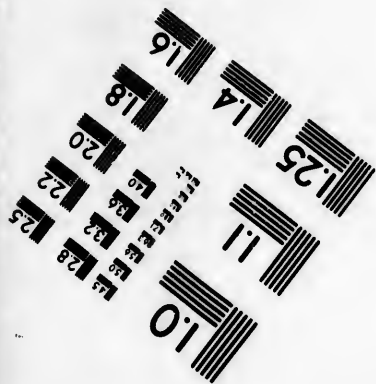
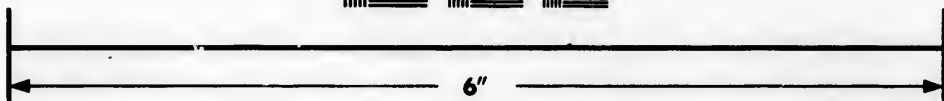
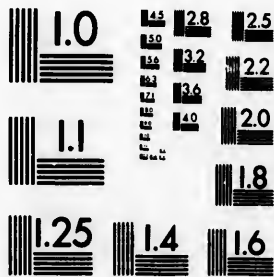


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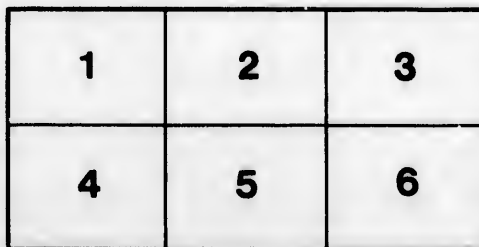
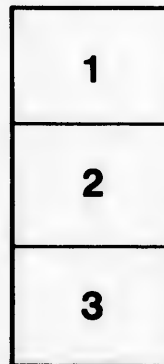
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IV. A STUDY OF NORTH AMERICAN GERANIACEAE.

By WILLIAM TRELEASE.

(Read Feb. 16, 1887.)

IN the following pages, I have brought together descriptions of our species of Geraniaceae, and a few biological notes on them, together with references on their pollination, dissemination, etc. No general revision of our species of this order has been undertaken since the publication of the first volume of Torrey and Gray's Flora of North America, 1838-40. The systematic literature and the synonymy of North American species will be found in Watson's Bibliographical Index to North American Botany, 1, 149, while the more important papers on the order as a whole and its subdivisions are indicated in Bentham and Hooker's Genera Plantarum, 1. A synopsis of the larger species of Geranium, by Engelmann, appears in Gray's Plant. Fendler., pp. 26-7.

I am indebted to Professor Gray and Mr. Watson for the free use of the Gray herbarium of Harvard University, and for many helpful suggestions; to Dr. Britton for the specimens contained in the Torrey and other herbaria of Columbia College; to Miss Carter for access to the herbarium of this Society; to Professors Prentiss and Dudley for the specimens in the Horace Mann herbarium of Cornell University, as well as for a large suite of duplicates of the eastern species; and to Dr. George J. Engelmann for forwarding me the specimens in the Engelmann herbarium of St. Louis. A number of friends have also favored me with smaller collections, chiefly of eastern species, the most valuable of these being a suite of specimens of *Oxalis recurva*, collected about Cincinnati, by Mr. C. G. Lloyd, and a Nuttall specimen of *Oxalis pumila* from Mr. J. H. Redfield, of Philadelphia, a fine suite of *O. Suksdorfii* from Mr. L. F. Henderson, of Portland, Oregon, and flowers from the type specimens of *O. Dillenii*, at Oxford, secured by Professor Gray.

GERANIACEAE, Bentham and Hooker, Genera, 1, p. 269.

Annual, biennial, or perennial plants; ours herbaceous or merely suffrutescens. Leaves alternate or occasionally opposite or pseudo-verticillate, simple, divided, or compound, mostly cut-toothed. Inflorescence sometimes evidently cymose, or the flowers solitary

and terminal or apparently racemose or umbellate. Flowers hermaphrodite, mostly 5-merous (3-4-merous in *Limnantheae*) and symmetrical, nearly hypogynous. Sepals and petals distinct or nearly so. Stamens mostly twice as many as the petals, distinct or somewhat connate in *Oxalis* and *Eupatiens*; anthers round-oval, more or less versatile, two-celled, dehiscing longitudinally. Carpels as many as the sepals, alternate with them and united about an axile column, except in *Limnantheae*; ovary deeply lobed, its cells 1- ∞ -ovuled; styles commonly united below, the capitate or lateral stigmas mostly distinct. Glands of the receptacle as many as the sepals and opposite them (reduced and opposite the petals in *Oxalis*), or wanting when the flower is spurred. Seeds with little or no albumen except in *Oxalis*; embryo straight or incumbent, the cotyledons somewhat plicate and lobed in the genera with dissected leaves. A heterogeneous order of about 750 species, chiefly of subtropical and temperate regions, related on the one hand to *Zygophylleae*, and on the other to *Rutaceae*. The suborders are treated as distinct by many continental writers.

GERANIEAE¹.

Flowers regular or nearly so, 5-merous, homogone²; sepals imbricate, persistent, enlarging somewhat in fruit; petals imbricate, deciduous; antheriferous stamens as many as and opposite the sepals or twice as many, with persistent filaments; glands opposite the sepals, conspicuous; carpels alternate with the sepals, 2-ovuled, becoming 1-seeded, breaking elastically from a persistent fluted beak.—*Geraniaceae* of continental writers; five genera, three of them confined to Asia and Africa, the other two widely distributed.

GERANIUM, L. Gen., no. 673; Benth. and Hook., Gen., 1, 272.

Usually caulescent herbs with simple radiately-divided petioled and stipulate leaves; peduncles mostly 2-flowered; stamens ten, all antheriferous (except in *G. pusillum*), mostly united a little at base; ovary deeply divided; ripened carpels dehiscent on the inner side, the styler appendage finally arched, glabrate on the inner side; seed round-oblong, smooth, reticulate-ridged, or hexagonal-pitted, with little or no albumen; embryo incumbent with sinuously folded cotyledons.—About one hundred species, almost confined to temperate regions.

SYNOPSIS OF NORTH AMERICAN SPECIES.

*Perennial from a stout caudex; flowers large, 15-30 mm.; seeds reticulate-ridged. Erect, not caespitose; leaves large, 100-200 mm.

Petals glabrous or only pubescent within; plant scarcely glandular except that the calyx hairs are often tipped with small glands.

¹ The characters given refer only to our representatives.

² That is, essentially alike in a given species, so far as the relative length of stamens and pistils is concerned.

- East of the Rocky mountains; calyx only moderately villous; pedicels canescent. *G. maculatum*.
- Northwestern; calyx and usually pedicels very villous. *G. erianthum*.
- Petals more or less villous within; at least the pedicels conspicuously glandular.
- Stout; flowers purple; glandular hairs rather short, dirty yellow; tip of beak short and thick. *G. incisum*.
- Slenderer; flowers mostly white; hairs long and white, tipped with purple glands; tip of beak longer and slenderer. *G. Richardsonii*.
- More or less spreading and cespitose; leaves of medium size, 30-75 mm.
- Upper leaves mostly as broad as long, with equal cuneate lobes.
- Pedicels, etc., mostly glandular; filaments mostly about equalling the pistil.
- *G. Fremontii*.
- Usually retrorsely canescent and not glandular; filaments a third longer than the pistil. *G. caespitosum*.
- Upper leaves longer than broad, the terminal lobe longest, ovate-lanceolate.
- *G. Hernandezii*.
- * * Annual or biennial; leaves seldom over 50 mm.; flowers smaller, 4-15 mm.; seeds smooth, reticulate, or pitted.
- Carpels not bristle-bearing above; leaves radiately lobed or mostly dissected.
- Peduncles mostly 1-flowered; leaves 3-cleft, with serrate divisions. *G. Sibiricum*.
- Peduncles 2-flowered; leaves several lobed.
- Peduncles and pedicels long and slender; carpels subglabrous, not wrinkled; seeds deeply pitted. *G. columbinum*.
- Peduncles and pedicels mostly short; carpels hairy or rugose.
- Seed reticulate or pitted.
- Pubescent or short-glandular.
- Coarse; branches uniformly leafy; lobes of leaves rather broad and short; seed very low-ridged except in the variety. *G. Carolinianum*.
- Slenderer; leaves crowded at the ends of the branches, their lobes long and narrow; seed deeply pitted. *G. dissectum*.
- Glandular-villous with purple-tipped white hairs; leaves shallow-lobed; seed reticulate-ridged. *G. rotundifolium*.
- Seed neither pitted nor conspicuously reticulate.
- Carpels finely appressed-pubescent, not wrinkled; flowers pale; stamens five.
- *G. pusillum*.
- Carpels subglabrous, transversely rugose; flowers deep purple; stamens ten.
- *G. molle*.
- Carpels bristle-appendaged at the upper end, strongly wrinkled; leaves 1-2-ternately divided; very graveolent. *G. Robertsonum*.

1.¹ *G. MACULATUM*, L. Spec., 681. A foot to a foot and a half high, erect, subsimple, not caespitose, pubescent or canescent with spreading or mostly retrorse hairs, occasionally villous; leaves mottled, the radical mostly 2-4, long-petioled, suborbicular, incisely 3- or sometimes 5-parted, the divisions cuneate, the lower 2-cleft and all once to thrice 3-lobed at apex with abruptly acute or subacuminate coarsely acuminate-serrate lobes, basal sinus open, V-shaped; cauline leaves mostly two and opposite, occasionally alternate or sessile, otherwise like the radical; stipules oblong-elongated-triangular, entire or acutely 1-3-lobed near the apex; peduncles 1-5, mostly 3, umbellately clustered between the stem-leaves, simple or once or twice umbellately branched, the lateral frequently bearing single or paired reduced leaves; pedicels mostly paired, at length about an inch long, erect in fruit, retrorse-canescens; bracts linear, similar to the stipules; flowers large, rose-purple; sepals ovate-oblong, abruptly awned, the outer mostly villous and the inner ciliate; petals about 15 mm. long, woolly-ciliate at base; filaments somewhat ciliate; beak of fruit 25-35 mm. long, finely pubescent, abruptly narrowed above; styles free for 2-3 mm.; divisions of ovary sparingly close-pubescent and villous, 3.5-4 mm. long; seed finely reticulate-ridged, as in the rest of this section, 1.5 x 2 mm.—Open groves, Canada and New England to Saskatchewan and Missouri, south to Florida (*vide* Torrey & Gray, Fl. N. A.) and Alabama (Mohr, Prelim. List Pl. Ala.); common in the northern states. I have seen no specimens from farther south than Georgia and Kentucky.—Pl. 9, figs. 1-2; 10, fig. 4; 12, fig. 5.

2. *G. ERANTHUM*, DC. Prodr., 1, 641. *G. maculatum*, β . Hook. Similar to the last, but more or less leafy-branched; leaves with more numerous narrower crowded lobes; pedicels scarcely over a half-inch long, erect in fruit, unequally canescent-pilose; calyx densely villous with long white hairs, many of them gland-tipped; petals purple, glabrous or minutely pubescent on the inner side; filaments long-pilose; beak 30-35 mm. long, canescent and somewhat villous, slender-tipped; styles free for 2-3 mm.; seed 1.5 x 3 mm.—Alaska and northwest British America; also in northeast Asia.—Pl. 9, fig. 3; 10, fig. 8.

3. *G. INCISUM*, Nutt., Torrey & Gray, Fl. N. A., 1, 206. *G. albiflorum*, var. (?) *incisum*, Torr. & Gr. *G. Hookerianum*, var. *incisum*, Walp. *G. viscosissimum*, Fisch. & Mey. *G. pentagynum*, Engelm. *G. Fremontii*, Macoun, Cat. nos. 325-6. *G. erianthum*, Torrey, Bot. Wilkes' Exped., 251. Habit of *G. maculatum* but coarser, uniformly leafy-branched above, the branchlets subtended by more or less reduced leaves; pedicels and often petioles or even the entire plant dirty glandular-pubescent and somewhat unequally villous; leaves incisely 3- or mostly 5-parted, the lowest divisions again 2-cleft and all rather narrowly cuneate, basal sinus usually narrow, V-shaped or nearly closed; pedicels at last an inch or two long, the longest more or less refracted in fruit; flowers about as large as in *G. maculatum* and similarly colored; outer sepals glandular and somewhat villous; petals (within) and filaments sparingly white-villous; beak 35-45 mm. long, very glandular, short-pointed; styles free for 4-6 mm.; divisions of ovary glandular, 3 x 5 mm.; seed 2 x 3 mm.—Woods and open places, mountains of British America to Dakota and California.—Pl. 9, figs. 4-5; 10, fig. 11; 12, fig. 1.

¹ Only the numbered species belong our flora as endemic or truly naturalized.

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4. *G. RICHARDSONII*, Fisch. & Mey. Index Sem. Petr., IV, 37. *G. albiflorum*, Hook. *G. Hookerianum*, Walp. Similar to the last but slenderer, inconspicuously retrorse-pubescent below, the peduncles and pedicels villous with spreading white hairs tipped with purple glands; uppermost reduced leaves lanceolate, serrate but not lobed; pedicels more or less reflexed or spreading and bent in fruit; sepals canescent and somewhat glandular; petals purple (?) or mostly white, villous on the inner side like the filaments; beak 25-30 mm. long, sparingly fine-pubescent and villous-glandular; styles free for about 4 mm.; divisions of ovary 2×4 mm., pubescent and somewhat glandular-villous; seed $1.5 \times 2.5-3$ mm.—Open places and ravines in the mountains, Saskatchewan to New Mexico and Arizona; also found in California.—Pl. 9, figs. 6-8; 10, fig. 1.

5. *G. FREMONTII*, Torrey, Gray's Plant. Fendler., 26. More or less caespitose from a very stout caudex, a span to a foot or two high, the smaller plants sometimes subcaulescent, the larger with slender spreading leafy branches, somewhat canescent, the pedicels and often branches and petioles yellow-glandular; leaves typically closely appressed-pubescent and stout-veined, round-reniform, 3-parted with broadly cuneate divisions, the lower once or, especially on the radical leaves, twice cleft on the lower side; radical leaves usually with closed sinuses, the cauline similar or mostly truncate at base, with divergent lobes, all of which are incisely once or twice 3-toothed at apex with crenate-acuminate coarse teeth; pedicels at length an inch or two long, refracted in fruit; flowers rose-purple; petals 12-15 mm. long, emarginate, somewhat villous within; filaments pilose, equalling or exceeding the pistil; beak 25-30 mm. long, dirty glandular; styles free for 4-5 or even 6-8 mm.; divisions of ovary 2×4 mm.; sparingly hairy and glandular; seed 2×3 mm.—Mountains of Utah, Colorado, and New Mexico. Perhaps not distinct from the next and very closely related to the preceding. The larger form with conspicuously refracted pedicels is var. *Parryi*, Engelm., Amer. Journ. Sci. and Arts, third series, XXXIII, 405.—Pl. 9, fig. 9.

6. *G. CAESPITOSUM*, James, Long's Exped., II, 3 (?); Gray, Pl. Fendler., 25 (!). Similar to the last, but mostly longer stemmed and more decumbent and spreading from a shorter or slenderer caudex, canescent but not glandular, except on some pedicels of a few specimens; leaves less frequently truncate at base, with a more or less open sinus, their lobes narrower; peduncles long; pedicels mostly refracted in fruit; sepals long-pointed; petals smaller, 8-12 mm. long, scarcely emarginate, villous within; filaments bearded, conspicuously longer than the pistil; beak 25-35 mm. long, gray-pubescent, stout-pointed; styles free for 4-5 mm.; division of ovary more or less villous, sometimes with a few very short glandular hairs; seed $1.5 \times 2.5-3$ mm., reticulate.—Mountains, San Bernardino Co., California (?) (*S. B. Parish*, 1806), Arizona, New Mexico, and Texas, to Mexico.—Pl. 9, fig. 10; 10, fig. 6; 12, fig. 3.

There is reason to doubt whether James' plant was not really the preceding, for he did not collect south of Pike's Peak, while this species, as I understand it, is distinctively southern.

G. PRATENSE, L., of Europe, is reported by Fowler (Prelim. List of New Brunswick Plants, 20), as escaped from gardens near St. John, N. B. But it need not be described here.

G. HERNANDEZII, DC. Prodr., 1, 640. Perennial and caespitose (?), large and spreading, the lower nodes much dilated, loosely villous with often gland-tipped white hairs; radical and lower leaves 50-75 mm. across, on petioles nearly a foot long, 3-cleft, the basal divisions sometimes again lobed on the lower side, all ovate-oblong, cut-toothed or lobed towards the apex; upper leaves much smaller, deltoid-cordate, 3-parted, the divisions acute and serrate-lobed, the ovate-lanceolate middle one largest; peduncles not over an inch long; pedicels mostly shorter; sepals long-awned, the inner somewhat red-margined; petals white (?), half as long again as the calyx, spatulate, entire; filaments ciliate; styles free for about 2 mm.—Huachuca Mountains, southern Arizona (*Leemmon*, 2651). Apparently the same as Mexican specimens (*Schaffner*, 191), but not in fruit.—Pl. 9, fig. 11.

G. SMIRNICUM, L. Spec., 683. A slender-stemmed, repeatedly forked, short-villous, Asiatic annual, having 3-5-parted leaves with coarsely serrate, broadly lanceolate divisions; small, dirty-white, purple-veined flowers mostly solitary on bent pedicels an inch long, the 2-bracted peduncles of equal length or shorter; sepals awned; petals about 5 mm. long; beak canescent, 15-18 mm. long; the divisions of the ovary puberulent and sparingly villous, 2×4 mm.; seed 1×2 mm., minutely reticulate-areolate. Collected as a roadside plant on New York Island in 1867 (*Denslow*), and, as I learn from Doctor Britton, observed near the same place within a year or two. It was also collected on a refuse-heap, in Cambridge, in 1885 (*Morong*).—Pl. 9, fig. 12.

7. *G. COLUMBINUM* L. Spec., 682. Very slender-stemmed, spreading and prostrate, hispid with a close gray pubescence which is retrorse except on the leaves and sepals, not at all glandular; leaves more or less 3-5-divided and dissected into numerous linear divisions; stipules setaceous-pointed; peduncles very long; pedicels at length an inch or two long; sepals ovate, awned; petals purple, about equalling the calyx, spatulate, mostly eroded; beak 15-20 mm. long, with a long slender tip, appressed-hispid; styles free for about 1 mm.; divisions of ovary 2×3 mm., nearly glabrous, keeled on the back; seed subglobose, 1.5×1.75 mm., deeply pitted.—Pennsylvania (*Porter*), Virginia (*Curtiss*, *Pech*), Dakota (*Gratfeller*). Introduced from Europe, etc.—Pl. 9, fig. 17; 10, fig. 7; 12, fig. 9.

8. *G. CAROLINIANUM*, L. Spec. 682. *G. atrum*, Moench. *G. lanuginosum*, Jacq. A span to a foot high, stout-stemmed, spreading when large, loosely gray-pubescent and mostly dirty-glandular; leaves incisely 3-5-parted, divisions cuneate, more or less deeply cut-toothed or dissected into linear lobes; peduncles and pedicels seldom over an inch long, often densely crowded, the pedicels frequently somewhat bent in fruit; sepals ovate, acuminate tapering to a prominent awn, with recurved margins; petals rose-colored, about equalling the calyx, obovate, emarginate; beak about 20 mm. long, short-pointed, loosely villous or glandular; styles free for about 1 mm.; divisions of ovary 2×4 mm., not keeled, villous-hispid, when ripe mostly black; seed 1.25×2.25 mm., low-reticulate.—Open places, Canada to Washington Territory, south to Florida, California and Mexico; most common in the South and West.—Pl. 9, fig. 13; 10, fig. 2; 12, figs. 6-7.

Var. *TEXANUM*, collected near New Braunfels, Texas, by Lindheimer, in 1848, differs in having deeply pitted round seeds like those of *G. columbinum*, but with the habit and

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foliage of *Carolinianum*. I have seen only a few plants, of a single collection, and have looked in vain for other characters by which this form can be separated, although the seeds indicate more than a varietal difference.—Pl. 12, fig. 8.

Var. *LONGIPES*, Watson, King's Rep., v, 50, of the mountains of Colorado and Utah, differs from the type in being of looser growth, with longer spreading peduncles and pedicels.

Bentham, in some instructive remarks on this species in *Flora Australiensis*, i, 296, regards it as only a form of the next, with which it certainly has much in common. While our plant is separated from the European *dissectum* without much difficulty, it must be admitted that Australian specimens are identical with those from the United States, with the exception that their clusters of fruit are mostly less dense and their roots perennial. Baron von Mueller, who for a time agreed with Bentham in referring the Australian form to *dissectum*, and once¹ called it *Carolinianum*, writes me that he has now adopted the name *G. pilosum* for it.

G. DISSECTUM, L. Moench, iv, 282. *G. Carolinianum*, Gray, Proc. Am. Acad., viii, 378. Very similar to the preceding, but the leaves rather more remote below, and, like the small pale flowers, clustered at the ends of the branches, their lobes longer and narrower; seed closely and rather deeply pitted.—Introduced into various places from Europe. I have seen specimens only from Oregon (*Hall*, 72) and Washington Territory (*Suksdorf*), but it is reported from various localities. Most of what has passed in America for this species is *G. Carolinianum*. Small specimens, like those of Hall, have much the habit of *G. pusillum*, but are distinguished by the seed.—Pl. 9, fig. 15.

G. ROTUNDFOLIUM, L. Spec., 683, from Europe, resembling *G. Carolinianum* in its fruit and seed, and of nearly the habit of *G. pusillum*, but with the leaves short-lobed and the stem, etc., villous with long white hairs tipped with purple glands, has been collected in Michigan (*Farwell*) and on ballast about New York city (*Brown*).—Pl. 9, fig. 16; 10, fig. 9; 12, fig. 4.

9. *G. PUSILLUM*, L. Spec., 2 ed., 957. Slender-stemmed, spreading, soft-pubescent, or the calyx, etc., villous and usually glandular; branches leafy; leaves small, round-reniform or the cauline truncate at base, equally cleft into nine oblong or linear lobes each more or less regularly 3-toothed at apex; peduncles frequently opposite the leaves, short, like the pedicels; sepals ovate, acute or acuminate, not awned; petals pale purple, about equalling the calyx; fruit very small; beak about 10 mm. long, short-pointed, puberulent; styles free for about 1 mm.; divisions of ovary 1×2 mm., finely canescent, keeled, not wrinkled; seeds 5×1.4 mm., smooth.—Open places, New York and Pennsylvania to Ohio; also reported from Canada (*Macoun*, Cat. iii, 502); introduced from Europe. Five of the filaments are said to be constantly without anthers, as in *Erodium*.—Pl. 9, fig. 14; 10, fig. 3; 12, fig. 10.

G. MOLLE, L. Spec., 682, a very similar European plant, but readily distinguished by its dark flowers with ten antheriferous stamens, glabrous transversely wrinkled carpels, slightly striate seed, and longer soft pubescence, has been introduced in New York (*Sartwell*, *Knieskeru*), Ohio (*Werner*), Washington Territory (*Suksdorf*) and Vancouver Island (*Macoun*); it is also reported in Ontario (*Macoun*, Cat., iii, 502), and has

¹ Key to the System of Victorian Plants, ii, 10.

been collected on ballast at New York City (*Brown*).—Pl. 9, fig. 18; 10, fig. 5; 12, figs. 13-14.

10. *G. ROBERTIANUM*, L. Spec., 681., *G. inodorum*, Don. A span to a foot and a half high, erect or spreading-decumbent, puberulent and loosely glandular-villous, purple-tinged, graveolent; leaves round-ovate, once or twice ternately divided, the ultimate lobes oblong, coarsely acuminate-toothed; stipules triangular, obtuse; pedicels half an inch or less in length, erect in flower and fruit; sepals ovate, lanceolate, long-pointed, connivent; petals rose-purple, 8-12 mm. long, spatulate, with long narrow claws; filaments glabrous; beak 20-25 mm. long, with a long slender point, minutely glandular-puberulent; styles free for about 1 mm.; divisions of ovary $1.5 \times 2.5-3$ mm., loosely wrinkled, sparingly pubescent, breaking away from the style with 2 long white apical bristles; seed 1×2 mm., smooth.—Damp ravines, etc., New Brunswick and Canada to New York, west to Minnesota and Missouri (*vide Tracy's List*); also found in Europe, Western Asia and North Africa.—Pl. 9, fig. 19; 10, fig. 10; 12, figs. 11-12.

Our *Geraniums* are annuals, becoming biennial, with the formation of a tap-root in some instances, or normally perennial, when they produce a larger or smaller rootstock which is considerably branched in one or two species. A number are weak-stemmed, and when these reach any considerable size they are decumbent, their enlarged nodes possessing the sensitiveness to gravitation which is characteristic of the swollen nodes of grasses, etc., which causes the stem to form abrupt geniculate bends at the lower joints. The pubescence consists of simple 1-celled pointed usually somewhat roughened hairs, frequently appressed and, on the lower part of the stem at least, retrorse, in a considerable number of species. Besides these there are in many species long, mostly spreading, white hairs, consisting of a long basal cell, and a single row of shorter cylindrical cells above. In *G. maculatum*, and especially *G. erianthum*, these, which abound on the calyx, often rendering it very villous in the latter, are tipped with rather small, purple glands, frequently rudimentary in the former. In *G. rotundifolium* and *G. Richardsonii*, though somewhat shorter and more rigid, they abound on the pedicels, etc., still preserving their white appearance; while in *G. Fremontii*, and especially *G. incisum*, they are of a dirty-yellow color. As a rule, hairs of this class appear to be pretty constant in their occurrence or absence in a given species; but some pedicels of *G. caespitosum* are nearly or quite destitute of glands, while others, even on the same plant, are evidently glandular-pubescent, and, judging from other plants, too much reliance should not be placed on characters derived from the pubescence. (Note 1.)

The inflorescence of *Geranium* is essentially cymose, the stem ending in a 1- or, mostly, 2-flowered peduncle, while lateral peduncles arise from the axils of the cauline leaves in simple plants of the *maculatum* type, their ultimate branches likewise ending in paired pedicels. In *G. maculatum* the lateral peduncles are sometimes more than 2, and bear reduced leaves, while in its western representatives they are regularly leafy and elongated, but otherwise similar. There is at first sight little to connect the more branched

¹ On *G. Robertianum*, see Rützou; Bot. Tidsskrift, xii; Just's Jahresbericht, ix, 420.

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decumbent forms with this simple type, for their leaves are scattered and, in *G. pusillum*, etc., the 2-flowered peduncles are frequently opposite the leaves. But in *G. Sibiricum*, which is more or less regularly dichotomous, the forks are occupied by mostly 1-flowered peduncles, clearly the terminal shoots, and in the slender-stemmed species with the peduncles opposite the leaves the former are as certainly terminal, the leafy prolongation of the stem being in reality an axillary branch. (Note 2.)

The most interesting part of a biological study of *Geranium* is that relating to its pollination, and in this respect it has a historical interest, for it was the detection of tufts of hairs fringing the bases of the petals in *G. sylvaticum*, which led Sprengel just a century ago to examine the flowers closely in an effort, if possible, to determine their use, for he was utilitarian enough to believe that not even a hair grew without purpose. His study, carrying him farther than he had at first anticipated, led to the publication, in 1793, of a work which he quaintly styles the "Disclosed Secret of Nature," which not only contains much of scientific value, but is one of the most interesting biological treatises ever written, and, guiding the researches of Darwin, Müller, Delpino, and many other observers, has contributed not a little to the foundation on which the theory of evolution by natural selection rests.

No great attention has been given to the pollination of our American species; but, so far as they have been observed, the facts agree closely with those brought out by Müller's study of the same or related species in Germany, so I cannot do better than refer to his admirable account of the latter.¹ I may add that the larger-flowered species are conspicuously protandrous, their two sets of stamens becoming erect, and dehiscing successively at the centre of the flower, which, after their anthers have fallen, is occupied by the now expanded stigmas; while in the species with smaller, less conspicuous flowers, the duration of the staminate stage is much shortened, or, in *G. pusillum*, where the number of stamens with anthers is reduced one-half, the flowers are synaemic or slightly protogynous and certain of self-pollination if crossing is not secured.

The large-flowered species are, in the main, incapable of self-pollination, and depend exclusively (except in occasional synaemic flowers) upon the good offices of insects, chiefly bees of different kinds, which are attracted by the conspicuous petals, the veins of which point to an abundance of nectar, secreted by five prominent glands at the bases of the sepals. This is protected from inclement weather by tufts of hairs fringing the petals below, and, usually, from creeping insects like ants which cannot effectively bring about cross-fertilization, by the retrorse or glandular pubescence of the pedicels or stem. Doubtless the facility with which several of the small-flowered species gain a foothold in new countries is to be explained by their ability to self-fertilize where they are not visited by appropriate insects, as well as by their annual habit and abundant seeding. *G. Robertianum* alone, with narrower flowers contracted into a sort of tube, is adapted to pollination by long-tongued insects like the *Syrphidae*, which visit it freely in Europe, though I do not know that its American visitors have been recorded. (Note 3.)

The ripening carpels, as they dry, contract in such a manner that the outside is shortest, so that there is a tendency for their ends to bend outwardly; and, ultimately, after dehiscing along the ventral suture, they break away at the base and suddenly curve up-

¹ Fertilization of Flowers, p. 149.

wards with considerable force (Pl. 10). The segments of the ovary having already bent themselves at a sharp angle with the beak, the result of this movement is to throw the seed, or even the entire carpel, to a considerable distance. So far as I have examined them in the field, or as the indications of herbarium specimens are to be trusted, our species behave uniformly in this manner (though in *L. pusillum* the carpels do not bend abruptly above the ovary) with the exception of *G. Robertianum* (Pl. 10, fig. 10) and some of the other small-flowered species, where the ripened segments of the ovary, though nominally dehiscent, remain closed about the seeds, imprisoning them. To compensate for this, these segments nearly separate from the styler appendages, with which, in *G. Robertianum*, they are finally connected only by a pair of slender silk-like bundles of fibres. When the style at length breaks away and suddenly becomes arched, these fibres give way and the ovarian segment with its enclosed seed is thrown off with much force, often to a distance of many feet. (Note 4.)

ERODIUM, L'Her., Geran. Pl. 1-6; Benth. and Hook. Gen., 1, 272.

At length mostly caulescent, with often pinnatisect leaves; peduncles mostly umbellately several-flowered; flowers nearly regular, the upper petals a trifle smallest; stamens with anthers 5, opposite the sepals, alternating with as many sterile filaments; carpels very sharp-pointed below, covered with obliquely ascending appressed hairs, at most tardily dehiscent; styles spirally twisted below when ripe, bearded on the inner side; seed obconical or oblong, not sculptured; otherwise as in *Geranium*.—About fifty species, mostly natives of the north temperate portion of the Old World, some of them widely distributed as weeds.

SYNOPSIS OF NORTH AMERICAN SPECIES.

- *Leaves round-ovate, with approximated lobes, or not lobed; seed large, 4-5 mm. long.
 Pedicels glandular, seeds stout. *E. macrophyllum*.
 Not at all glandular, seeds slender. *E. Texanum*.
- * * Leaves ovate-oblong, with approximate lobes; seed smaller, not over 3 mm. long.
 Fruit very small, beak 25 mm. long. *E. malachoides*.
 Fruit much larger, beak 70-120 mm. long.
 Leaves pinnatifid with irregularly toothed segments. *E. Botrys*.
 Cauline leaves bipinnatisect with linear-oblong segments; sepals and fruit very large. *E. Ciconium*.
- * * * Leaves oblong, with remote segments; seed as in the last.
 Leaves pinnatifid, or bipinnatifid, with irregularly serrate segments; stipules obtuse. *E. moschatum*.
 Leaves bipinnatisect, with narrow sharp-toothed segments; stipules acute. *E. cicutarium*.

1. *E. MACROPHYLLUM*, Hook. and Arn., Bot. Beechey, 327. Aspen to a foot or more high, branched when large, canescent-hispid and with copious interspersed glandular hairs, at least on the pedicels; radical leaves reniform, triangular-ovate, with a broad sinus, obtuse, doubly crenate or with about 5 round lobes; cauline leaves subdeltoid, incisely 5-lobed, with coarse round-acuminate teeth; lower petioles longer than the blades; stipules herbaceous, ovate, acuminate; peduncles mostly exceeding the leaves, 2-7-flowered, the pedicels somewhat refracted; bracts lanceolate; sepals ovate, with spreading acute or acuminate-pointed tips, usually scarious-margined, purple-veined, at length 12-15 mm. long; petals 10-15 mm.; beak finally 40-50 mm. long; divisions of ovary more densely hairy than in our other species, conspicuously truncate, 3×9 mm.; seed 1.5×4.5 mm.—Texas to California.—Pl. 10, fig. 12.

2. *E. TEXANUM*, Gray, Pl. Lindheimer, 157. *E. macrophyllum*, Gray, Ives' Rep. 8. Very similar to the last but not at all glandular; pedicels and flower-buds silvery canescent; leaves triangular-cordate, with a broad sinus, obtuse, 3-parted, the cauline often with sinuses widened below, the basal divisions mostly cleft on the lower side and the terminal trilobed; sepals abruptly acuminate-pointed, 8-12 mm. long; petals purple, 15-18 mm. long, sometimes greatly reduced or wanting; beak 50-70 mm. long; divisions of ovary not prominently truncate, $1.5-2 \times 9$ mm.; seed $.8-1 \times 3.7-4$ mm.—Texas to California.—Pl. 10, fig. 13.

E. MALACHOIDES, Willd., Spec. III, 639, a somewhat glandular, small-flowered plant, with ovate somewhat incisely 5-9-lobed irregularly toothed leaves, short-pointed sepals about 5 mm. long, and very small fruit, the beak 25 mm. long, divisions of ovary 1×4 mm., obliquely truncate, seed $.8 \times 2.5$ mm., has been collected on ballast at New York City (*Brown*).—From the Mediterranean region.—Pl. 10, fig. 14.

E. BOTRYS, Bertoloni, Amoen. Ital., 35, with loosely white-villous stems and petioles, incisely 5-9-parted ovate-oblong leaves, the cauline with rather narrow acute divisions, thin ciliate stipules, pointless sepals 8-9 mm. long, and large fruit, the beak 70-120 mm., and scarcely truncate divisions of ovary 1.5×11 mm., has been collected in the Sacramento Valley, California (*Greene*) and on a refuse-heap in Boston (*Murray*).—From South Europe.—Pl. 10, fig. 16.

E. CICONIUM, Willd., Spec. III, 629, with glandular somewhat canescent stems, ovate leaves, the cauline bipinnatisect, abruptly awn-pointed sepals at length 8-10 mm. long, and large fruit, the beak over 70 mm., divisions of ovary 2×9 mm., has been collected on ballast at Philadelphia (*Martindale*).—Also from the Mediterranean region.—Pl. 10, fig. 15.

3. *E. MOSCHATUM*, Willd., Spec. III, 631. Villous with coarse thin-walled spreading hairs; leaves oblong, pinnately divided, divisions 9-13, the lower remote, ovate, incisely lobed or irregularly biserrate; stipules ovate-deltoid, thin and scarious, obtuse; sepals abruptly mucronate, 8-10 mm. long; petals rose-colored, 3-5 mm. long; beak 40-45 mm.; divisions of capsule 1×4 mm., obliquely truncate; seed 1×2.5 mm.—California to Mexico, becoming a common roadside weed. A native of the Mediterranean region, also introduced into South America and Australia. Said to give an unpleasant taste to milk and butter when eaten by cattle. The form with rather deeply cut leaf segments approaches var. *pimpinellaefolium*, of the next.—Pl. 10, fig. 17.

4. *E. CICUTARIUM*, L'Her., Ait. Hort., Kew, II, 414; Brewer and Watson, Bot. Calif. I, 94; Vasey, Rep. Depart. Agric., 1881-2, 253, Pl. 22. Loosely white-villous; leaves oblong, pinnately 9-11-divided; divisions remote, ovate, pinnatisect with oblong or linear sharply serrate segments; stipules scarious, lanceolate, acute; peduncles about 9-flowered; sepals about 8 mm. long, mostly abruptly pointed, the awn tipped with 1-2 long white hairs; petals rose-purple, about 5 mm. long; beak 30-40 mm.; divisions of capsule 1×5 mm., obliquely truncate; seed $.8 \times 2.5-3$ mm.—Oregon to Nevada and Texas; also met with occasionally as a weed or ballast-plant elsewhere (Mich., *Tuthill, Bailey*; Mass., *Murray, Lowell, Oakes*; Maine, *Farlow*; New York, *Knieskern, Holton*; Pennsylvania, *Redfield*; New Jersey, *Parker*; New Brunswick, *Hay*). Introduced from south Europe. Flowering in dry places when less than an inch high. Relished by cattle, and said to impart a pleasant taste to their milk.—Pl. 10, fig. 18.

So far as their vegetation is concerned, the species of *Erodium* agree in the main with *Geranium*. As a rule they are less branched. (Note 5.) The inflorescence differs chiefly in that the umbels are more than 2-flowered, and the pedicels are always more or less reflexed during the maturation of the fruit, to become erect, ultimately.

The flowers are usually turned more to one side when open, than in *Geranium*, and this change in their position is accompanied by a slight degree of irregularity, the two or three petals on the lower side being larger, by which they are fitted to serve as an alighting place for insect visitors—chiefly bees. The flowers are usually distinctly protandrous, and secrete an abundance of nectar. In the main they differ very little from those of *Geranium* in the way in which they are pollinated. *E. cicutarium* has been shown by Ludwig to be gyno-dioecious. (Note 6.)

The contrivances for dissemination are even more interesting in this genus than in the last. The fruit is essentially the same in both, the segments of the ovary being prolonged in flat bands that extend along an axile beak and form the styles above. These appendages or awns consist in both genera almost exclusively of mechanical (bast) fibres. In *Geranium*, those forming the outer part contract to a greater extent than those nearer the axis, as the fruit ripens, so that ultimately the base of the awn curves outwards in a radial plane, as has already been explained. In *Erodium* the carpels remain practically indehiscent and are firm and sharp-pointed at the base, gradually enlarging upwards, and are covered below with obliquely ascending stiff hairs, supported at the base by firm cells projecting from the epidermis of the ovary. The awn is similar to that of the last genus, but while its outer fibres merely shorten in drying, the inner ones, for the lower half, contract spirally, so that the ripened carpel is not only thrown elastically from the plant, but the awn ultimately becomes coiled below into a close helix, from the top of which the upper half bends away in a gradual curve. The awn is also bearded below, on the inner side, and when it at length becomes twisted, the long loose hairs point outwardly in such a manner as to act in some measure as a parachute, favoring the further removal of the fruit by the wind.

When moistened, the awns become straight, resuming their coiled form again when allowed to dry, and repeating these changes with every alternation of moisture and dry-

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ness. Supposing the basal point of the carpel to be slightly caught in the soil, which readily happens either as the fruit falls or when its movements begin, its withdrawal is rendered difficult by the stiff ascending hairs with which the ovary is clothed; so that while the crowding of the awn against bits of stubble, pebbles, or whatever small objects it may chance to have fallen among, tends to press the fruit farther into the earth with every movement, whether the result of moistening or drying of the awn, the probability of its withdrawal, when once caught, is small. In some experiments performed in my laboratory several years since, by Mr. E. H. Parker, it was observed that after the fruit had been buried in damp soil for a few days, the awn softened at its base, so that a pull, which otherwise might have withdrawn the fruit, merely broke away the awn,

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Fruit of *Erodium glaucophyllum*, $\times 2$.

thus removing the only source of danger to the self-planted seed, a provision which was also noticed in *Stipa*, and has been recorded for these genera by Roux and Darwin respectively.

The contrivances in the fruit, therefore, are of a double nature, referring not only to its removal from the parent plant, but to its insertion in the soil when a suitable point has been reached. It is interesting to note that similar provisions are met with in widely separated genera (*Anemone* § *Pulsatilla*, and species of *Stipa* and *Aristida*), not at all related to *Erodium*; as well as in *Pelargonium*, a genus which stands very near the latter, the fruit of which is less elastic, and consequently more dependent upon the wind for dissemination, although it is ultimately planted in the same manner.

Our species of *Erodium*, including those which have become naturalized or are merely occasional ballast-plants, belong to the section with the arched upper half of the awn naked or at most short-pubescent; but in another section, represented by *E. glaucophyllum* and several other species, this appendage is much elongated, and plumose with a double series of long silken hairs. There can be little doubt that the carpels of species of this section are carried about freely by the wind, while they may at length be planted by the coiling and uncoiling of the lower part of the awn, as in the species already described. This may also be expedited by the action of the wind upon the plumed awn, after the fruit has once caught in the soil, as I have convinced myself by grasping the ovary between my thumb and finger, and blowing irregularly upon the plume; the result in every instance being to crowd the ovary down several millimeters in a short time. (Note 7.) Here again it is interesting to observe an identical contrivance in *Stipa pennata* and related species, which differ from others of the genus in possessing a long-plumed awn.¹ *Monsonia*, a close relative of *Erodium*, likewise includes species with plumed and plumeless fruit.

LIMNANTHEAE.

Flowers regular, very slightly perigynous, 3-5-merous, homogone; sepals valvate, persistent and somewhat enlarged in fruit; petals convolute or open, withering-persistent; stamens twice as many as the sepals, all with anthers; glands opposite the sepals, evident; carpels opposite the sepals, their 1-ovuled ovaries distinct, the style rising from the centre; fruit a series of semi-drupaceous rugose-tuberculate nutlets.—*Limnanthaceae* of continental writers; two genera, exclusively North American.

LIMNANTHES, R. Br., London and Edinb. Philos. Mag., ii, 70; Benth. and Hook., Gen., t, 274.

Rather succulent annual herbs with alternate once to thrice pinnately dissected petioled mostly stipulate leaves; flowers solitary at the ends of bractless axillary peduncles, 4- or mostly 5-merous; petals obovate-cuneate, mostly emarginate, convolute; filaments distinct, somewhat dilated at base, their tips at first recurved outwards; anthers at length introrse; style about equalling the stamens; seed exalbuminous, closely invested by the pericarp; embryo straight, with plane cotyledons. *Floerkea*, Baillon, Adansonia, x, 362; Hist. des Pl., v, 20, in part.—Four species, confined to the Pacific slope.

1. L. ALBA, Hartweg, Benth., Pl. Hartw., 301. A span or two high; young leaves and flower-buds very white-lanose; leaves remotely 5-9-divided, the divisions linear-oval, mostly 10-15 mm. long, entire, 3-lobed or trifid; sepals ovate-lanceolate, acute or acuminated; petals pale yellow or white, emarginate or truncate, 10-12 mm. long; stamens about

¹The experiments of Mr. Parker with this grass (which consisted in barely starting the point of the fruit in loose earth, and placing it where the air from a slightly opened window blew upon it intermittently) demonstrated that

this force alone is sufficient to bury the grain completely in sandy soil within twenty-four hours, while the hygroscopic action of the lower part of the awn is also efficient. See, further, Lubbock, Rept. Brit. Assoc. 1881, 668.

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half as long as the petals, anthers 2 mm. long; fruit obovoid-pyriform, prominently rugose-tuberculate, 2.5×4 mm.—California. A low plant, with petals no longer than the sepals, is found near Yreka by Greene.—Pl. 12, fig. 19.

2. *L. DOUGLASHI*, R. Br., *l. c.* *Floerkea Douglasii*, Baillon, *l. c.* Glabrous; sepals narrower; petals deep yellow, pale-margined, occasionally rosy tipped, conspicuously veined, spatulate-cuneate and emarginate, to obovate-cuneate; fruit varying from nearly smooth to strongly tuberculate; otherwise like the last.—California to Oregon.—Pl. 12, figs. 16-17.

3. *L. ROSEA*, Hartweg, Benth., Pl. Hartw. 301; Brewer and Watson, Bot. Calif. II, 438. Very similar to *L. Douglasii*; leaf-lobes usually narrower and linear; petals mostly broader and, like the stamens, marked by numerous very delicate interrupted longitudinal rose-purple lines; fruit very rough.—California. Perhaps no more than a variety of the last. Flowers heliotrope-scented.

4. *L. MACOUNII*, n. sp. *Floerkea proserpinacoides*, Macoun, Rept. Geol. Surv. Canada, 1875-6, 192; Cat. Can. Pl. 1, 91, in part. *Limnanthes Douglasii*, Macoun, Cat. III, 502. Glabrous, 2-3 inches high; divisions of the leaves 5-9, remote, 3-6 mm. long, ovate, mostly 3-cleft, their lobes broad and very acute; flowers 4-merous, not showy as in the other species; sepals oblong, rather obtuse, enlarging somewhat in fruit; petals white(?), oblong-cuneate, erosely truncate, 3-4 mm. long; stamens about equalling the petals, anthers 4 mm. long; fruit obovoid, 3 mm. long, with very prominent tubercles.—Vancouver Island (*Macoun*). Collected only once, in 1875.—Pl. 12, fig. 18.

FLOERKEA, Willd., Neue Schr. Gesellsch. naturf. Fr., Berlin, III, 448; Benth. and Hook. Gen., 1, 275.

Flowers 3-merous; petals oblong, entire, shorter than the sepals, open in aestivation; otherwise as in *Limnanthes*, which, as Baillon, Eichler, and others have shown, is much too close.

1. *F. PROSERPINACOIDES*, Willd., *l. c.* *F. lacustris*, Pers. *F. palustris*, Nutt. *F. uliginosa*, Muhl. *Cabomba pinnata*, Röm. and Schult. *Nectris pinnata*, Pursh. Glabrous, weak-stemmed, a span to a foot high; divisions of the leaves mostly 5, lanceolate or occasionally elliptical, 10-15 mm. long, remote; flowers very inconspicuous; sepals ovate, acute, enlarging in fruit; petals white, 1-2 mm. long; stamens about equalling the petals, anthers .2 mm. long; fruit subglobose, loosely tuberculate above, 3-4 mm. long.—Rich, damp woods, Canada and New England to Oregon and California; south to Pennsylvania and Missouri.—Pl. 12, fig. 20.

The *Limnantheae* do not appear to have been much studied from a biological standpoint. In the large-flowered species the abundance of nectar is advertised by a pronounced fragrance as well as by the color of the corolla, the veins or striae of which also serve as nectar-marks. They are said to be much visited by bees, and are clearly

adapted to pollination by these insects. Darwin¹ has shown that the flowers are fertile with their own pollen. *Floerkea* and, apparently, *Limnanthes Macouarii*, with smaller, inconspicuous flowers, are apparently adapted to pollination by small bees and are likely to be found fully self-fertile, but no observations have been made on them. The seeds of both genera are enclosed in integuments consisting of brown, rather thin-walled cells, the outer and inner layers of which are collapsed and closely surrounded by the indehiscent, rugose-tuberculate pericarp, which is soft, and consists externally of thick-walled, rather pale cells, some of which, on the outside, develop into thick-walled, verrucose, rounded papillae. I am unable to offer any suggestion concerning their dissemination, or the use of the peculiar roughening of the pericarp. (Note 8.)

OXALIDEAE.

Flowers regular, 5-merous, homogone or heterogone; sepals imbricate, persistent; petals convolute, distinct or somewhat united near the base, deciduous; stamens twice as many as the sepals, sometimes with an additional set of auricles or sterile scales; glands greatly reduced or wanting, alternate with the sepals when present; carpels alternate with the sepals. *Oxalideae* of continental writers.—Five genera, three of them confined to tropical Asia, one South American, the other widely distributed.

OXALIS, L. Gen. n., 382; Benth. and Hook. Gen., I, 276.

Annual or perennial often bulbiferous herbs, sometimes suffruticose or frutescent, with compound petiolate mostly estipulate leaves; stamens ten, monadelphous below, in two sets of different length, all antheriferous; ovary somewhat lobed, forming a loculicidal capsule tipped by the persistent distinct styles; seed with a longitudinally-dehiscent ariloid outer coat, the firm more or less viscid inner integument usually sculptured; embryo straight, with plane cotyledons, in abundant albumen. *Oxys* of older writers.—About 220 species, mainly in South America and Africa.

SYNOPSIS OF NORTH AMERICAN SPECIES.

*Caulcescent; flowers yellow, sometimes, like the rest of the plant, tinged with red-purple.

- Leaves unifoliolate with free setaceous stipules *O. dichondraefolia*.
 Leaves pinnately trifoliolate, estipulate *O. Berlandieri*.
 Leaves palmately trifoliolate, estipulate or with short adnate stipules; leaflets subsessile, more or less obliquely obovate-cuneate.
 Leafy branches from a stout woody caudex *O. Wrightii*.

¹Cross and Self-fertilization, Index.

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Stems not from a caudex, but mostly perennial from slender rootstocks.

Flowers usually small, homogone, the styles about equalling or longer than the longest stamens *O. corniculata*.

Flowers large and showy, heterogone or appearing so.

Repent, with adnate stipules; flowers doubtfully trimorphic.

O. corniculata, var. (?) *macrantha*.

Erect, stipules none; flowers clearly trimorphic.

Low, slender-stemmed; leaflets not margined (Oregon). *O. Suksdorfii*.

Tall and rather stout, leaflets dark margined (Middle States). *O. recurva*.

** Acaulescent; leaves and scapes from the end of a slender perennial scaly rootstock; flowers white or pinkish, somewhat yellow at base and mostly red-veined, homogone; leaves palmately trifoliolate.

Scapes 1-flowered; capsule round-ovoid *O. acetosella*.

Scapes umbellately several-flowered; capsules linear *O. willifolia*.

*** Acaulescent; leaves and scapes from a scaly bulb; flowers heterogone, rose-violet; leaves palmately 3-10-foliolate; sepals (and usually leaflets) tipped with orange callosities.

Leaflets constantly 3.

Obovate or transversely lunate-oblong; capsule round-ovoid *O. violacea*.

Obovate-deltoid; capsule linear-oblong *O. latifolia*.

V-shaped; capsule ovoid-oblong *O. vesperilionis*.

Leaflets 3-5 (mostly 4), deeply obovate *O. divergens*.

Leaflets 5-10, narrow, deeply notched, bilobed, or Y-shaped *O. decaphylla*.

1. *O. DICHONDRAEFOLIA*, Gray, Pl. Wright., 1, 27. Caulescent, a span to a foot high, perennial, appressed-pubescent; branches spreading or procumbent, woody and rough-barked at base; leaves unifoliolate, leaflet round-ovate, wavy-margined, cordate, abruptly depressed and mucronate at apex, 12-30 mm. long; petiole as long, or somewhat exceeding it; stipules setaceous, free from the petiole, often 10 mm. long; flowers homogone (?), 12 mm. long, solitary on axillary peduncles equal to or surpassing the leaves, and with two setaceous bracts near the summit; sepals triangular-lanceolate, acute, dilated at base; petals spatulate, entire, submucronate and slightly ciliate above, half as long again as the calyx; capsule round-ovoid, 10 mm. long, pubescent; seeds about three in each cell, with prominent tubercles arranged in transverse, more or less oblique rows, 1.4 x 2.2 mm. — New Mexico (*Wright*) and Texas (*Berlandier*, *Wright*, *Palmer*, *Reverchon*) to Mexico. — Pl. 11, fig. 1.

2. *O. BERLANDIERI*, Torrey, Bot. Mex. Bound., 41. Caulescent, a span or less high, perennial "from a slender subterranean rhizoma," somewhat woody below and much branched, gray- or rusty-pubescent; leaves pinnately trifoliolate, estipulate, on petioles about 15 mm. long; terminal leaflet obovate-oblong, 10-15 mm. long, on a stalk half as long, lateral ones smaller, opposite, oblong, very short-stalked, all obliquely emarginate at apex, nearly glabrous above; flowers heterogone (?), about 12 mm. long, umbellate at the ends of axillary peduncles about equalling the leaves; umbels mostly 3-flowered; pedicels usually shorter than the flowers; sepals lanceolate, acute; petals obovate, suben-

ture, thrice as long as the calyx; capsule ovoid, about 5 mm. long, pubescent; seeds 1-3 in each cell, fusiform, somewhat flattened, with 8 prominent longitudinal zigzag wings or rows of teeth, .8 × 1.6 mm.—Texas (*Berlandier*, 1094-2524, *Boundary Commission*, *Schott*, 149); not collected recently.—Pl. 11, fig. 2.

3. *O. WRIGHTII*, Gray, *Pl. Wright.*, 1, 27. Caulescent, perennial from a stout, conical, subterranean caudex, at the apex of which the decumbent leafy branches are clustered, otherwise very similar to the next.—Arizona and Indian Territory to Texas, extending into lower California and Mexico. An Arizona specimen (*W. F. Parish*, 32) is densely gray-tomentose below.—Pl. 11, fig. 3.

4. *O. CORNICULATA*, L. *Spec.*, 435. *O. pusilla*, Salisb. Caulescent, an inch to a span or more high, annual or perennial, slender-stemmed, erect or procumbent, in some forms rooting at the nodes, gray or rusty strigose-pubescent; leaflets 3, obovate, broader than long, 10-15 mm. wide, the long slender petioles dilated below the basal pulvinus into round or truncate ciliate stipules; flowers 5-8 or in some forms 12 mm. long, solitary or usually paired, on bibracteate peduncles equal to or exceeding the leaves; pedicels mostly longer than the flowers, reflexed in fruit; sepals oblong, rather obtuse; petals obscurely crenulate or emarginate, about twice as long as the calyx; styles about equaling the long stamens, or, in larger-flowered specimens, exceeding them; capsule erect, oblong, 10-20 mm. long, strigose; seeds about ten in each cell, but varying greatly in number, ovate, acute above, much flattened, with 1-3 deep marginal grooves and numerous transverse ridges somewhat interrupted by two low longitudinal elevations on each side, .8-.9 × 1-1.5 mm., mostly dark brown when ripe.—Over the entire country; flowering through the season. A cosmopolitan weed with many forms, several of which have received specific names, but are now generally united.—Pl. 11, fig. 4.

Var. (?) *MACRANTHA*. Decumbent from a stout or slender horizontal rootstock, the branches erect, a span high, pilose with spreading pointed hairs; leaflets narrower; flowers pale, 10-15 mm. long, extremely variable in the relative length of stamens (or perhaps heterogone-trimorphic), otherwise as in the type.—Arkansas to Texas and along the Gulf to Florida; also in California.—Pl. 11, fig. 5.

Some plants are very similar to specimens from Australia referred to *O. microphylla* (now regarded as a variety of *corniculata*), but are not the form usually known by that name. If the flowers are truly trimorphic this will have to be separated from *corniculata*. It may possibly be *O. pilosa*, Nutt., of which I have seen only a fragmentary fruiting specimen, and is apparently *O. pumila*, Nutt., which I have seen from the Torrey herbarium and that of the Philadelphia Academy, through the courtesy of Doctor Britton and Mr. Redfield, so that if it is ever raised to specific rank it will have to bear the latter name.

Var. *STRICTA*, Sav., *Lam. Diet.*, iv, 683. *O. stricta*, L. and most authors. *O. Dillenii*, Jacq. *O. florida*, Salisb. *O. Lyoni*, Pursh. *O. furcata*, Elliott. Annual, or often perennial by running rhizomes, erect, a span to a foot high, the stem subglabrous to very villous, but usually only slightly strigose; leaves without stipules; inflorescence in luxuriant specimens a dichotomous cyme, in others umbellate; flowers about 8 mm. long; petals subentire; otherwise similar to the type and of like distribution, but beginning to flower later. According to Eichler the first flower is frequently 6-merous.

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Jacquin, whose illustrations otherwise well represent our extreme form of *O. corniculata* and its variety *stricta*, figures the former without stipules, and the latter with rounded stipules, while the reverse is true.¹ Elongated acute stipules, such as Salisbury² and Sowerby³ figure, have not been observed in our specimens, but can readily be conceived as resulting from the prolongation of the acute outer angle of such truncated stipules as some of our plants possess. The pubescence of most forms of this species consists of spreading or appressed unicellular pointed hairs, with thick verrucose walls, intermingled with which are a very few blunt hairs consisting of a single row of smooth, thin-walled cells. In var *stricta* the pointed rough hairs are abundant on the leaflets, pedicels, etc., but they are commonly less numerous on the lower part of the stem and petioles. Where these are hairy (and they are extremely villous in some plants growing in shaded places), the pubescence often consists almost exclusively of the thin-walled hairs, which are often of unusual length, and easily show their septate character under a hand-lens; the same is sometimes true of the capsules.

5. *O. SUKSDORFII*, n. sp. *O. corniculata*, Gray, Proc. Amer. Acad., VIII, 378. Perennial from a slender creeping rootstock, slender-stemmed, erect, a span or two high, more or less pilose, or loosely villous; leaves estipulate, long-petioled, trifoliolate, leaflets deeply obovate, with unequal lobes as much as 25 mm. wide; flowers mostly paired on long axillary peduncles, heterogone-trimorphic, bright yellow; bracts subulate; sepals obtuse, downy; petals thrice as long as the calyx, 15 mm. long, wavy-margined, not emarginate. Fruit not seen, but presumably as in *O. corniculata*.—In woods; Oregon (*Nuttall, Hall, Henderson, Suksdorf*); collected in June by Mr. Suksdorf.

6. *O. RECURVA*, Elliott, Bot. S. Car. and Georgia, I, 526. Annual (?) or perennial from a slender rootstock, erect, simple, 1-2 ft. high, glabrate or somewhat soft-villous; leaves long-petioled, estipulate; leaflets large, as much as 60 mm. wide, broadly obovate with a shallow sinus, somewhat pubescent and ciliate, narrowly margined with brown-purple; flowers umbellate or subcymose, 12-15 mm. long, yellow, brown-striate at base, heterogone-trimorphic; otherwise similar to *O. corniculata*, var. *stricta*.—Open woods, etc. Carolina (*vide Elliott*), to Pennsylvania (*Carey*), west to Ohio (*Lea, Lloyd*) Indiana (*vide Barnes*, Bot. Gaz., II, 21) and Tennessee (*Gattinger*). Flowering from May to June or the early part of July.—Pl. II, fig. 6.

Elliott based his description on the short-styled plant, which he says is "very common near Charleston, intermingled with *O. stricta*, with which it has been confounded." *Carey*, whose specimens, so far as I have seen them, were all long styled, regarded it as *O. Dillenii*, from which, however, it is quite distinct, judging from the figure, in *Dillenii's* Hort. Ethel., II, Pl. 221, on which the latter is based, and a single flower of the original of the figure, kindly secured for me, at Oxford, by Dr. Gray. *Lea*, who appears to have studied it carefully about Cincinnati, contributed a suite of specimens, representing the three forms of flowers, to *Torrey*, but was apparently misled into considering the length of stamens and pistil merely variable, trimorphic heterogony not having then been discovered. I am indebted to Mr. C. G. Lloyd for a suite of specimens from the vicinity of Cincinnati.

¹ Oxalis Monogr., Pl. 4-5.

² Trans. Linn. Soc., II, Pl. 23, fig. 5.

³ English Bot., Pl. 1726; Third ed., Pl. 321.

7. *O. ACETOSELLA*, L. Spec., 433. *O. Americana*, Bigel. *O. Montana*, Raf., Annals of Nature, 1, 12. Acaulescent, perennial by a slender simple or sparingly branched rootstock, more or less rusty-pubescent; leaves few (usually 3-6) a span or less high; petioles slender, articulated with their dilated bases, that persist on the rootstock clustered at the end of each year's growth; leaflets 3, broadly obovate, with a minute appendage in the narrowed base of the sinus; scapes solitary or few, slightly exceeding the leaves, 1-flowered, 2-bracted about an inch below the flower; bracts broad and rather obtuse; flowers open cup-shaped, 10-15 mm. long, homogone (but usually appearing as if the long-styled form of a trimorphic species); sepals ovate-oblong, rather obtuse; petals 3-4 times as long as the calyx, emarginate; capsule subglobose, 2-3 mm. long, its cells 1-2-seeded, glabrous; seeds ovoid, acute above, with about 5 shallow longitudinal grooves on each side, and obscurely pitted.—Damp woods from the mountains of North Carolina far northward, where it ranges from the Atlantic to the Saskatchewan. Also found in Europe, Asia and North Africa. Recurved scapes bear cleistogone flowers, mostly concealed among the moss, etc., at the base of the plant.—Pl. 11, fig. 7. A form with deeper-colored flowers found in New Brunswick, etc., is var. *subpurpurascens*, DC. Prod. 1, 700.

Var. *OREGANA*. *O. Oregana*, Nutt. in Torrey and Gray, Fl. N. Am., 1, 211. *O. acetosella*, Hook., Fl. Bor.-Amer. 1, 118. Larger in every way and more rusty-pubescent, as much as a foot high and with leaflets in extreme cases over 40 mm. long; flowers 20-25 mm. long; capsules 10 mm.; seeds 2.5 x 3.5 mm.; otherwise as in the type.—California to Washington Territory. The description of fruit and, in part, of inflorescence, in Botany of California, 1, 96, relates to the next species.—Pl. 11, fig. 8.

8. *O. TRILIFOLIA*, Hook., Fl. Bor.-Amer., 1, 118. *O. macrophylla*, Dougl. in Hook. l. c. *O. Oregana*, Brewer and Watson, Bot. Calif., 1, 96, in part; Gray, Proc. Amer. Acad. VIII, 378. Habit of the last, sparingly pubescent or glabrate; leaves a span to a foot high, leaflets 25-45 mm. long and usually about as broad; scapes mostly several, a little longer than the leaves, umbellately about 6-flowered; pedicels at length equalling the capsules; bracts acute; flowers small, 5-12 mm. long, homogone; petals deeply emarginate or bifid and nearly white; capsule linear, 25 mm. long, its cells about 6-seeded, glabrous; seeds red-brown, oblong, obscurely coarse-pitted and somewhat longitudinally striate, 1 x 2.2 mm.—Damp woods, Washington to Oregon.—Pl. 11, fig. 9.

9. *O. VIOLACEA*, L. Spec. 434. *O. longiflora*, L. *O. pulchella*, Salish. Acaulescent, perennial from a stout brown bulb with rusty-ciliate scales, glabrous or the pedicels and bases of the leaves glabrate; leaves several from each bulb, a span or less high, leaflets 3, about 10 mm. long, broadly obovate with an open sinus, the midrib tipped on the lower side with a pair of usually prominent confluent orange callosities¹; scapes several, mostly about twice as long as the leaves, umbellately 3-12-flowered; pedicels at length rather longer than the flowers; bracts acute; flowers 15-20 mm. long, heterogone; sepals ovate, obtuse, with two more or less confluent orange callosities on the outer side at the tip; petals thrice as long as the calyx, undulately obtuse or truncate, rose-purple or sometimes white; capsule round-ovoid, about 5 mm. long, its cells about 3-seeded, glabrous; seeds

¹ These callosities, or so-called glands, are common to many species of this section of *Orealis*. In *O. Martiana*, *bipartita*, etc., an intramarginal series of small callosities of

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compressed ovoid, irregularly rugose-tuberculate, 1.5 mm. long.—Woods, Vermont to Florida, west to the Rocky Mountains and Texas; the western form common in dry open groves.—Pl. 11, fig. 10.

10. *O. LATIFOLIA*, HBK., Nov. Gen., v, 237, Pl. 467, var. Acaulescent, a span or more high, from a small scaly bulb which bears numerous subterranean bulbiferous shoots two or three inches long, subglabrous; leaflets 3, without apical callosities, very broadly obovate-deltoid with oblong divergent lobes, more or less ciliate; flowers about as in the last; alternate filaments with lateral auricles; capsule (immature) linear-oblong, 10 mm. long, its cells about 5-seeded; seeds flattened, ovate, acute above, transversely rugose, with about 4 longitudinal grooves on each side, .75 × 1.2 mm.—Arizona (Pringle, 1881, no. 300, *Leunmon*, 2654), from Mexico and South America. Leaves smoother, less conspicuously veined and more deeply parted than in the figure cited, and the stamens different, but agreeing well with various Mexican specimens referred to *O. latifolia* (e. g. *Batteri*, 1122).—Pl. 11, fig. 12.

11. *O. VESPERTILIONIS*, Torr. and Gray, Fl. N. Amer., 1, 679. *O. Drummondii*, Gray, Pl. Wright., II, 25; Torrey, Bot. Mex. Bound., 41; Watson, Index, 1, 153. Hemsley, Biol. Centr. Amer., 1, 163. Acaulescent from a scaly bulb, glabrous; leaves few, about a span high, leaflets 3, open V-shaped, more or less conspicuously calloused in the sinus, the linear blunt lobes 10-25 mm. long, usually 5 mm. or less wide; scape nearly twice as long as the leaves, mostly solitary, umbellately about 6-flowered; pedicels at length an inch long; bracts acutish; sepals with 4-6 narrow callosities, flowers otherwise about as in *O. violacea*, heterogone; capsule ovoid-oblong, somewhat pubescent, 10 mm. long, its cells about 4-seeded; seeds as in *O. decaphylla*.—Texas (*Lindheimer*, 175, 311, 457, *Wright*, 716, *Drummond*, 8).—Pl. 11, fig. 13.

12. *O. DIVERGENS*, Benth., Pl. Hartweg., 9. *O. vespertilionis*, Gray, Pl. Fendler., 27. *O. violacea*, Gray, Pl. Wright., 1, 27, II, 25. An inch and a half to a span high, glabrous (or somewhat hairy?), with the flowers and habit of *O. violacea*. Leaflets 3-5, mostly 4, deeply obovate or emcuate-bilobed, without an apical callosity, 10-20 mm. long and about as broad, the sinus extending to the middle, lobes divergent, mostly narrowed upwards; fruit?—New Mexico (*Fendler*, 91, *Wright*, 908) and Arizona (*Rusby*, September, 1883), from Mexico.—Pl. 11, fig. 11. Similar to *O. tetraphylla*, Cav., but smaller. A large specimen distributed by the Department of Agriculture without locality or date may possibly be the latter.

13. *O. DECAPHYLLA*, HBK., N. Gen., Sp., v, 238, Pl. 468. Acaulescent from a more or less hairy bulb which produces short-stalked bulblets, glabrous; leaves several, about a span high; leaflets 5-10, linear-obovate-Y-shaped, 20-35 mm. long, the sometimes sparingly ciliate lobes 3-5 mm. wide, midrib ending abruptly, not callous-tipped; scapes mostly twice as long as the leaves, umbellately about 10-flowered; flowers heterogone about as in *O. violacea*, but the sepals mostly with 4-6 callosities; capsule ovoid-oblong, 8 mm. long, its cells about 4-seeded; seeds pale brown, compressed, round-ovoid, longitudinally 8-10-creased and transversely wrinkled, .7 × .9 mm.—Arizona (*Greene*, 1880, no. 211, *Pringle*, 1881, 301, *Leunmon*, 2653) and New Mexico (*Wright*, 909), extending into Mexico. In some Mexican specimens, apparently to be referred here, the scape

and petioles are puberulent or loosely villous, and the leaflets are occasionally somewhat hairy. It should be noted that our flowers of this species and *O. latifolia* are much larger than those figured by Kunth.—Pl. 11, fig. 14.

A comparative biological study of the species of this genus, with abundant material, would be of unusual interest. Those like *O. corniculata*, var. *stricta*, which produce leafy stems, but spread by subterranean shoots, show how the caulescent type may be connected with the acaulescent, as represented by the *acetosella* group, which produce their leaves and flowers from the apex of a slender rhizome. These forest-inhabiting species, with persistent stipular-dilated leaf-bases aggregated about the terminus of each year's growth, while the scales are remote elsewhere, pave the way for the *violacea* group, many of which are prairie or desert species. In some tropical American species of this group, the so-called stipe, rising to the surface of the ground, is sparingly scaly, suggesting the rhizome of *O. acetosella*, while the subterranean part of *O. emeaphylla* might be called with almost equal propriety a stout scaly interrupted rhizome, or a closely aggregated series of bulbs. But, in the majority of these species, vegetative propagation is effected by bulbiferous shoots, the bases of which disappear after a time, while the inner leaf-bases persist at the apex as fleshy reservoirs of food, and the outer scales, at length dry and sclerotic, usually villous-ciliate or quite hairy, sparingly glandular and charged with resin-cells, serve as protecting organs. The earliest vegetative energy of these bulbiferous plants in early spring goes to the expansion of foliage and flowers, but is soon diverted to the formation of a fleshy tap root, rich in water which is drawn upon as the season of abundant moisture is succeeded by the drought of summer, so that plants that grow in exposed districts are able to mature their fruit, while those in the woods frequently bloom through the late summer and autumn, long after their leaves have disappeared; finally the remaining store of water is applied to the ripening of the bulb.

Hildebrand,¹ who has considered this subject at length, notes, apparently with reason, that African species, which are exposed to greater heat during the dormant season than those of America, uniformly produce bulbs that are protected by a thicker scaly coating, while, by the greater length of their subterranean shoots, they are carried deeper into the earth. The enlargement of the apices of these shoots with an accompanying reduction of their scales, or of the apices of slender rhizomes like those of *O. corniculata*, var. *stricta*, results in tubers such as characterize *O. crassicaulis*² and other species, several of which bear large and edible tubers.

While these cases may serve to illustrate the modification of the simple caulescent type in one direction, *O. Wrightii* departs from the *corniculata* type in developing a stout subterranean caudex, from the summit of which the leafy branches spring, and this form is much intensified in a group of acaulescent South American species with thick

¹ Schutzanrichtungen bei den Oxalschwibeln (Ber. deutsch. bot. Gesellschaft, II, 108); Lebensverhältnisse der Oxalsarten, Jena, 1884,—abstract in Bot. Centralbl., XIX, 225.

² Zuccarini: Nachtrag Monogr. Amer. Oxalsarten, Pl. 2.

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trunks, of which *O. articulata*¹ is a representative. On the other hand, there is no doubt that the latter approach the bulbiferous type, through the *enneaphylla* form already described.

Commonly the leaflets are digitately clustered at the end of an elongated petiole; but the pinnate type, represented among our species by *O. Berlandieri*, is not uncommon in the tropical American species, and in the section *Biophytum* the elongated leaves consist of a large number of crowded leaflets. On the other hand the suppression of all but the terminal leaflet results in the unifoliolate leaf of *O. dichondraefolia* and a few species that do not occur in our territory; and in *O. rusciformis* (sometimes quoted and figured as *O. frutescens*), the reduction and final abortion of the leaflets, accompanied by an unusual dilatation of the petioles, results in a perfect phyllodia as those of *Acacia*,—but these stand with their edges tangential to the stem, not radial as in the latter genus. A transition to this type is afforded by a considerable series of species in which the petioles are more or less dilated and efficient in assimilation. On the other hand, Hildebrand² has pointed out that the leaves of seedlings of *O. Lasianhra* are at first trifoliolate, though the later leaves consist of 7-9 leaflets.

The leaves of *Oxalideae* have long been known to possess the power of movement in a marked degree. The change of position of the leaflets at night, so that they are then exposed to a minimum cooling by radiation—the so-called sleep of the leaves—is a familiar example. Under the influence of light and warmth, this position is exchanged in the daytime for one in which they have the best exposure for assimilation; but a sudden and intense illumination causes the leaflets to close again more or less, and continued exposure to either light or darkness for a period of days breaks the readiness of their response to either, while it has been shown that if so fastened that they cannot close at night, they soon become feeble or die.

In *Averrhoa*, the leaflets are usually in evident motion, from an intensification of their circummutation,—a movement which has been carefully studied by Mr. Darwin in many plants. In this respect they resemble the small lateral leaflets of *Desmodium gyrans*, the common "telegraph plant" of greenhouses. It is also known that the leaves of *Biophytum*, to a certain extent those of *Oxalis acetosella*, and in a still less degree of other species, are influenced by shocks, which cause the leaflets to assume the nocturnal position with more or less rapidity, as in *Mimosa*, *Robinia*, etc. The seat of these different movements is in the pulvini near the base of the general petiole and of the short stalks of the leaflets, and in the midribs of the latter.

The flowers of most species are solitary or umbellately clustered; but in the former case the peduncle is 2-bracted some distance below the flower, and the umbels are likewise subtended by two or more bracts. In specimens of *O. violacea*³ some of the branches of the umbel have been observed to branch, and this, with the constant presence of the bracts referred to, indicates that the inflorescence in these cases is in reality a reduced cyme. A typical dichotomous cyme is, in fact, regularly developed in luxuriant specimens of *O. corniculata*, var. *stricta*⁴. In *O. Brasiliensis*, bulblets have been observed,

¹ Bot. Magazine, cx, Pl. 6748.

² Bot. Zeitung, 1887, 3.

³ Zuccarini: Monogr. Oxalid., 19; Jacquin: Hort.

Vindob. 84, Pl. 180.

⁴ On this subject see Zuccarini: Nachtrag Monogr. Amer. Oxaliden, 190; Wylder: Pringsheim's Jahrb. wiss. Bot. ix; Eichler: Blüthenanlagen, ii, 304, etc.

replacing flowers, and Plukenet¹ states that the flowers of our *O. violacea* are sometimes succeeded by bulblets,—an occurrence that cannot be common in the wild plant.

The flowers are typically open funnel-shaped, expanding in sunshine, the degree of warmth playing a very important part in this process, at least in some species². The stamens are in two sets of unequal length, as in *Geranium*, etc., while the styles appear to be typically about equal to the longer set. But in the majority of species the flowers of different individuals are quite dissimilar in this respect, so that these species are what Hildebrand³ and Darwin⁴ have called heterostyled, or Gray⁵, heterogone. In *Oxalis* the heterogony is typically trimorphism, three forms of flowers existing in about equal numbers on different plants of a given species, the pistils of one being shorter than the shortest stamens (short-styled), those of the second being intermediate between the two sets (mid-styled), while those of the third are longer than either set of stamens (long-styled). Connected with these differences in the length of the pistil are differences in the stamens, so that the two sets of either form of flower correspond in length respectively with the pistils of the two other forms. Hildebrand, who examined the specimens of *Oxalis* in several large herbaria, has recorded his observations on this point in detail⁶. But while the appearance in a majority of cases was that of trimorphism, only one or two forms of flowers were found in many of the species examined. In most instances, however, these correspond to one of the three forms that I have characterized. The same may be said of the many figures of Jacquin⁷ and others who have illustrated this genus. It was also shown by Hildebrand⁸ that, in some trimorphic species submitted to experiment, the greatest fruitfulness resulted only from the fertilization of a pistil by the pollen from stamens of its own length,—a rule that has been found to apply generally to heterogone plants⁹; and Hildebrand has recently again remarked on the frequent self-sterility of a single form¹⁰. The pollen and stigmas of such trimorphic species as have been examined in this respect, also show the differentiation usual in trimorphic plants, the pollen grains of the long stamens being largest, those of the short stamens, smallest, and those of the mid-length, intermediate in size; while the stigmatic papillae of the long-styled flowers are longest, those of the short-styled, shortest, and those of the mid-styled, of intermediate length.

In the examination of herbarium or greenhouse material of trimorphic species, the number of specimens being limited, it may readily happen that only one or two of the forms are found, when a search in the field among hundreds of individuals would reveal all in approximately equal numbers. But even under these conditions, one or more of the forms may not be found in localities where an introduced species has multiplied non-sexually¹¹, or where but two forms have been introduced; for these, propagated sexually, but without the intervention of the other forms, may possibly reproduce only themselves¹². Hence the presumable trimorphism of such species as were known to have one or two of the forms of flowers usual in such cases has not been generally disputed.

Some years since, having access for the first time to numerous wild plants of a sup-

¹ Abnages-tum Bot. 1, Pl. 102, fig. 1.

² Cf. Pfeiffer: Physiol. Unters. 1873.

³ Monatsber. Berlin. Akad. 1866, 369.

⁴ Different Forms of Flowers, various places.

⁵ Amer. Journ. Sci. and Arts, 3 Ser., XIII, 82.

⁶ Monatsber. Berlin. Akad., 1866, 351.

⁷ *Oxalis* Monographia, 1794.

⁸ Bot. Zeitung, 1871, 315, 331.

⁹ Darwin: Different Forms of Flowers, etc., Chapter 5.

¹⁰ Hildebrand: Bot. Zeit. 1887, nos. 1-3.

¹¹ Darwin: Different Forms of Flowers, 182.

¹² Hildebrand: Monatsber. Berl. Akad., 1866, 373; Bot. Zeit., 1887, 5; Darwin: Different Forms of Flowers, 268.

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Akad., 1866, 373; Bot. Forms of Flowers, 268

posed trimorphic species (*O. violacea*), and observing only long- and short-styled plants, I made measurements of the flowers of many plants, but found only these two forms, although the plant is very abundant and a native species. I have since examined a great many more plants about Madison, Wisconsin, in the vicinity of St. Louis, Mo., and from central Illinois, without finding a single mid-styled flower; and my correspondents who have paid attention to the subject have had the same experience. Numerous herbarium specimens, representing nearly the entire range of the species, are also all long- or short-styled. From a careful consideration of these facts, I have been convinced that this species has become dimorphic from the suppression in some manner of the mid-styled form, for it cannot be doubted that it is descended from originally trimorphic parents, since the stamens are still in two remote sets, not as yet combined in a single set, though in flowers of both sorts they appear to be somewhat closer together than they should be in a trimorphic species. Mr. B. M. Vaughan, who studied *O. violacea* in my laboratory some years since, thought that he detected an abortion of the pollen of the mid-stamens in both long- and short-styled flowers, indicating a loss of function that might be held as indicative of their ultimate disappearance. How far this may be true I do not know. Mr. Darwin, to whom some of these facts were communicated shortly before his death, also thought that this might be a trimorphic species becoming or become dimorphic¹. I may add that our other species of the *violacea* group are found only under these two forms in herbaria, so far as I have examined them; but Hildebrand has cultivated the mid-styled form of *O. respertilloniis*².

Our yellow-flowered caulescent species of the *corniculata* group are more puzzling than those which have just been considered. In the typical smaller-flowered form of *O. corniculata* and its variety *stricta*, the styles are a little shorter than, or about equal to, the longer stamens, and the flowers are unquestionably homogone³. But in the common villous St. Louis plant, which is regarded as a form of var. *stricta*, the flowers are larger and the pistil appears to have increased in length correspondingly with the petals, as may be seen from the following measurements, from the base of the flower (Table I). These flowers might be taken for the long-styled form of a trimorphic species; but the pollen-grains from both sets of stamens are essentially of the same size, so that this theory is untenable⁴, and both *corniculata* and this variety are to be regarded as merely variable in the relative length of stamens and pistil⁵.

There are also numerous stipulate specimens which could be referred to *O. corniculata* in the broad sense in which that species is understood, if it were not that they are still larger-flowered and may be trimorphic. I append some measurements of the stamens

¹ As I stated in the American Naturalist, in 1882, Hildebrand (Monatsber. Berl. Akad., 1866, 357,—and recently in Bot. Zeitung, 1887, 22) reports one mid-styled specimen of *O. violacea*, without locality, in the herbarium of Alexander Braun; and a figure of a mid-styled flower of what is called *O. violacea* is given by Payer (Organogenie, Pl. 11, fig. 19,—copied in Luer's Handb. Syst. Bot., II, 168). I also find several mid-styled specimens under this name, from about Buenos Ayres, in the Gray herbarium, but they are not our North American plant.

² Lebensverhältnisse der Oxalisarten, 36.

³ See Hildebrand: Monatsber. Berl. Akad., 1866, 368; Bot. Zeit., 1887, 37.

⁴ Hildebrand (Monatsber. Berl. Akad., 1866, 368-9) found one long-styled specimen of *stricta* collected by Treviso (but without indication of locality), and one from Missouri, while a specimen from Kentucky is said to be short-styled.

⁵ See Darwin's Different Forms of Flowers, 181.

TABLE I.—Large-flowered *O. corniculata*, var. *stricta*.

Length of Stamens.	Stamens.	Pistil.	Corolla.	
From one plant	3 mm.	4 mm.	7 mm.	10 mm.
	3	4	7	10
	3	5	7	9
	3	4	6	9
	3	5	6	9
	3	4	5	6
	2	3	5	8
	3	4	7	8
	3	5	8	9
	3	5	6	8
From one plant	3	4	5	6
	3	4	5	8
	Average.			
	3 mm.	4.3 mm.	6.2 mm.	

TABLE II. *O. corniculata*, var. (?) *macrantha*.

A. Long-styled.			
Locality.	Length of stamens.	Stamens.	Pistil.
Florida.	4 mm.	5 mm.	7 mm.
"	5	6	6.5
New York.	4	5	7
California.	4	5.5	6
B. Mid-styled.			
	Stamens.	Pistil.	Stamens.
New York.	4 mm.	5 mm.	6 mm.
California.	5	7	9
"	6	7	8
"	4.5	5.5	6
C. Short-styled.			
	Pistil.	Stamens.	Stamens.
Florida.	5 mm.	6 mm.	7 mm.
D. Doubtful.			
	Stamens.	Stamens.	Pistil.
Florida.	5 mm.	6 mm.	6 mm.
"	5	6	6

and pistils (Table II), but have not had an opportunity to measure the pollen of the different sets of stamens. Some of the specimens come very near *O. pilosa*, Nutt., as represented by a flowerless specimen of Nuttall in the Torrey herbarium. It will be seen that the last two (and others have been observed) have the styles equal to the longer stamens, as in typical *corniculata*, although the flowers are very much larger. Botanists who are able to study this large-flowered form in the field should make the measurements on a large number of specimens, necessary to determine whether it is heterogone or not.

While the heterogony of this form is at best only presumable, we have two truly trimorphic species of this section, as may be seen from Tables III-VI.

As these species are all very closely related, they appear to illustrate the manner in which an originally homogone species, variable in the relative length of stamens and pistils in some of its forms, may give rise to others which are trimorphic.

The specimens of *O. aclosella* and its variety *Oregana*, and of *O. trilliifolia*, that I have examined, agree in having the two sets of stamens very unequal in length, while the pistils mostly considerably surpass the longer set¹. The appearance is, therefore,

¹ Cf. Darwin: Different Forms of Flowers, 182; and

Hildebrand: Monatsber. Berl. Akad., 1866, 366; Bot., Zeit., 1887, 36.

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Stamens.	Pistil.
mm.	7 mm.
	6.5
	7
5	6

Pistil.	Stamens.
mm.	6 mm.
	9
	8
5	6

Stamens.	Stamens.
mm.	7 mm.

Stamens.	Pistil.
mm.	6 mm.
	6

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TABLE III. *O. SUKSDORFII*.

A. Mid-styled.			
Length of stamens.	Pistil.	Stamens.	Corolla.
5 mm.	6 mm.	8 mm.	16 mm.
B. Short-styled.			
Pistil.	Stamens.	Stamens.	
5 mm.	6 mm.	8 mm.	16 mm.
6	7	10	18
5	7	9	13

TABLE IV. POLLEN OF *O. SUKSDORFII*.¹

A. Mid-styled flower.		B. Short-styled flower.	
Long Stamens.	Short Stamens.	Long Stamens.	Mid Stamens.
50 μ	33 μ	50 μ	43 μ
43	36	50	43
? 40	36	47	? 50
43	36	50	40
43	33	50	36
47	34	53	47
47	33	47	40
47	33	47	40
47	36	47	36
47	33	53	36
43	33	47	47
47	36	47	43
47	33	47	47
43	36	50	43
47	33	50	40
Average 45.4 μ	36.2 μ	49 μ	42 μ

as if these might be the persistent long-styled form of originally trimorphic ancestors. But as the pollen of the two sets of stamens does not show the differentiation that would be expected in that case, it is more probable that they are to be compared with the still undifferentiated and homogene *O. corniculata*.

In all of our species the flowers are adapted to pollination by bees, which are attracted by their conspicuous color, and usually directed by veins of a deeper shade to a more or less abundant supply of nectar secreted by a series of small glands at the bases of alternate stamens, on the outside. This is generally protected from rain and dew by the hairiness of the longer stamens or styles, as well as by the closing of the flowers at night and in cloudy weather. *O. corniculata* and *O. acetosella*, the only cosmopolitan species, apparently owe their extensive distribution to the facility with which they are self-fertilized. The small flowers of the former are freely self-fertile, although they are visited and intercrossed by small bees in sunny weather, presumably with benefit to the species; and the latter produces reduced but extremely fruitful cleistogamous flowers on pedicels that are concealed at the base of the plant².

While the North American species deviate very little from the open funnel shape that appears to be typical of the genus, this is not true of all species. The corolla of *O. macrostylis*³, for example, a South American species, is lengthened into a slender tube 2 x 15-25 mm., a modification which clearly adapts the flowers to pollination by lepidoptera. (Note 10.)

Oxalis is a genus with explosive fruit. (Note 11.) At maturity the carpels dehisce along

¹ In both tables of pollen measurements, the shorter diameter of freshly swollen grains from herbarium specimens is given.

² According to Hildebrand (*Lebensverhältnisse*, 22) *O.*

Oregana, in cultivation, produces only open flowers through the entire season.

³ Jacquin: *Oxalis Monogr.*, Pls. 9-12. On this species, see further Walpers, *Repertorium*, t. 477; and Hildebrand: *Monatsber. Berl. Akad.*, 1866, 361-2.

the dorsal suture¹, and, at the slightest touch, their seeds are expelled in rapid succession to a distance of several feet. In gathering *O. corniculata*, I have been surprised at the sudden pattering of a dozen seeds against my face and clothing, while the capsule was apparently still closed, and it was only on closely examining it that I could convince myself that it was really dehiscent and empty, the valves remaining close together. The mechanism by which the seeds are expelled is quite unlike that of any other plant with which I am acquainted. In the ripening of the seed the inner integument becomes firm and hard, while the outer develops into a thick fleshy loose ariloid envelope, that ultimately splits longitudinally on the side opposite the raphe, and, pressing upon the somewhat flattened sides of the seed, forces it out, much as a boy would snap an orange seed from between his thumb and forefinger.

TABLE V. *O. RECURVA*.

A. Long-styled.		
Length of stamens.	Stamens.	Pistil.
5 mm.	6 mm.	9 mm.
6	8	10
4	6	8
5	7	9
B. Mid-styled.		
Stamens.	Pistil.	Stamens.
4 mm.	6 mm.	8 mm.
C. Short-styled.		
Pistil.	Stamens.	Stamens.
4.5 mm.	6 mm.	8 mm.
4	6	8

TABLE VI. POLLEN OF *O. RECURVA*.

A. Long-styled flower.		B. Short-styled flower.	
Mid-stamens.	Short-stamens.	Long-stamens.	Mid-stamens.
33 μ	27 μ	36 μ	34 μ
30	27	35	33
27	30	33	30
30	23	33	33
30	23	36	36
30	27	33	30
27	27	33	33
27	23	33	33
27	21	33	30
30	23	36	30
27	30	34	33
30	30	33	34
27	27	33	33
27	27	36	33
27	23	36	30
27	23	36	33
30	20	33	33
27	27	36	33
27	23	34	33
27	30	33	33
27	27	33	33
27	27	33	33
Average 28.2 μ	25.7 μ	34.1 μ	32.4 μ

BALSAMINEAE.

Flowers irregular, 5-merous, usually unsymmetrical from the suppression of 2 sepals; homogone; sepals and petals imbricate, deciduous; stamens 5, glands weak; carpels alternate with the sepals, several-ovuled.—*Balsaminaceae* of continental writers; two genera, one containing only a single species.

¹In § *Biophytum* they separate stellately and open on the inner suture.

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IMPATIENS, L. Gen. no. 1008; Benth. and Hook., Gen., 1, 277.

Annual herbs with succulent translucent stems, and thin alternate petioled simple leaves, without stipules; flowers several, on loosely branched bracteate axillary peduncles; sepals 3, the posterior petaloid, saecate, and mostly slender-spurred; petals 5, the lateral ones on each side united; stamens united somewhat by their appendaged filaments, and with more or less connate anthers; style almost none; ovary not deeply lobed, its valves breaking elastically from their septa and coiling; seed oblong, with four longitudinal ridges, otherwise nearly smooth, exalbuminous, the embryo straight with nearly plane cotyledons.—About 135 species, 20 in Africa; most of the others in tropical Asia.

1. *I. FULVA*, Nutt. Gen. 1, 146. *I. biflora*, Walt. *I. nolitangere*, 5, Michx. *I. maculata*, Muhl. Two to four feet high, branched, glabrous, somewhat orange or purple-tinted; leaves usually 2-3 in. long, a little glaucous below, elliptical-ovate, rather obtuse, coarsely crenate-serrate, the short teeth mucronate or the lower subulate, base subcordate or mostly acute; lower petioles about equalling the blade, the upper shorter; peduncles equal to the leaves or the upper longer; pedicels 2-4, each with a single linear bract about the middle; flowers orange-yellow mottled with red-brown; saecate sepal longer than broad, rather abruptly contracted to a slender spur which is half as long as the sac or more, notched at the end, and usually closely incurved; cleistogene flowers produced in abundance, the coherent nearly regular perianth carried up on the maturing ovary; capsule oblong, 1-4-seeded; seeds somewhat compressed, 3 × 5 mm.—Wet places, Canada to Florida, west to Oregon and Alaska (*file Mechan*); introduced into England. Pale, spotless flowers sometimes occur; and others destitute of a spur have been collected from Massachusetts (*Robbins*) to the Columbia Valley (*Lyall*). Very similar to the European *I. nolitangere*, which has a more corneoploid sac with its spur not toothed at the end, and larger lateral petals.

2. *I. PALLIDA*, Nutt. l. c. *I. nolitangere*, Michx. *I. aurea*, Muhl. Larger in every way, as much as 5-6 feet high, and paler; leaves sometimes 10 × 17 mm., usually 5 × 9 or less; flowers pale yellow, less prominently mottled; hooded sepal as broad as long, the notched spur not so closely incurved and less than one-third its length; bracts ovate, acute; otherwise like the last.—Wet places, Canada to Georgia, west to Saskatchewan and Oregon, usually less abundant than the preceding. A pink-flowered form is found in New York (*Dudley, Cayuga Flora*, 19).—Pl. 12, fig. 15.

The lower teeth of the leaves of some species of *Impatiens* are more or less nectariferous at the apex; or, as in the garden balsam (*I. balsamina*), the petiole also bears several such glands, which are homologous with the serrations of the blade. According to Delpino, these are contrivances by which a body-guard of ants is kept on the plant, for its defence against caterpillars and other enemies.

The flowers of *I. pallida* and *I. fulva*, like those of the related European *I. nolitangere*, secrete nectar in a spur formed from the prolonged posterior sepal, and advertised by the bright coloring of this sepal and the petals. They are protandrous, and evidently adapted to pollination by rather long-tongued humble-bees, which find an alighting place

rapid succession surprised at the capsule was could convince together. The other plant with becomes firm pelope, that upon the some- an orange seed

RECURVA.	
Short styled flower.	
Stamens.	Mid-stamens.
36 μ	31 μ
35	33
33	30
33	33
36	36
33	30
33	33
33	33
36	30
33	33
33	31
33	33
36	33
36	30
36	33
33	33
33	33
33	33
33	33
34.1 μ	32.1 μ

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on the lower petal and the floor of the sacate sepal, and touch anthers or stigma with their backs while feeding on the nectar. Bennett, the only one who has carefully studied the flowers from this standpoint, has shown that the appendages on the inner side of the filaments form a hood which, in conjunction with the pendent position of the flowers, effectually prevents self-pollination. The nectar spurs are frequently perforated by humble-bees, and hive-bees subsequently make use of these perforations to abstract nectar. Delpino has shown that some exotic species are apparently pollinated by lepidoptera,—the long-spurred *I. Sullawa*, which is now extensively grown as a greenhouse or border plant, is evidently of this class, and according to Baillon, *I. Humboldtiana*, of Madagascar, is ornithophilous. It should be noted also that humming-birds are not infrequent visitors to our own *I. fulva*. Both of our species bear regular cleistogamous flowers on the axillary peduncles, and the greater part of their fruit results from the fertilization of these reduced flowers, which are very abundant.

The ripening capsules are in a state of tension which finally results in the outer part of the valves breaking away below from their septa, which remain, with the seeds, attached to the persistent axile column. The liberated valves then rapidly coil up, stripping or shaking off the seeds as they do so, and often throwing them to a considerable distance from the plant. (Note 12.)

The tribe *Pelargoniceae*, which is not represented in our district, but is well known in the cultivated "geraniums" (*Pelargonium*) and nasturtium (*Tropaeolum*), possesses some interesting peculiarities connected with pollination, which can only be indicated in the briefest outline here. The flowers are protandrous, with one sepal produced as a long spur that is adnate to the pedicel in the former, and free in the latter genus. The epidermis, lining the narrow cavity of this spur, is provided below with short, unicellular hairs, the walls of which are thickened in a peculiar manner at the apex, the interior of the swollen tip finally undergoing a mucous degeneration connected with the secretion of nectar. Occasionally the cavity of the spur is double in *Pelargonium*, and in abnormal cultivated forms it sometimes disappears; the well-marked veining of the upper petals, which serves as a nectar-mark, then disappearing also, as Mr. Darwin has shown.

In *Pelargonium zonale*, etc., the flowers are well adapted to pollination by butterflies. Owing to their lateral position, their petals are unequal, as has been shown to be the case in *Ecodium*. This irregularity is somewhat intensified in the common "rose-geranium" (*P. graveolens*), and very much so in *P. tetragonum*, etc., the flowers of which Delpino has not inaptly compared with the papilionaceous type of Leguminosae. Not a few species of this genus are nearly scentless during the day, but extremely fragrant at night, and in this and other peculiarities indicate adaptation to cross-fertilization by nocturnal moths. *Tropaeolum*, with numerous species, presents a series ranging from such as are bee-pollinated to others which are as clearly ornithophilous. (Note 13.)

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1. On the general anatomy of *Geranium* see Irmsch: Bot. Zeitung, 1874, 545, etc. Modified stomata (water-pores) of *G. Robertianum* are discussed by Reinke; Jahrb. wiss. Bot., x. The appearance of adventive buds on the roots, in some cases, is noted by Warning; Bot. Tidsskrift, II; Just, v, 371. Weiss: Pflanzenhaare, 1867, and Anatomie der Pflanzen, 1878, I; Just, VI, 33-4, describes the characteristic forms of trichomes.

2. On the inflorescence of *Geranium* see Wydler; Jahrb. wiss. Bot., XI, Heft 3; Just, v, 362; Eichler; Blüthen diagramme, II, etc.

3. On the morphology of the flowers of *Geraniaceae* see Frank; Jahrb. wiss. Bot., x; Eichler; Blüthen diagramme, II; Bailon; Hist. des Plantes, v, etc., where other references are to be found. Instructive observations on teratological flowers of *G. Robertianum* are given by Christ, in the Botanische Zeitung für 1887, 6, pl. 1, as this is being written.

On the pollination of *Geranium* see Axell: Anordnungsgarnia Fanerog. Befr. 106 (several species); Fennell: Journ. Bot., 1872, 25 (*G. Robertianum* self-fertile in late autumn); Bonnier: Ann. Sc. nat., 6 sér., VII, 146, pl. 8, f. 118-132 (histology of nectar-glands); Bonnier and Flahault: Ann. Sc. nat., 6 sér., VII, 111 (brighter color of *G. Robertianum* at high elevations); Buckley: Fairy Land of Science, 221 (*G. sylvaticum*); Darwin: Cross- and Self-fertilization, 420 (secretion of nectar after fall of petals in *G. phacum*); Delpino: Ulteriori Osservazioni, II^a (nectary, 97); pollination, 105; early falling of anthers, 163; visits of *Rhyngis rostrata* to *G. pyrenaicum*, 317; Fecond. delle Piante Autocarpee, 30; Dodel-Port: Illustr. Pflanzenleben, Lieferung 7; Errera: Compt. rend. Soc. roy. Bot. Belg. XVII, 15, 42 (*G. phacum*); Errera and Gevaert: l. c. XVII, 132 (*G. phacum*); Goodale: Wild Flowers of America, 18; Hecke: Comptes rend., 1878, ? (movements of stamens); Henslow: Trans. Linn. Soc. n. s., I, 357-8 (self-fertilization); Hildebrand: Bot. Zeit., 1865 (experiments on *G. pratense*); Geschlechtervertheilung, 17, f. 3 (*G. pratense*, protandrous); Irmsch: Bot. Zeit., 1874, 565 (normally reduced flowers of *G. sanguineum*); Körner: Flowers and their unbidden guests, 112 (*G. Robertianum*); Kirby and Spence: Entomology, 462 (Bees, *Epomis variegatus*, sleep suspended by their mandibles from the beak of *G. phacum*, according to Linnaeus); Knaggs: Lepidopterist's Guide, 88 (lepidoptera at flowers); Lubbock: British Wild Flowers (*G. sylvaticum*, 2; *G. pratense*, 37; comparison of large- and small-flowered species, 43, 72); Scientific Lectures, 14 (résumé); Mignault: Nat. Canadien, XII, 247; Miller: Nature (visitors of *G. sylvaticum* and *G. pratense*, XI, 33; gynodioecism of *G. sylvaticum*, XVII, 519; Weltere Beobachtungen, II, 217-8 (visitors); Befruchtung der Blumen, 166 (comparative study of the German species); Alpenblumen,—(study of Alpine species); Fertilization of Flowers, 119 (general review of European species); Rieen: Atti Soc. Ital. Sci. Nat., XI, 256 (*G. phacum*); l. c. XIV, 252 (*G. sanguineum*); Roth: Heftträge (1783), II, 70 (nectary); Soyer-Willemet: Le Nectar, 36 (nectary); Sprengel: Neu entdeckte Geheimnisse der Natur (1793) (*G. sylvaticum*, I, 338; *G. palustre*, 335; *G. Robertianum*, 337; *G. sanguineum*, *pratense*, *reflexum* and *molle*, 338); Thomson: Trans. Bot. Soc. Edinburgh, XIV, 232 (*G. microphyllum* and *molle* in New Zealand).

Griseb (Gard. Chron. n. s., v, 699, VI, 49) gives an account of a supposed hybrid of *Pelargonium zonale* and *G. pratense*. On the histology of the embryo see Flahault: Ann. Sc. nat., 6 sér., VI, 112; Gérard: Ann. Sc. nat., 6 sér., XI, 330.

4. On the mode of dissemination of *Geranium* see Bishoff: Lehrb. Bot., II, 470; Hildebrand: Verbreitungsmittel der Pflanzen, 37; Jahrb. wiss. Bot., IX, 269, pl. 25(=3), f. 38. Lubbock: Pop. Sci. Monthly, XIX, 161; Flowers, Fruits and Leaves, 57 (from Fortnightly Review); Steinbrink: Bot. Zeit., 1878, 580; Zimmermann: Jahrb. wiss. Bot., XII, 566, pl. 36. Also Gibson: Harper's Mag., Oct., 1885, 687; Olvers: Bot. Centralbl., XXI, 318 (Just, 1881, 685).

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- On plumose fruits of *Mansonia* see Ascherson, *l. c.* The dissemination of *Pelargonium* is discussed by Delphino: Pensieri sulla Biol., 11; F. Darwin: Tr. Linn. Soc., Bot., 2 ser., i, 165, pl. 23, f. 5; Hildebrand: Jahrb. wiss. Bot., ix, 268, pl. 25, f. 39, 47-8; Mallet: Mag. Nat. Hist., ix, 23; Stearns: Am. Nat., xii, 416; Steinbrück: Bot. Zeit., 1878, 611; Zimmermann: Jahrb. wiss. Bot., xii, 571, pl. 36, f. 25-8. In this genus the contraction of the awn depends largely upon the thickened epidermal cells, while torsion is effected by the mechanical fibres. According to Stearns, *Pelargonium* fruits are less readily self-planted than those of *Erodium*. Several observers have noticed that the fruits of *Erodium*, like those of *Stigma*, etc., are injurious to animals when eaten, and may even penetrate the flesh when they become entangled in their hair. See various places in Nature: Huth: Kosmos, ix, 277, etc.
- For descriptions of the seed-coats see Marloth: Engler's Bot. Jahrb., iv, 237.
- The cotyledons of a number of species are described by Godron (Rev. Sc. nat. Sept., 1877) who bases a series of groups of species on their form.
8. On the morphology of the *Linnæatheae* see Ballou, *l. c.*; Almqvist: Bot. Notiser, 1879, 109, etc. The movements of the stamens, referred to above, are also noted by Heekel: Comptes Rend., 1878, lxxxvii.—; Just, vi, 317. On the anatomy of the Embryo see Flahault: Ann. Sc. nat., 6 sér., vi, 111, pl. 3, f. 21.
9. On the leaf-movements of *Ocailideae* see Ballou: Hist. des Plantes, v, 21; De Brignoll (see Morren); Bruce: Philos. Trans., 1785, lxxv, 356; Cooke: Freaks of Plant Life, 243; Darwin: Power of Movement in Plants, various places; Köhnter: Annals of Bot., ii, 2; Lynch: Journ. Linn. Soc., Bot., xvi, 231-2; Masters: Pop. Sci. Rev., vii, 26; Morren: Bull. Acad. roy. Sc. Belg., vi, 68, transl. Ann. Nat. Hist., iv, 388; Pfeffer: Physiolog. Untersuchungen, 1873, 74; Period. Bewegungen Blattorgane, 1875 (Just, iii, 795); Pflanzenphysiologie, ii, 238; Virey: Journ. de Pharmacie, Paris, May, 1839, 289, criticised by Morren, *l. c.* 70.
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- The histology of the embryo is discussed briefly by Flahault: Ann. Sc. nat., 6 sér., vi, 115.
12. On the general histology of *Impatiens* see Boyse: Nova Acta Leop.-Carol. Acad., xliii, 181.
- The foliar (extraxillary) nectar-glands are considered by Bonnier: Ann. Sc. nat., 6 sér., vii, 98; Delphino: Prodr. Monog. Plante formidabile, 1886, 36; Kerner: Flowers and their Unbidden Guests, 137; Reinke: Bot. Zeitung, 1874, 59; Jahrb. wiss. Bot., x, 162.
- For the pollination of the genus see Allen: Proc. Essex Inst., iv, 53 (humming birds at *I. fulva*); Axell: Anordningarna (cleistogamy, 12, 79; protandry, 106); W. W. Bailey: Bull. Torrey Bot. Club, vi, 173 (perforation of *I. fulva* by *Bombus*); Ballou: Bull. Soc. Linn., Paris, 1881, 286 (Delphino: Rivista Bot., 1881, 37; Just, ix, 518) (*I. Humboldtiana* pollinated by birds); Beal: Am. Nat., xiv, 201; Bennett: Journ. Linn. Soc., Bot., xiii, 147, pl. 3 (Journ. of Botany, ix, 376); Pop. Sci.

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EXPLANATION OF PLATES.

PLATE 9. FOLIAGE OF GERANIUM.

Figs. 1-2. *G. maculatum*: 1, radical; 2, cauline. 3. *G. erianthum*: cauline. 4-5. *G. incisum*: 4, radical; 5, cauline. 6-8. *G. Richardsonii*: 6-7, radical; 8, cauline. 9. *G. Fremontii*: five leaves, the upper two radical, the others cauline. 10. *G. caespitosum*: two leaves, the left-hand, radical. 11. *G. Hernandezii*: two cauline leaves. 12. *G. Sibiricum*: cauline leaf. 13. *G. Carolinianum*: two leaves, the upper radical. 14. *G. pusillum*: three leaves, the lowest radical and exceptionally large, the others cauline. 15. *G. dissectum*: cauline leaf. 16. *G. rotundifolium*: cauline leaf. 17. *G. columbinum*: cauline leaf. 18. *G. molle*: two cauline leaves. 19. *G. Robertianum*: cauline leaf.—All reduce, one-half.

PLATE 10. GERANIUM AND ERODIUM.

Figs. 1-11. Geranium: 1, *G. Richardsonii*; 2, *G. Carolinianum*; 3, *G. pusillum*; 4, *G. maculatum*; 5, *G. molle*; 6, *G. caespitosum*; 7, *G. columbinum*; 8, *G. erianthum*; 9, *G. rotundifolium* (the summit of the beak a little too short); 10, *G. Robertianum*; 11, *G. incisum*.—All $\times 2$.

Figs. 12-18. Erodium: 12, *E. macrophyllum*, two leaves, carpel and seed; 13, *E. Texanum*, three leaves, carpel, and seed; 14, *E. matachoides*, two leaves, carpel, and seed; 15, *E. cicutarium*, leaf; 16, *E. botrys*, three leaves; 17, *E. moschatum*, leaf, carpel, and seed; 18, *E. cicutarium*, leaf, carpel, and seed.—Leaves reduced one-half; carpels $\times 2$; seeds $\times 5$.

PLATE 11. OXALIS.

Fig. 1. *O. dichondriifolia*: leaf and seed (the latter surrounded by its outer envelope). 2. *O. Berlandieri*: leaf and seed. 3. *O. Wrightii*: leaf and seed. 4. *O. corniculata*: leaf; α , stipules of two leaves (magnified). 5. *O. corniculata*, var. *macrantha*: leaf. 6. *O. recurva*: leaf. 7. *O. acetosella*: leaf and seed. 8. *O. acetosella*, var. *Oregana*: leaf. 9. *O. trifolifolia*: leaf and seed; α , cross-section of seed. 10. *O. violacea*: leaf; α , two leaflets of the common form of the prairie states. 11. *O. divergens*: leaf. 12. *O. latifolia*: two leaflets. 13. *O. vespertilionis*: two leaflets. 14. *O. decaphylla*: three leaflets and seed.—Leaves reduced one-fourth; seeds $\times 20$.

PLATE 12. SEEDS OF GERANIUM AND IMPATIENS; FRUIT OF LIMNANTHES AND FLOERKEA.

Figs. 1-14. Geranium: 1, *G. incisum*; 2, *G. Richardsonii*; 3, *G. caespitosum*; 4, *G. rotundifolium*; 5, *G. maculatum*; 6, *G. Carolinianum*; 7, cross-section of same; 8, *G. Carolinianum*, var. *Texanum*; 9, *G. columbinum*; 10, *G. pusillum*. 11-12. *G. Robertianum*; 11, detached segment of ovary; 12, seed. 13-14, *G. molle*: 13, seed, 14, the same in segment of ovary. 15. *Impatiens pallida*: α , cross-section. 16-19. *Limnanthes*: 16-17, *L. Douglasii*; α , cross-section; 18, *L. Macmilli*; 19, *L. alba*. 20. *Floerkea proserpinacoides*.—1-14, $\times 20$; 16-20, $\times 10$.

leaf; 5, cauline.
ers cauline. 10.
trium: cauline
lical and excep-
G. columbinum
ff.

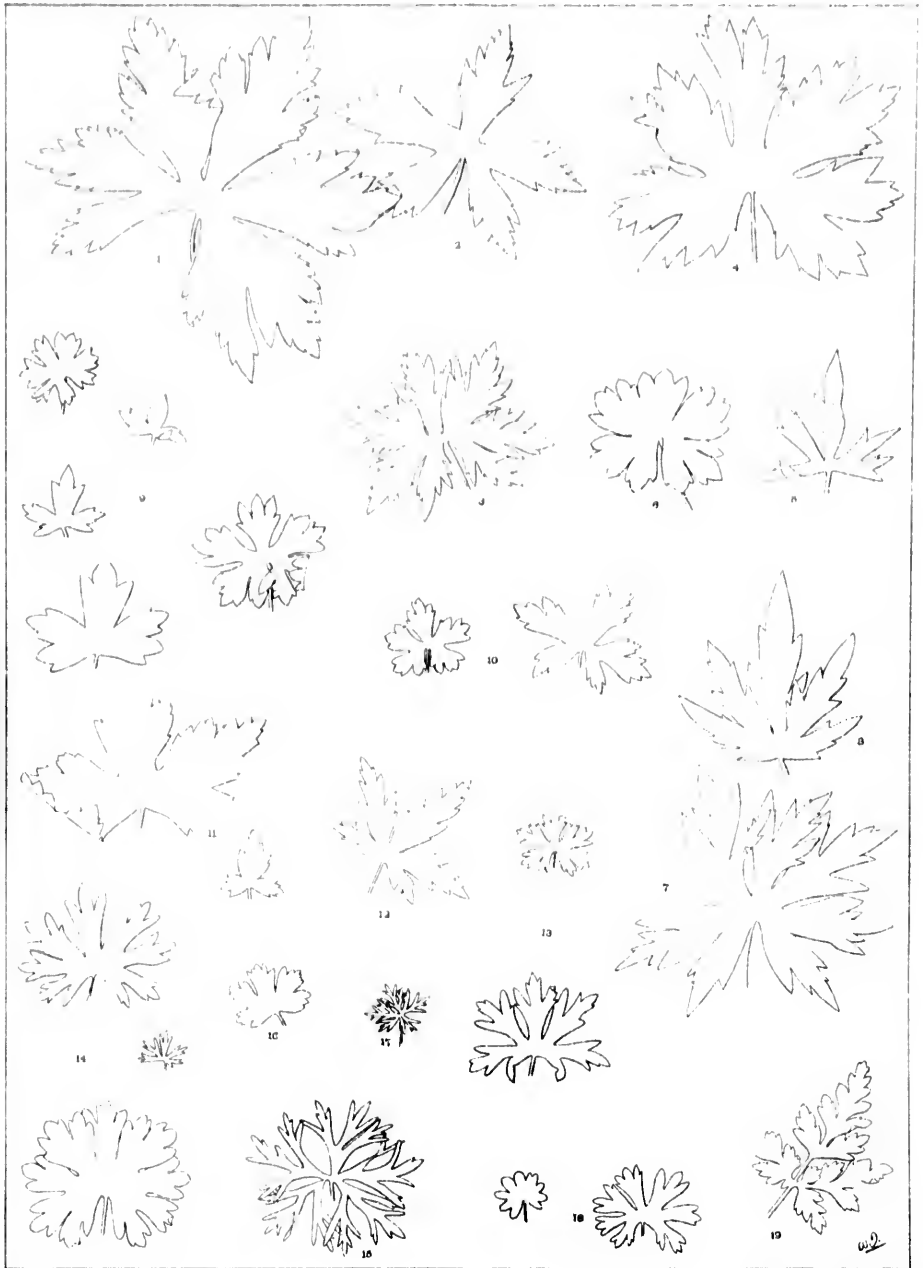
molle; 6, G. caes-
oo short); 10, G.

leaves, carpel, and
es; 17, E. moscha-
× 2; seeds × 5.

eriantheri: leaf and
5. O. corniculata.
regana: leaf. 9. O.
on form of the prai-
14. O. decaphyla

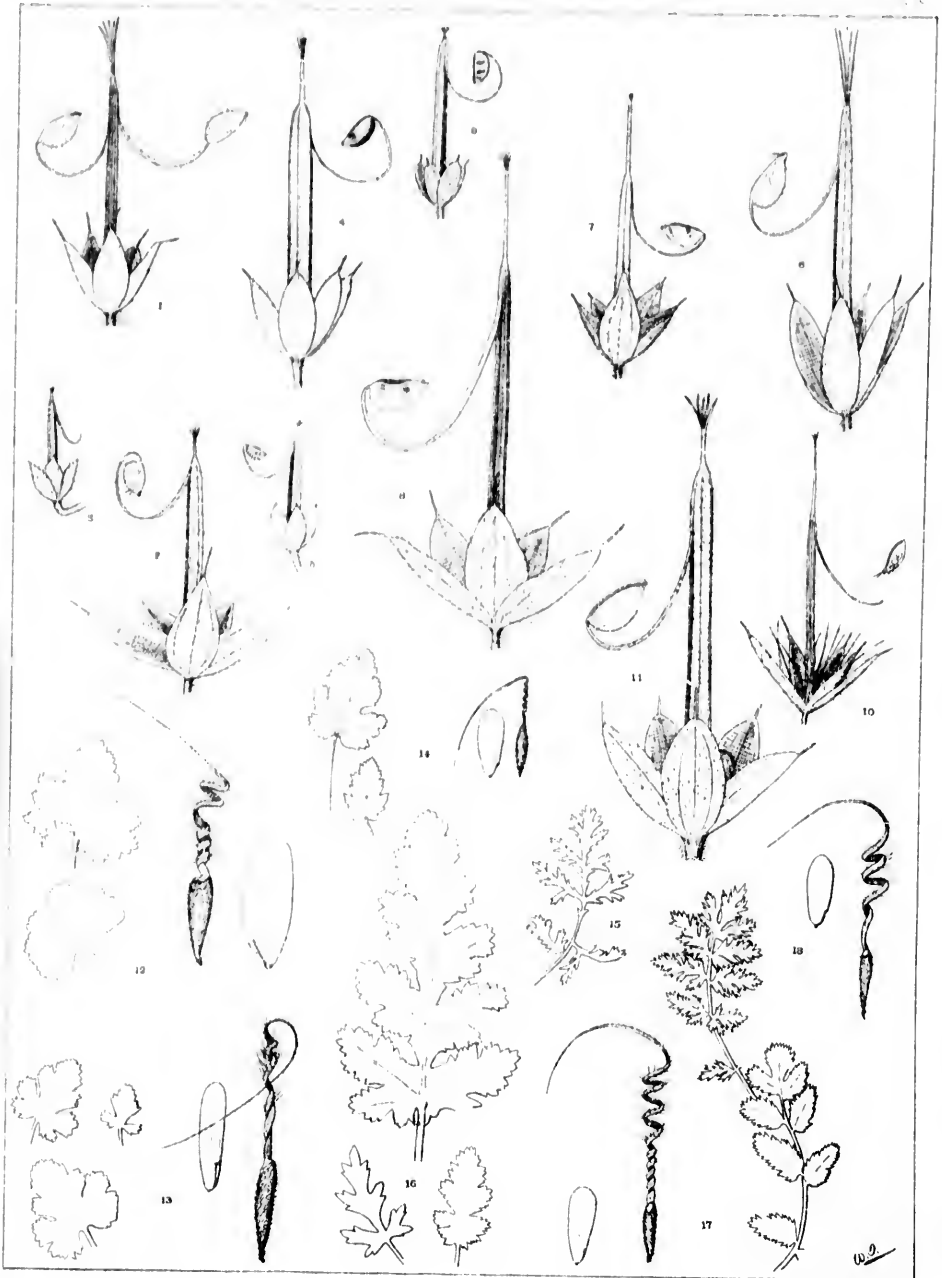
D FLOERKEA.

; 5, G. maculatum; 6,
m; 10, G. pusillum.
e same in segment of
s-section; 18, L. Ma-



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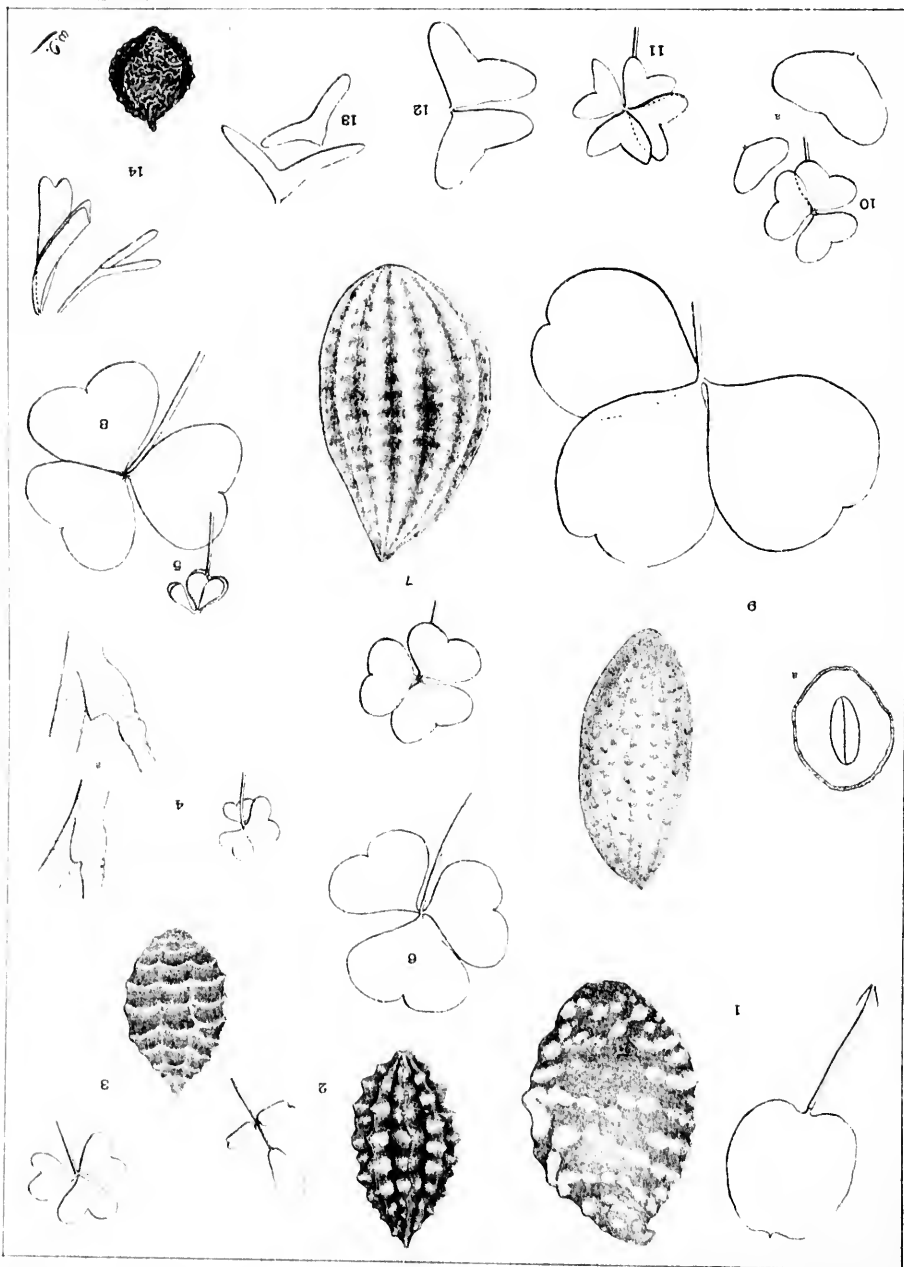
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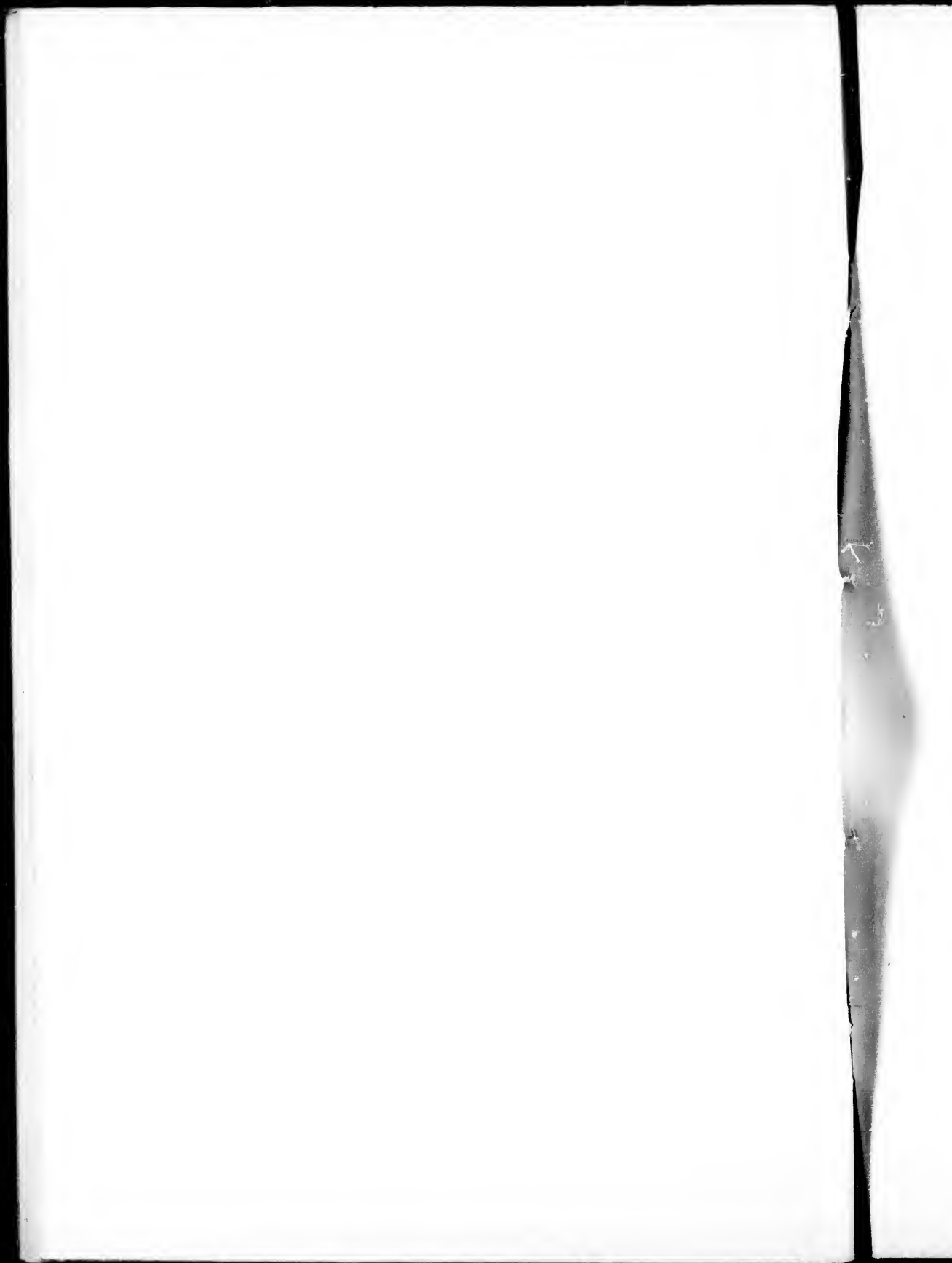
TRELBASE, AMERICAN GERANIACEÆ.

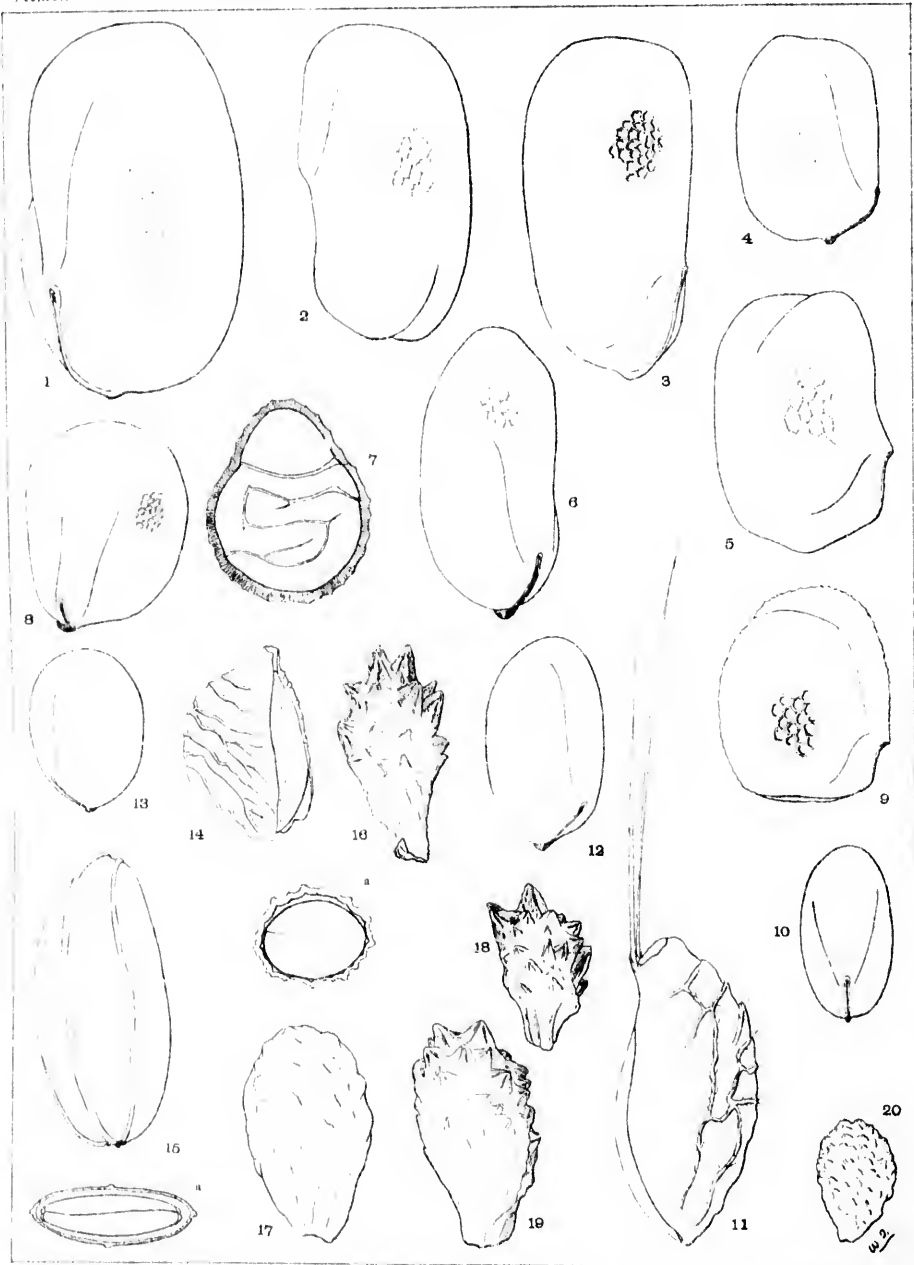


FRUITS, AMERICAN SERRIACEAE.

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TRELLISE, AMERICAN SPERMATOPHYTES.

