

g. 5; 12, figs.

root and a half
lous, purple-
ultimate lobes
half an inch or
d, connivent;
nts glabrous;
ruent; styles
sparingly pu-
ed 1 x 2 mm.,
west to Min-
ern Asia and

a tap-root in
ller rootstock
eak-stemmed,
larged nodes
swollen nodes
at the lower
at roughened
retorse, in a
s long, mostly
shorter cylin-
which abound
a rather small,
and *G. Rich-*
pedicels, etc.,
ly *G. incisum*,
be pretty con-
s of *G. caesp-*
ume plant, are
eliance should

a 1- or, mostly,
uline leaves in
ding in paired
an 2, and bear
leafy and elon-
more branched

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.