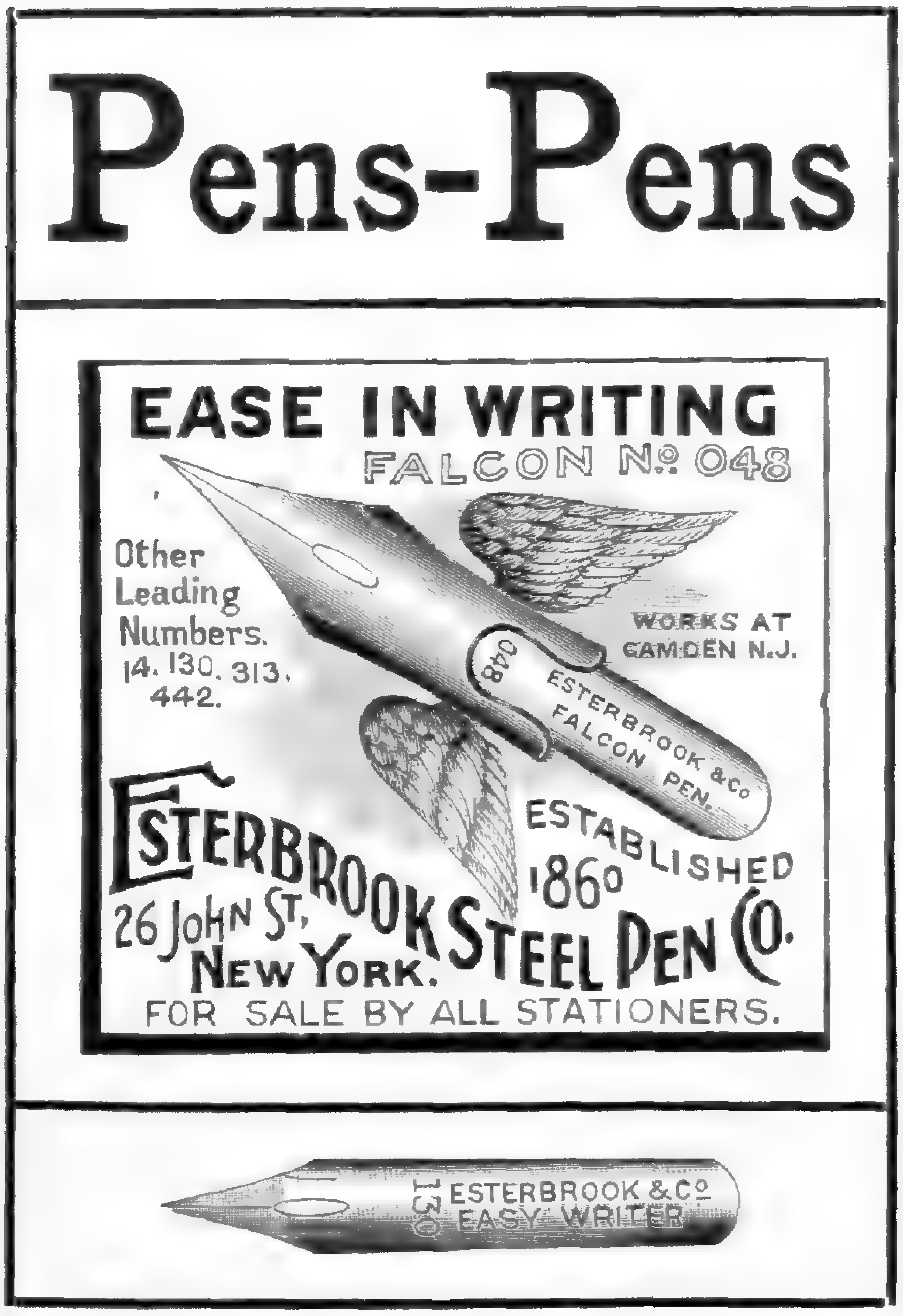

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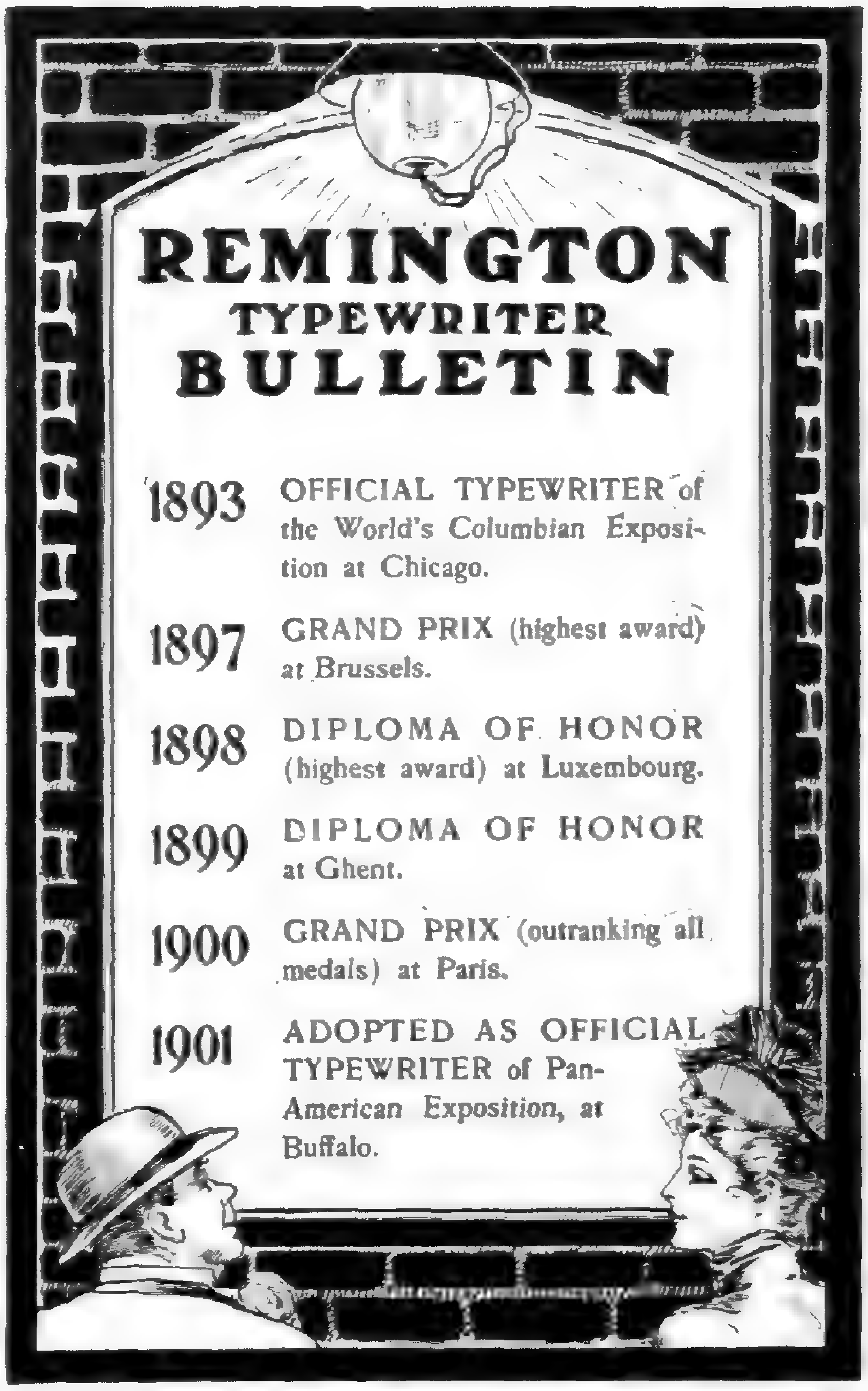

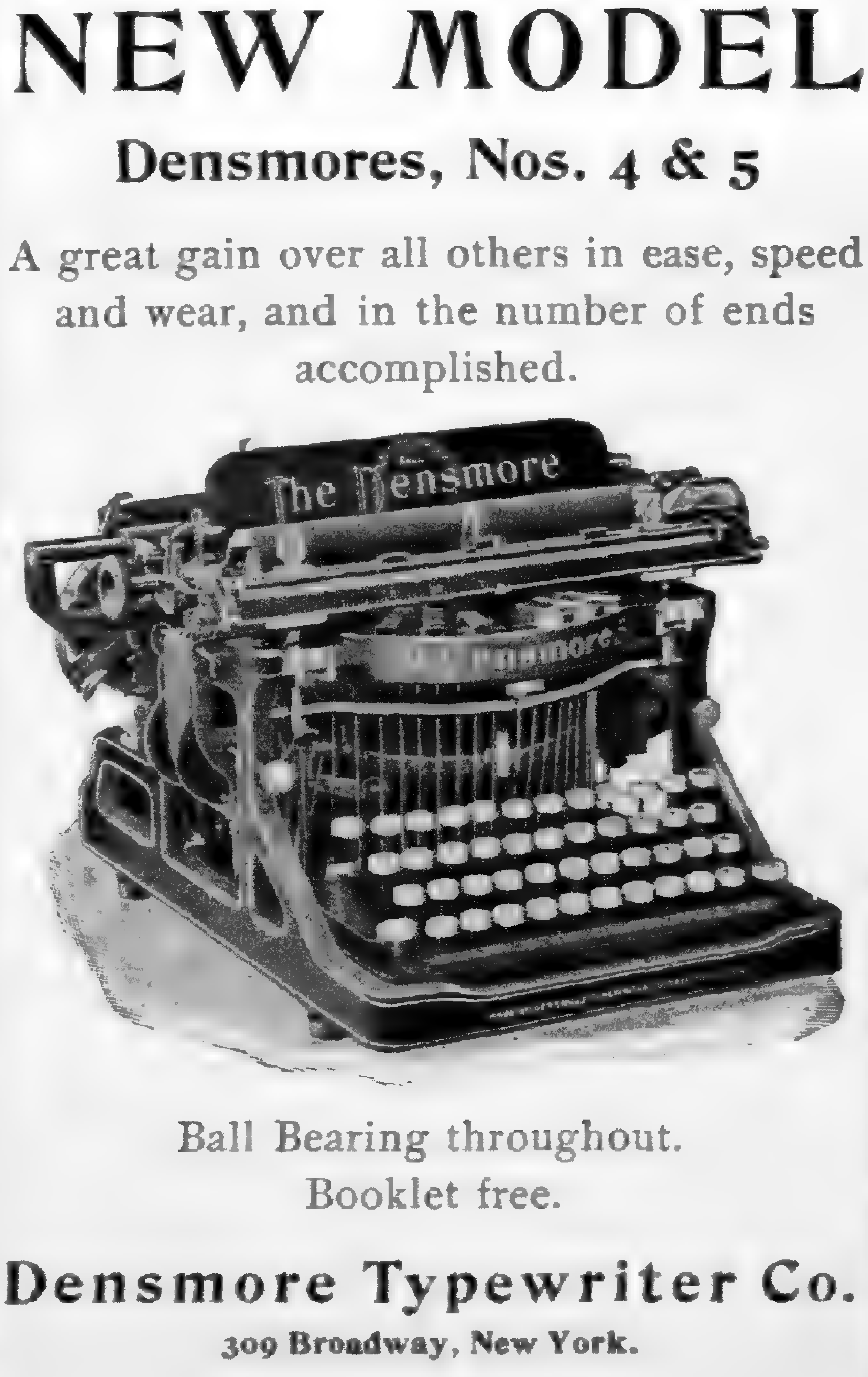

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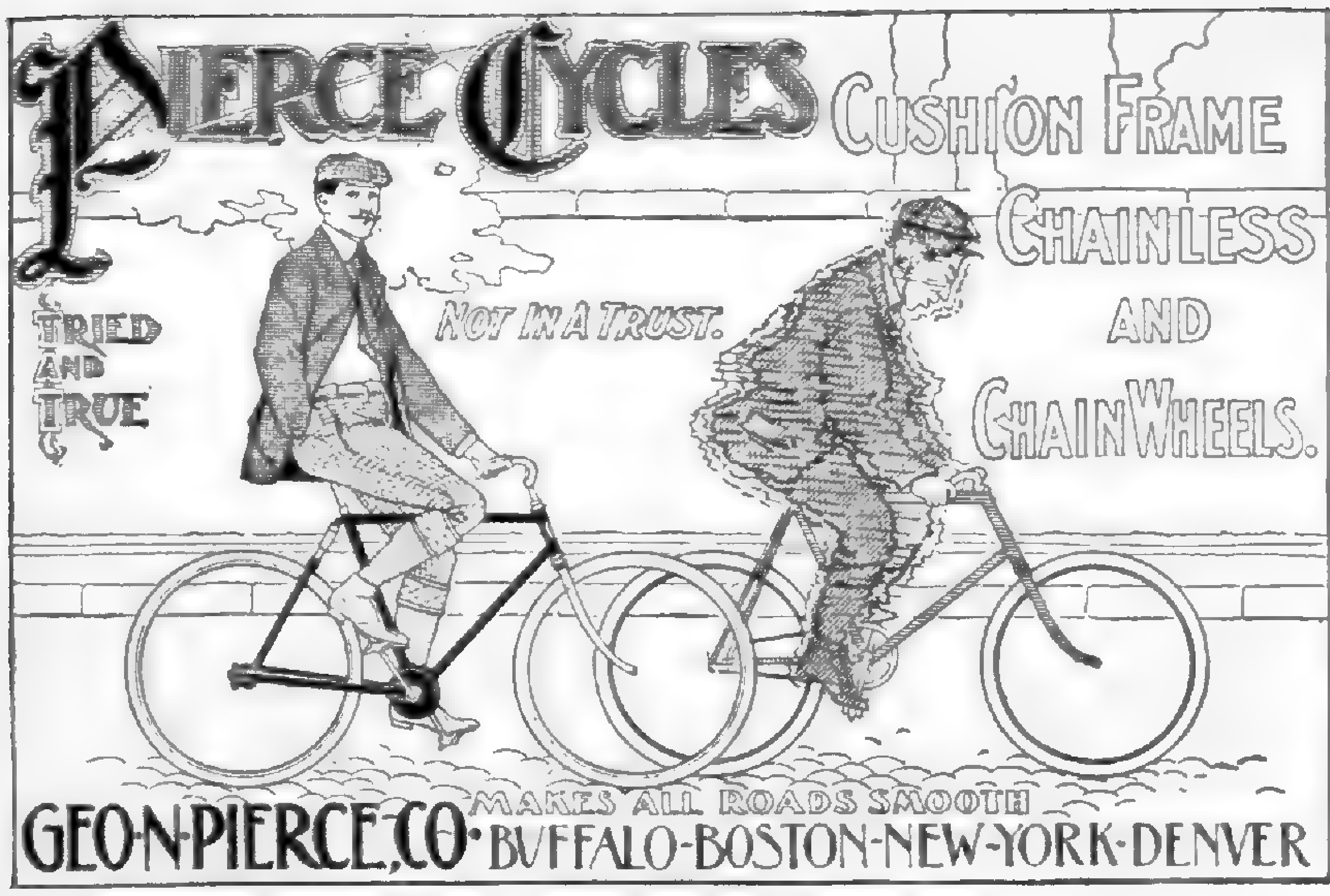

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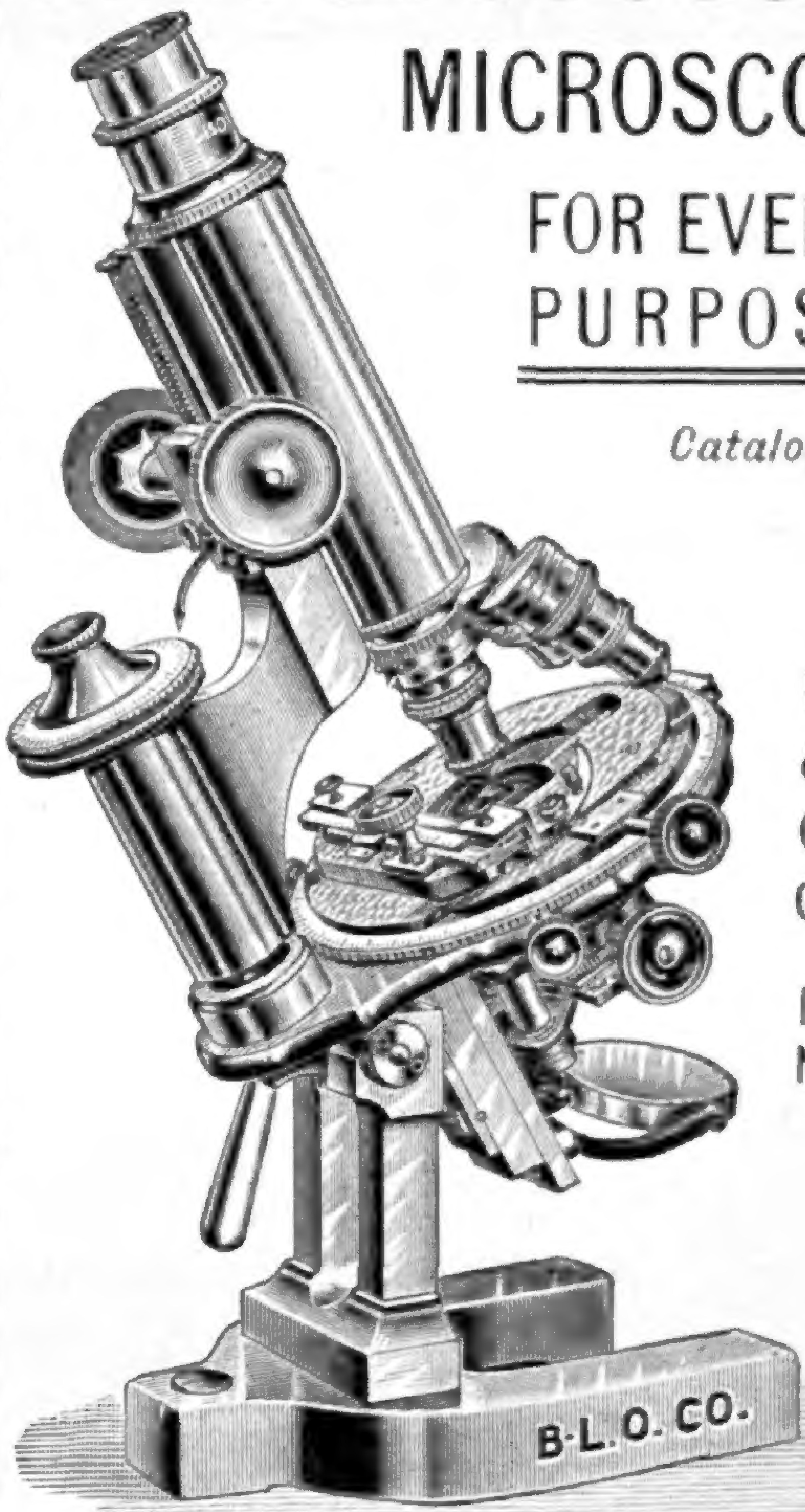
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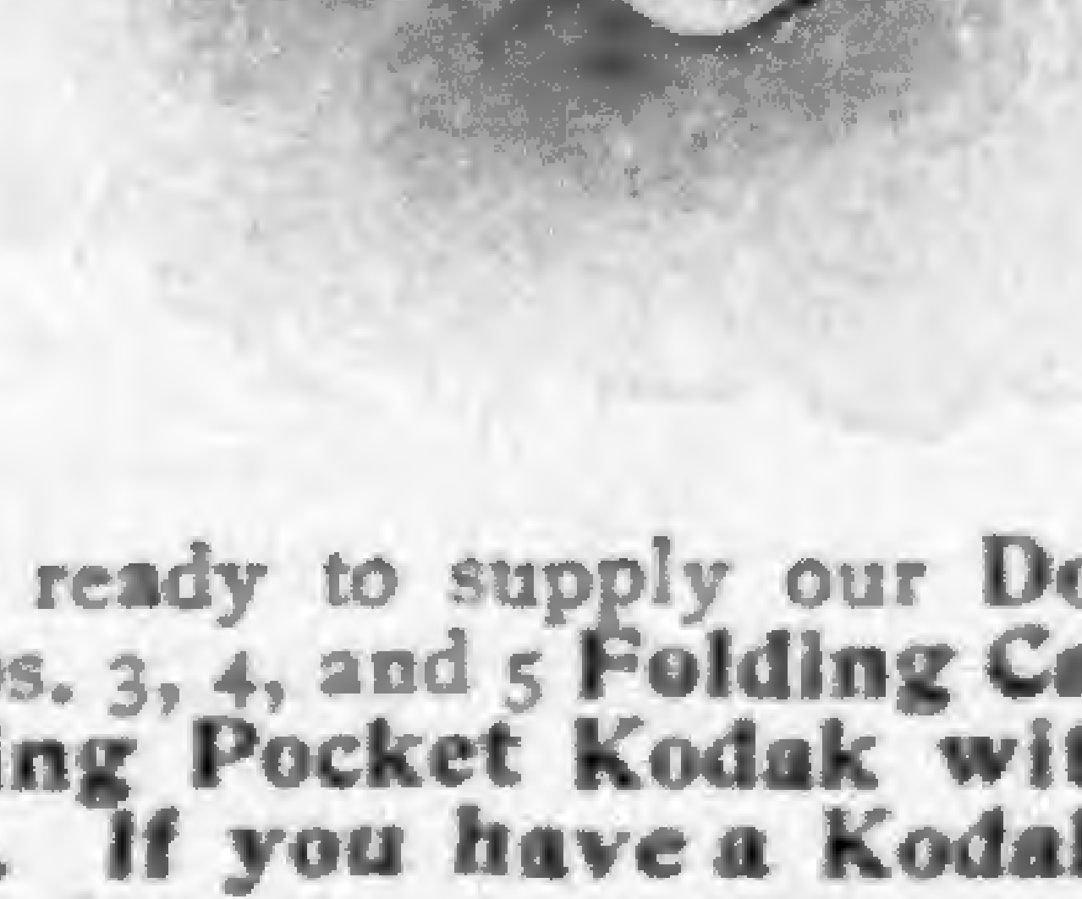

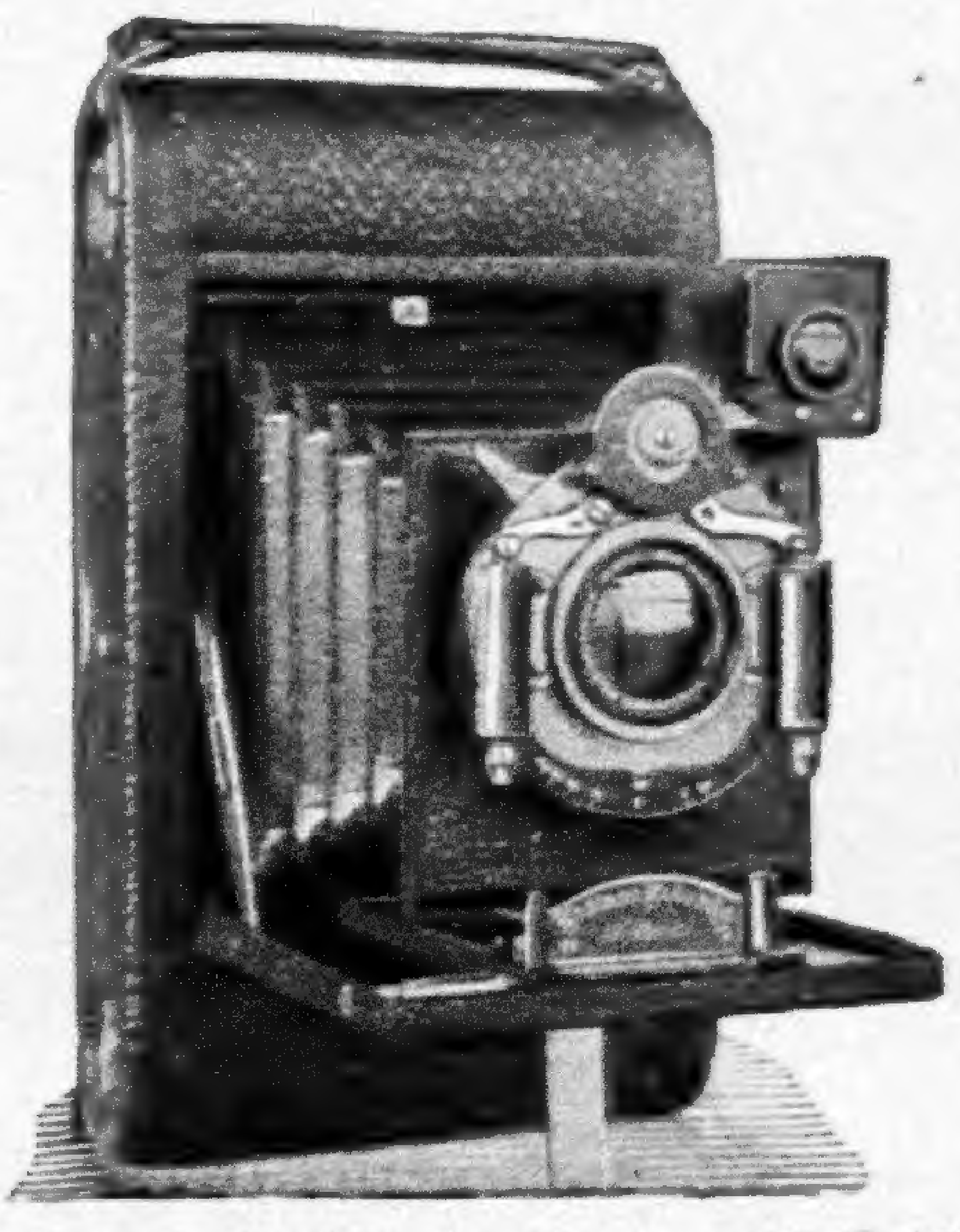


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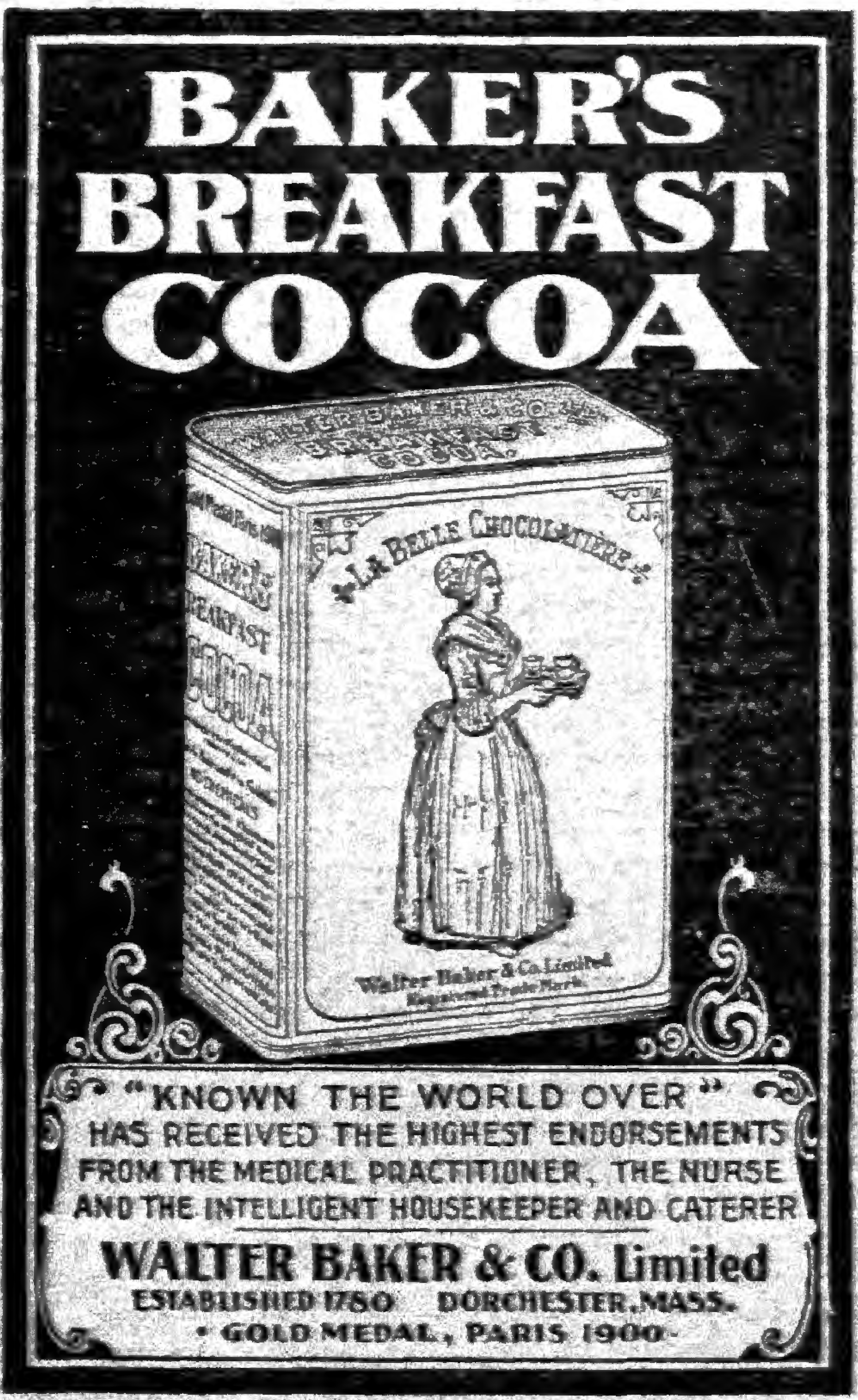

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